



NETWORKS

ESB NETWORKS 2027

Lighting the way to a better energy future

www.esbnetworks.ie



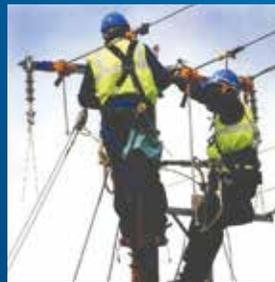
As part of the ESB Networks 'Strategy to 2027', our objective is to become a world-class sustainable networks business. We are at the forefront in defining the Smart Networks of the future and this is being achieved through research initiatives and participation in national and international collaborative alignments.

This publication traces the journey of ESB Networks:

>> past...



>> present...



future >>



FOREWORD



We stand at a crucial turning point. Ireland has committed to delivering 40% of its electricity from renewables by 2020. The Irish economy is ever more dependent on secure, high-quality electricity infrastructure and ESB Networks plays a vital role in

supporting these issues.

In 2027, ESB Networks will be celebrating 100 years serving all electricity customers and the Irish state, providing the infrastructure on which our society has developed.

Over the 'boom' years, while making over 100,000 new connections per year, ESB Networks was making strategic investments in the long-term sustainability and quality of our networks. In renewing networks, 80,000km of MV networks were rebuilt and over 40,000km converted to 20kV, network transformer capacity was increased by almost 50%, and average customer electricity outage duration per year was reduced by 72%.

Having developed robust, high-quality networks, the next challenge is to realise their full potential. Smart operations and development of planning, leveraging sensors and widespread, high-speed, reliable communications will fundamentally increase the efficiency and effectiveness of our networks. This kind of innovation in investment goes beyond laying lines and cables and involves the integration of traditional electricity networks with Information Technology and communications systems. It is a revolutionary process which we are undertaking in an informed and diligent way, working with all stakeholders across industry, academia and most importantly our customers.

This publication sets out our vision of Networks 2027. What I can assure you is that along with our focus on safety, customers are central to ESB Networks' development and that ESB Networks, will deliver this network of the future.

Jerry O'Sullivan
Managing Director, ESB Networks

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The History of ESB

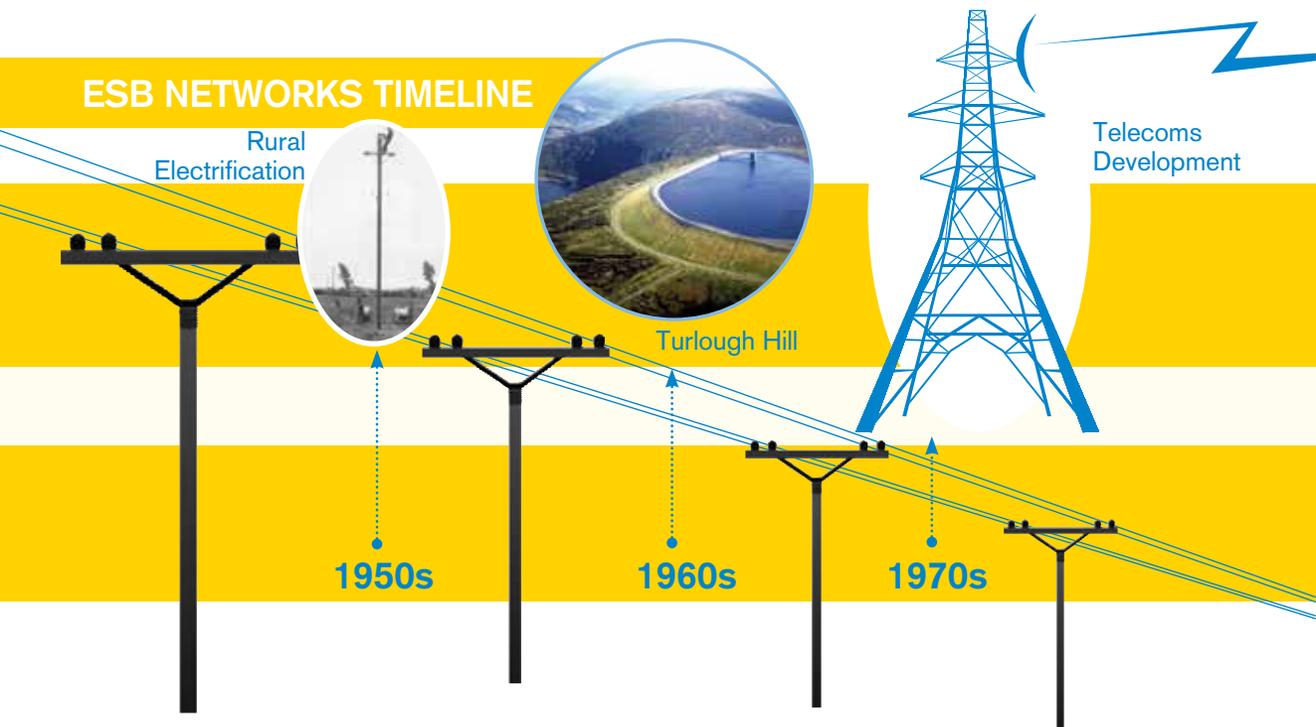
1946 saw the beginning of Rural Electrification, a visionary project, installing the electricity infrastructure which powered the people of Ireland – supplying energy, light, heat and enhancing the quality of life. These networks and the power they supplied enabled the social, economic and industrial development which saw Ireland grow from an underdeveloped peripheral region to one of the most developed countries in the world.

ESB Networks have continued to develop and refurbish the Irish electricity infrastructure to a world-class standard catering for today's Irish economy.

The most transformational change in the electricity and energy industry will occur between now and 2027, driven by European energy policy, mandating 20% reduction in CO₂ emissions, fuelling 20% of energy requirements from renewables, and to be 20% more energy efficient.

Challenges

The very distributed rural population in Ireland is reflected in the size and scale of an electricity distribution system that is unique. Ireland has four times the European average of length of network per capita, approximately 66% of Irish medium voltage networks are single-phase, and a ratio of over 6:1 overhead to underground networks exists – on an island at the edge of the Atlantic. All these factors contribute to the significant challenges ESB Networks contend with in maintaining networks to ensure customers receive a top-quality electricity supply and that the lights are always on. Not to mention the challenges we face in developing the Smart Grid of the future.





Targets for the Future

In the future, customer's use of electricity will change dramatically. Through smart metering, customers will become more actively involved in managing their electricity, delivering benefits for themselves and the wider system. Fossil-fuelled transport and heating systems will begin to be replaced by carbon-free electricity-powered systems.

Long before the phrase 'Smart Networks' was ever conceived, ESB Networks realised that the distribution networks are key to the secure and sustainable delivery of energy to customers. Thus, a core value and strategy in the history of

This is delivered by...

2.1m wooden poles

230,000 overhead distribution transformers

20,000 ground-mounted urban distribution transformers

150,000km of overhead MV/LV network

22,000km of MV/LV urban underground network

746 HV substations (400kV-38kV)

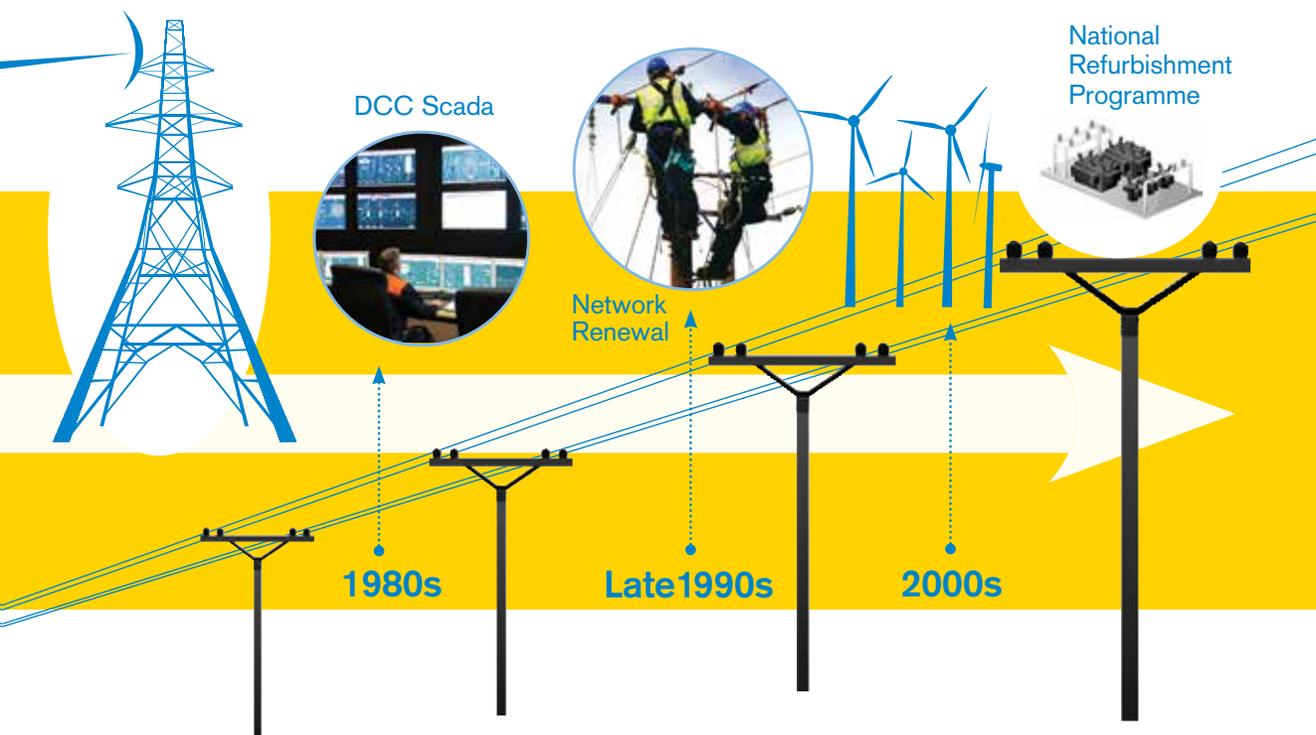
2.3m meters

7,174km of Transmission network

ESB Networks is in ensuring that losses are minimised, supply is reliable, secure and of a high quality.

As ESB Networks now embraces the smart technologies of the future, this history of innovative design and system management will help Ireland achieve its climate change goals. ESB Networks will facilitate the connection of renewable

generation (fueling over 40% of the country's energy), deploy smart metering nationally, install electric transport infrastructure, facilitate active participation of customers and continue to build low-loss networks improved with integrated intelligence with high-speed communications delivering the world-class electricity network of 2027.



Where we are Now

ESB Networks is responsible for the construction and maintenance of all of the electricity infrastructure in Ireland including the transmission, sub-transmission, medium and low voltage networks. ESB Networks is also the Distribution System Operator. ESB owns and funds all investment in the Transmission and Distribution systems in Ireland.

WHERE WE ARE NOW

ESB Networks have developed one of the most modern and robust electricity networks in the world. Over the 2000-2012 period, ESB Networks have efficiently refurbished and upgraded the national electricity network to meet the challenges of aging networks, rapid load growth, unprecedented levels of new connections and the emergence of distributed wind generation. This has increased network reliability, reduced network losses and

increased safety, whilst reducing the network operational charges for the customers. ESB Networks invested €7bn in delivering on a very complex suite of technical work programmes, while staying within the revenue allowances set by the Commission for Energy Regulation. An independent, international survey of electricity network companies acknowledged ESB Networks as having the third most advanced networks worldwide as of today.

IN THE LAST 10 YEARS ESB NETWORKS HAVE:

CONNECTED UNPRECEDENTED LEVELS OF NEW CONNECTIONS

CONNECTED 694,151 NEW CONNECTIONS
– UP TO

106k
IN ONE YEAR

PROCESSED **700,000** CHANGE OF SUPPLIER REQUESTS AND FACILITATED THE OPENING OF THE ELECTRICITY MARKET

ACHIEVED

90%
CUSTOMER
SATISFACTION
LEVELS

90% OF ALL
CALLS ARE
ANSWERED
WITHIN
20 SECONDS
(independently evaluated
through a survey
conducted by REDC)

REBUILT

80,000km
of medium voltage
(MV) network and
replaced up to 100,000
poles per year to
deliver a more reliable
and safe network –
reducing line drops
and improving
performance in poor
weather conditions



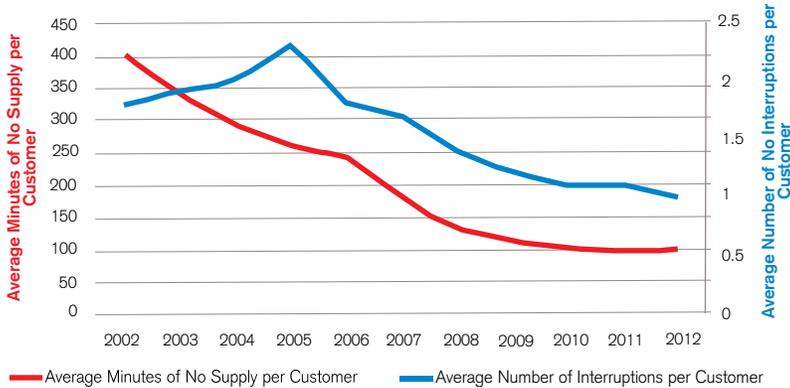
IN THE LAST 10 YEARS – ESB NETWORKS HAVE:

IMPROVED NETWORK RELIABILITY AND STORM RESILIENCE

- >> **72%** reduction in customer minutes lost
- >> **39%** reductions in customer interruptions



Reductions In Customer Electricity Interruptions Achieved

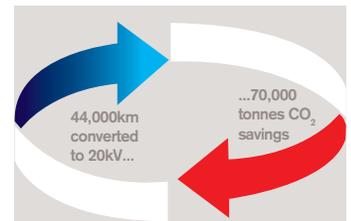
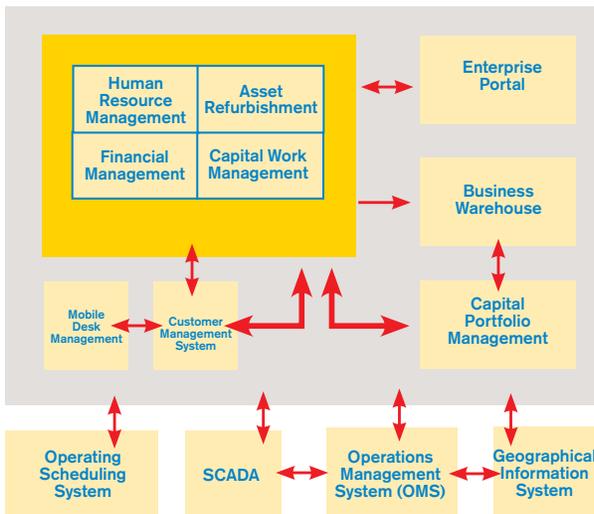


INCREASED DISTRIBUTION NETWORK STATION CAPACITY BY ALMOST 50%

- >> Adding almost 1,500MVA of 110kV/38kV station capacity
- >> Adding almost 1,700MVA of 110kV/MV station capacity
- >> Delivered 15 new HV stations in Dublin alone

IMPLEMENTED A FIRST-CLASS INTEGRATED IT PLATFORM

Implemented an integrated IT platform to manage work programme delivery, asset management, financial management, personnel and payroll, and meter operations.



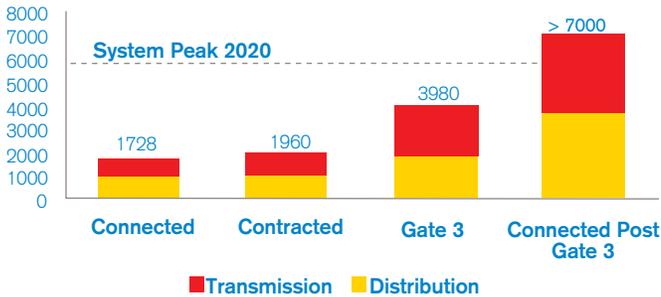
CONVERTED 40,000km OF MV NETWORK FROM 10kV TO 20kV OPERATION

- >> Reducing voltage drop by 75%
- >> Increasing the rural network capacity by over 200%
- >> Reducing network losses by 75%
- >> Reduce network emissions – equivalent to 2.5 million electric kettles per year



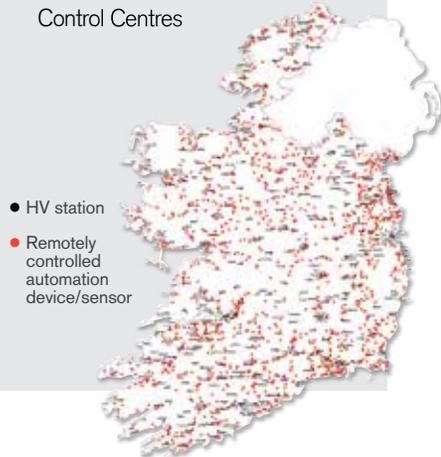
CONNECTION OF RENEWABLE GENERATION

- » Connected 1,728MW of Wind Generation
- » A further 1,960MW with signed connection agreements
- » A further 3,980MW of connection offers issued



CENTRAL OPERATION OF THE NETWORK

- » Developed state-of-the-art Outage Management System, enabling reduced customer outages and reduced operational costs
- » SCADA control of all 38kV stations down to MV busbar level
- » Installation of over 1,400 remote automation devices
- » Two centralised Distribution Control Centres

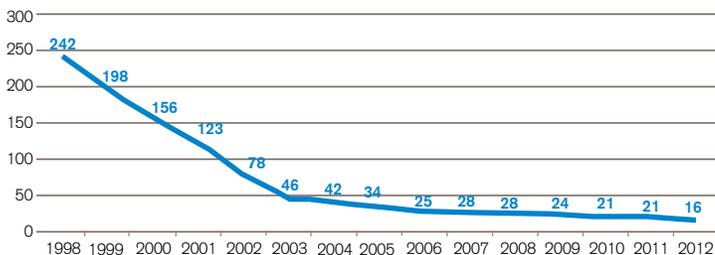


DEVELOPED A TELECOMS INFRASTRUCTURE TO MEET THE NEEDS OF ELECTRICITY SUPPLY



ESBN optical fibre, microwave and polling radio networks

Number of Lost Time Incidents By Year 1998-2012



PAS 55 STRUCTURE



Achieved the PAS 55 accreditation – international reference standard for the optimal management of physical assets, providing the definition of good practice in the whole life management of assets.

MADE THE WORKPLACE A SAFER PLACE BY REDUCING LOST TIME ACCIDENTS BY

87%

Drivers of Change

By 2027:

- >> Have an active electricity network enabling a low-carbon economy:
 - >> Maximise renewables
 - >> Smart metering in every home and business
 - >> Empowering all customers to play a part in load management
 - >> Harness the benefits of new storage technologies and new flexible loads
 - >> Increase network security and efficiency

This will be delivered through:

- >> Knowledge sharing and collaboration with national and international partners
- >> Focused research
- >> Demonstration and testing of new technologies
- >> Prudent implementation of proven technologies



» **40%** of electrical energy from renewables by 2020

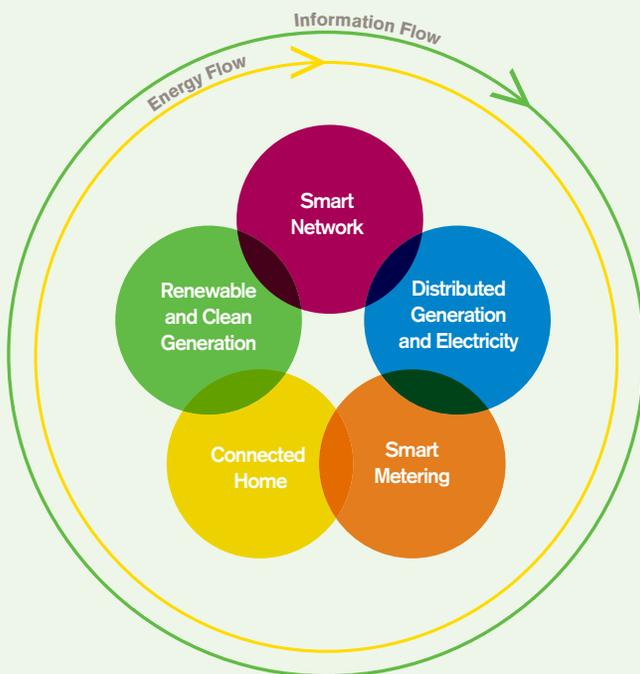
» Smart metering for domestic and commercial customers

» Facilitate up to **250,000** electric vehicles

» ESB – carbon neutral by 2050



Implementing this vision will deliver a world-class, sustainable network for Ireland



ESB STRATEGY

Delivery of this vision of Networks 2027 will provide, within the regulatory framework, networks infrastructure and services that support economic growth and sustainability targets. This will also deliver business and value growth, underpinned by excellence in safety, service, asset management and people development.

Together with the provision of continued security and reliability of supply, Ireland's electricity

network of the future is the key pillar to unlock the potential of new energy sources and technologies, enabling the delivery of a clean, secure and competitive energy system for the country. In this roadmap to the network of the future, ESB Networks address these objectives in order to create a network in 2027 that will meet the goals and expectations of the country and ensure that these are delivered as effectively and efficiently as possible.

ESB NETWORKS WILL:

- » Collaborate with National & International partners to undertake essential RD&D to define the future networks
- » Develop and validate intelligent tools and methods which will enable us to take on new and evolve existing roles required by the increased volume of Renewable Generation connected to our distribution networks
- » Create and improve existing tools and methods to support distribution network planning, operation and maintenance and to more effectively manage the changing roles in the future grid architecture.
- » Have implemented active distribution networks, to provide system support, facilitate real-time data exchange and empower the consumer

Delivered through
ESB Networks
Integrated Future
Networks Model



DELIVERING THIS VISION OF NETWORKS 2027 WILL...

Transformational changes in the energy sector are on the way across the world that will see a new era in electricity generation, its delivery to customers and the way customers will use it. The electricity network is key to delivering this change.

In Ireland, the abundance of renewable resources, the strength of the electricity network, the co-operation of the electricity participants, industry, academia and indeed the ever adaptable Irish people, enable us to be at the heart of this change. Through the level of wind-powered generation already being managed, the comprehensive preparations for smart metering and the progressive electric cars programme, along with the international and national collaborations that have been formed, Ireland is already a step ahead on the road to change.

A 'Smart Network' is required to deliver these transformational changes and meet future customer needs. Smart Networks will be the key driver of change and will enable the delivery of both EU and national climate change targets within the regulatory framework.

Drivers of Change

Ireland has signed up to binding EU targets for the decarbonisation of the energy sector and has designed an ambitious programme to use the country's indigenous renewable resources to deliver on these targets.

In the country's framework for a secure, competitive and efficient energy sector, the three main targets have already been set:

- > 40% of electrical energy to be delivered from renewable resources by 2020
- > Implementation of the smart metering programme
- > 10% of all domestic transport to be fuelled by electricity by 2020

However, these targets are just interim points on the ultimate goal: to have a zero/near-zero carbon electricity sector in Ireland and Europe by 2050.

EU TARGETS ON ENERGY EFFICIENCY

20% reduction in greenhouse gas emissions

20% improvement in energy efficiency

20% energy from renewable energy

EU directives ➡ smart metering

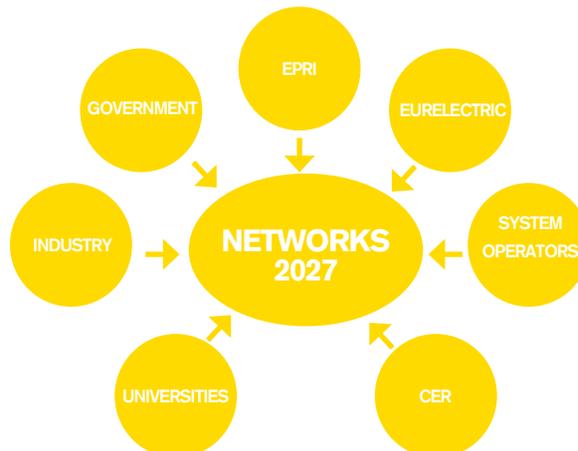
IMPLICATIONS FOR IRELAND'S ELECTRICITY SECTOR

40% of electrical energy supplied from renewable sources

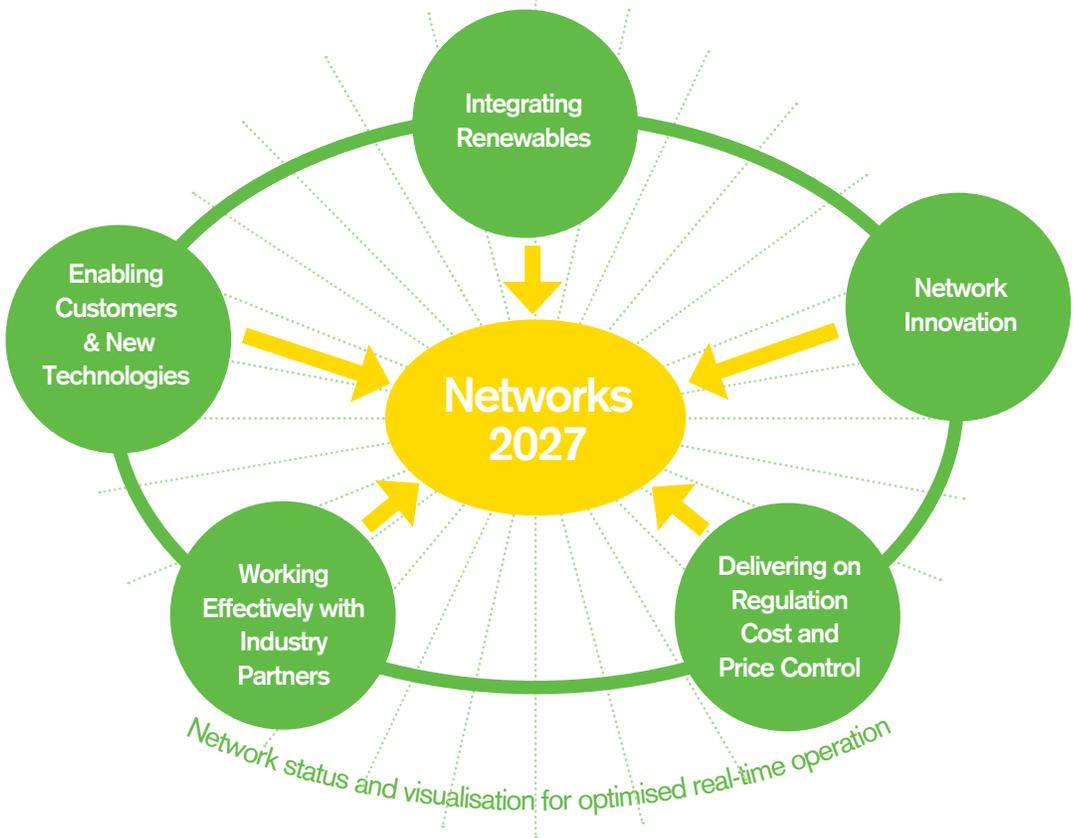
10% of all vehicles fuelled by electricity

Smart meter programmes

Network losses reduction



THE KEY ELEMENTS FOR DELIVERY



ESB Networks Approach to Future Networks

ESB's corporate strategy has embraced the sustainability challenge and has set an overall target to be carbon neutral by 2050. In line with corporate strategy and country deliverables, ESB Networks' integrated smart network model defines how both these objectives can be delivered.

This document defines ESB Networks approach to each of the key elements required to deliver Networks 2027 as outlined in the diagram above.

Collaborative Efforts to Deliver for Society

Across the world, the electricity industry, technology suppliers and academia are also addressing these challenges and ESB Networks are committed to joining collaborative research initiatives to progress this journey.

ESB Networks are one of the core members of the Energy Research Centre at UCD. Growing from this, a focused Sustainable Electrical Energy Research Cluster initiative has joined committed partners from across academia and

the energy industry, funded by Science Foundation Ireland, to identify and address the technical challenges of the electricity system in the coming years. In an international context, ESB Networks research is one of the US Electric Power Research Institutes' (EPRI) Smart Grid Demonstrations, sharing the lessons learned and learning from other demonstrations across the world. Through close partnership of generators, system operators, regulators and government, focused on a common goal, Ireland has the potential to deliver real innovation through our internationally recognised innovation hub and test bed, which will deliver a class-leading electrical system for the future.



ESB's corporate strategy has embraced the sustainability challenge and has set an overall target to be carbon neutral by 2050

Integrating Renewable Generation

BY 2027:

- >> ESB Networks will have enabled the connection of more than 5,000MW of generation capacity to the electricity network grid – with more than 2,500MW connected via the distribution system
- >> ESB Networks will do our part in facilitating the achievement of government targets in the wave and ocean energy sector

BY 2027:

Connect more than
5,000MW
of renewable generation

Manage more than
2,500MW
of distribution connected generation

Facilitate the delivery of
**ocean
& tidal**
energy projects



ESB Networks will lead the development of smart networks to enable optimum penetration and integration of renewable resources

ESBN's projects are innovative, comprehensive, deeply relevant and absolutely vital

– PowerGrid International, February 2011

ESB NETWORKS STRATEGY:

Ireland is committed to having 40% of its electricity supplied from renewable resources by 2020 – the highest renewable electricity target in Europe and one that will increase by 2027.

ESB Networks have built connections for over 1,728MW of wind farms. More than half of the eventual capacity, made up of over 400 medium-sized wind farms, will be connected to the distribution system.

However, reaching this target poses challenges – innovation will be vital to integrate these levels of wind generation. ESB Networks are working with industry partners and academia to design, research

and develop innovative network connections, using new technologies and operational methods to optimally manage variable generation on the distribution system.

This award-winning research, being conducted as part of an International Smart Grid Demonstration initiative organised by Electric Power Research Institute (EPRI), is already delivering positive results and paving the way for these technologies to be standard features of 2027 networks. Ireland's huge renewable generation resource is the vehicle for Ireland to deliver clean, secure and competitive energy to Ireland – it is critical that we deliver.

ESB NETWORKS WILL:

have implemented fully researched, developed and tested methods by 2027 to:

- » minimise generation connection costs through innovative, but secure, connections
- » optimally and dynamically manage networks, realising the potential of distributed renewable generation to minimise network losses
- » minimise the impact of renewables on voltage quality using the dynamic reactive capabilities of wind farms
- » facilitate maximum levels of active customer load management, matching flexible customer loads to variable generation

CONNECTING CLEAN ENERGY SOURCES

Ireland is already a world leader in its effort to harness potential renewable resources – particularly wind. ESB Networks are a core partner in this endeavour; facilitating reliable and efficient connections, while progressing world leading research to advance connection methods and management of variable generation on the distribution system.



The Irish Government has formally committed at European level to have a higher penetration of renewables than any other country in the EU by 2020 [see Figure 1]. Over half of the renewable capacity will be connected to the distribution system. For distribution connected generation, ESB Networks is responsible for the connection design and subsequent operation on the distribution network. Many new and unique challenges are posed, however, we are meeting these challenges through commitment and innovation.

The Challenges

To facilitate our high and growing wind penetration, new and innovative approaches are being implemented to manage and operate distribution connected wind. The power flows from wind connections can lead to system constraints being hit – voltage variability and rise outside standard, loading beyond the thermal limit of the lines (without costly network reinforcement), variation in frequency (controlled by TSO), high reactive power demands and other operational challenges.

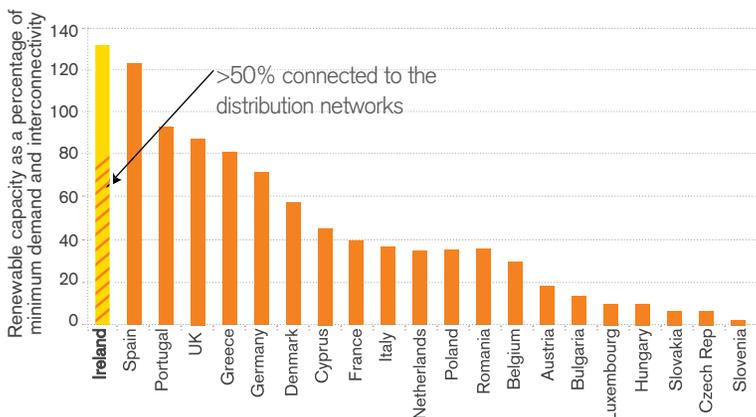


Figure 1: Total wind capacity according to NREAPs, as a percentage of minimum demand and interconnectivity in summer 2020 (source: EURELECTRIC/Pöyry Study 2011)



Without effective new planning and operational strategies, this would affect the quality of supply to all existing and future load customers.

Connection of Renewables

Through the progressive GATE connection processing system, a co-ordinated development approach was adopted early on, which has enabled almost 2,000MW to be connected to date.

Advanced Award-Winning Research Programme – The Way Forward

ESB Networks will build on its existing award-winning, international research to develop and demonstrate advanced operational procedures and technologies for integrating renewable generation on the distribution networks.

ESB Networks are committed to implementing fully researched technologies and procedures, enabling the optimised management of wind generation on the distribution network.

ESB Networks is working with all system operators on the island of Ireland to deliver the benefits of this research in large scale deployments and operational policies.

Through these technologies and procedures ESB Networks will enable Ireland to become one of the most efficient wind generating countries globally.

These developments will play an integral part in Ireland reaching its renewable generation targets by 2020, as well as reinforcing ESB Networks' reputation as having one of the worlds most advanced distribution systems.

Flexibility and coordination

Electric vehicles, electrical domestic water and heating loads, smart homes and other developing technologies will offer flexible demand. We are

testing how this can help to maximise renewables at local level, reducing network losses and minimising network reinforcement.

ESB Networks advanced research and field trials are demonstrating how in-built capabilities of turbines and existing network technologies can be used innovatively. By carefully coordinating the technical requirements of wind farms and customer load, there is potential to further increase the connected wind generation while ensuring high supply standards are maintained.

Demonstrations to date have delivered

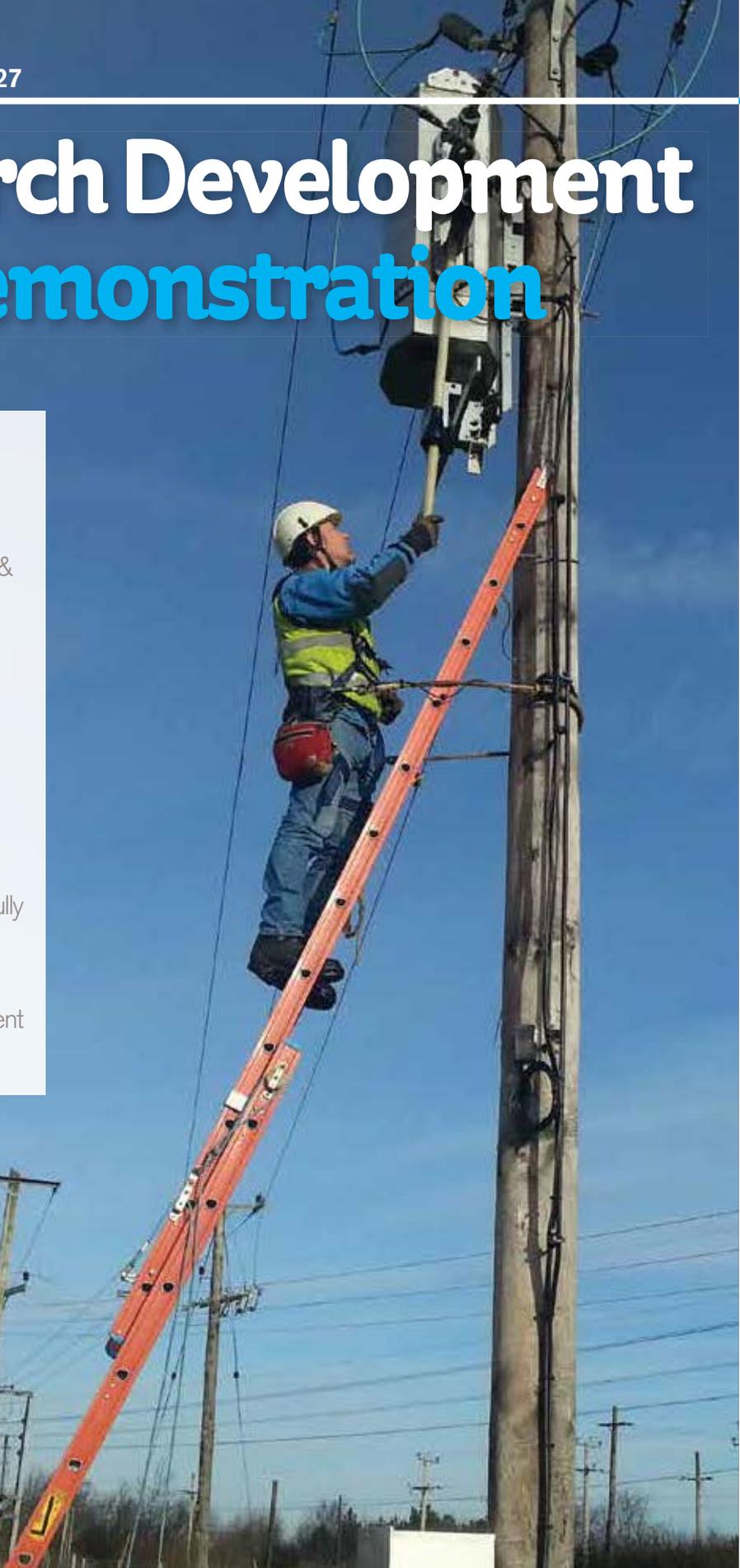
- > Active voltage and reactive power control using inbuilt turbine capabilities and innovative deployment of conventional network technologies
- > Optimised station design for wind connections
- > Insight into loss reduction, voltage dip response, hosting capacity increases, reactive power management



This research was initiated in collaboration with EPRI with contributions from UCD Electricity Research Centre and ESB International and was awarded Renewables Integration Project of the Year at Distributech 2011. We are extending this vital R&D with a range of international partners going forward.

Research Development and Demonstration

ESB Networks is working towards 2027 by undertaking strategic Research Development & Demonstration (RD&D), to meet the changing needs of distribution system management and all electricity system customers. Leveraging and assessing technological developments, we carefully balance innovation and experience to deliver the most effective and efficient solutions.



KEY THEMES WE ARE ADDRESSING ARE:

- » **Wind generation** – increasing flexibility in the connection and operation of wind to improve system performance and cost efficiency
- » **Customer technologies & demand response** – enabling all stakeholders, leveraging potential flexibility and maintaining quality of supply for all customers
- » **Operational efficiency** – improving continuity and loss efficiency
- » **Underlying systems** – the vital communications, monitoring and control infrastructures

THROUGH OUR RD&D WE:

- » have and continue to work with partners in over 16 countries
- » are linked with all Irish Universities and Institutes of Technology
- » have over 10 test bed projects nationwide with more coming online



Development and testing the systems to enable variation and increases in connected generation based on real time conditions without network reinforcement.



FINESCE

This EU FP7 supported research is a multi-national collaboration joining experts and stakeholders to develop distribution system solutions within “future internet smart utility services”. ESB Networks is undertaking 2 field trials

1 Demand response from EVs – demonstrating 4G field area communications, flexible control to allow for a range of commercial applications, and real time distribution system management

2 Advanced substation control – switchgear control integrating new control protocols and optical network switching.

Wind Integration

Since 2009, ESB Networks has pursued a range of projects to reduce connection costs, enable active management of wind generation and support system services.

Optimal station design – standard designs were delivered in collaboration with ESB International to meet the specifications of efficient generation connections. These are now being deployed across Ireland.

Variable access – development and testing the systems to enable variation and increases in connected generation based on real time conditions without network reinforcement.

Active Voltage and Reactive Power Management

– developing the use of inbuilt turbine capabilities and network voltage regulators, we have demonstrated system capabilities and the impact on voltage performance, capacity and losses. With up to four pilot sites presenting a variety of conditions, we are deploying larger schemes and addressing control strategies and systems support.

SMART GREEN CIRCUITS: OPERATIONAL EFFICIENCY

Meeting the needs of decarbonisation and a recovering economy demands improvements in how we develop and operate the distribution system.



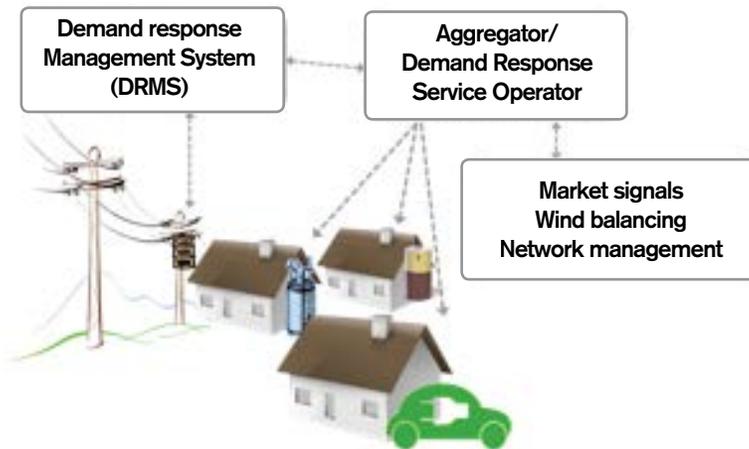
Losses reduction – strategies to address fundamental distribution system losses include converting our 10kV networks to 20kV, which doubles the capacity and quarters distribution losses, and installing amorphous core and Hexaformer transformers. These advanced transformers reduce iron losses by 70% over conventional models. We are also testing how controlling network configurations can reduce losses and increase network capacity, including closing medium voltage loops and actively switching networks based on the time of day, season or wind generation.

Continuity and Security – new innovative systems can ensure we keep the lights on in every corner of Ireland. We are carefully developing these to match the needs of the Irish distribution system, including self healing networks which automatically restore supply within 3 minutes, single phase reclosers which isolate outages to the smallest number of customers, medium voltage arc suppression to avoid and reduce faults and smart fault passage indicators which detect fault currents and direct our network technicians directly to fault sites.

Energy Efficiency – in addition to loss reduction, we have developed and tested Conservation Voltage Reduction (CVR) schemes, where a small, almost undetectable, reduction in voltage can provide customers with energy savings. Over 12 months we tested CVR, proving the energy savings and ensuring that customers were in no way impacted. Implementing CVR nationally, with a 3% voltage reduction could save >300,000,000 units of electricity per year from customers' electricity bills or >200,000 Tonnes CO₂.

Systems support and communications – CVR, active network management, wind integration and demand response are just some of the new actions in distribution management which require communications, monitoring and control systems. ESB Networks is working with internal experts and industry-wide stakeholders to deliver and test the most effective and cost efficient solutions including WiMax and LTE, optical fibre, radio solutions and operational visualisations and interfaces.





ROLE OF THE DSO

The entire electricity industry is changing, society's needs are advancing and ESB Networks is evolving to meet these needs. ESB Networks is a core partner in EvolvDSO, which is a trans-European project supported by the EU, bringing together major distribution system operators with transmission system operators, industry and academia. It aims to re-define the role of the DSO, so we can identify actions we need to take and the benefits we can deliver to the industry and every customer we connect.

ESB Networks has joined the electricity system operators of the island of Ireland in signing a ground breaking Memorandum of Understanding. This is a commitment to work together in redefining roles, responsibilities, interactive operational frameworks and delivering infrastructure. It leads the way to effective system development, combining expertise, perspectives and resources. This is a core step to providing opportunities for innovators in industry and research, helping us work with the industry to identify development paths.

The implications of this commitment go far beyond just the four system operators. It addresses national and regional needs, over the entire industrial and societal value chain and was identified as a key action in the DCENR's Action Plan for Jobs.

NEW CUSTOMER TECHNOLOGIES AND DEMAND RESPONSE

New customer technologies and systems offer opportunities to customers to save money and take control of their energy needs. However management and support from ESB Networks is vital to ensure that this doesn't strain the distribution system or unfairly impact on any electricity user.

EVs – The Irish Government has set an ambitious target of 10% of all vehicles to be fuelled by electricity by 2020. ESB is preparing for this by installing 1,500 public charge points (2-6 hours for full charge), and 30 DC fast charge points (80% charge in 20-25 mins) at filling stations on major national routes. We are installing the first 2,000 home charge points free of charge. See www.esb.ie/ecars.

This charging infrastructure could fundamentally impact the planning and operation of distribution networks. Since 2009, we have been developing both innovative and conventional solutions to address this. These involve field testing the impact of EVs on different network types, identifying driving patterns and charging needs, determining where and how to deliver developments to support charging, and testing EVs as a means of active demand response.

Demand Response – Customers could profit from offering demand to

be controlled to meet wind generation or market needs. ESB Networks is developing a real time Demand Response Management System enabling careful load balancing at distribution level to facilitate all stakeholders – both domestic and commercial - while ensuring that supply security and power quality is never impacted.

Data Protection and Cyber Security – In all our RD&D, careful technological implementations deliver robust protection of all new data streams. These ensure the security and privacy of treatment of all data, from major network assets down to individual customers. This R&D experience feeds into cyber security and data handling process development. We are working with leading international technology suppliers, dedicated industrial experts in EPRI, and regulatory and policy bodies in the EU.

Smart Metering and Data Analysis – While there is on-going development of the technologies and systems for the Smart Metering Rollout, ESB Networks is undertaking advanced data analysis to discover how we can optimise operations and designs based on real customer behaviour and patterns.





Partnership Across the Industry

WORKING INNOVATIVELY WITH PARTNERS ACROSS THE INDUSTRY

ESB Networks is responsible for the construction and maintenance of all Irish electricity networks and operation of the distribution networks. It is absolutely vital that we continue to work with all stakeholders to ensure that our networks develop to meet the changing needs and priorities of the citizens and economy of Ireland.

ESB NETWORKS WILL WORK WITH:

- » the Commission of Energy Regulation (CER) to ensure the best interests of all Irish electricity customers and users are met
- » the Transmission System Operator (TSO) to manage more complex distribution and transmission system interdependence
- » the Irish Government and SEAI to develop environmental strategies
- » our own internal highly innovative staff
- » academia and industry to progress research and deployment innovation

Working within the Regulatory System

The network of the future will be delivered under Ireland's regulatory framework set by the Commission for Energy Regulation. See the Delivering Price and Regulation section later in this publication.

Working with the TSO, to manage the Smart Networks of the future

High penetrations of wind generation and new potential for load management will utterly change the nature of both transmission and distribution systems. It is vital that the two system operators work closely to deliver co-ordination of operations, clear interface parameters and strategic planning of networks



By 2027:

» ESB Networks will continue to play a central role in industry at home and abroad, working with Irish policy makers, suppliers, manufacturers, the TSO and all stakeholders to develop our networks along the most efficient, effective and economical path

communications and control systems to optimally deliver on shared goals.

Working with Suppliers to facilitate new Customer Services

Smart metering offers up a world of opportunities for information, load management and innovative pricing, as well as improving accuracy of meter reading, streamlined change of supplier processes and advanced

pay as you go billing systems. ESB Networks are working closely with all suppliers to deliver the smart meter processes and systems. Use-of-system and demand response price innovation will be used to facilitate increased renewables and reduce infrastructure costs.

Working with wind industry to maximise renewables

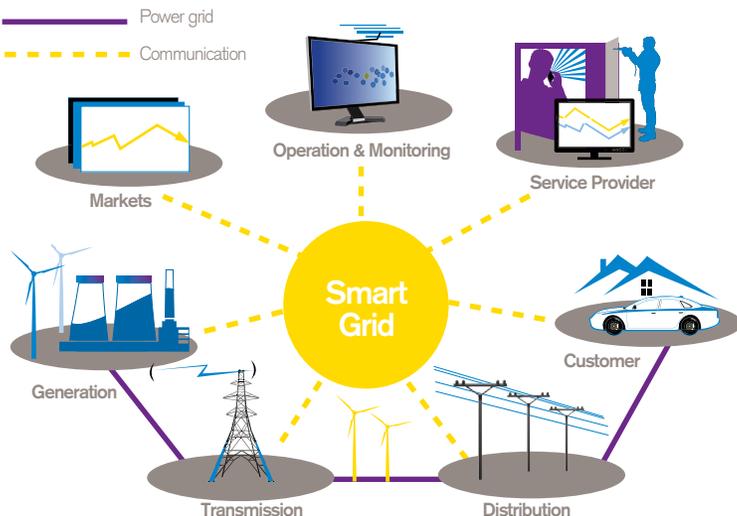
Noting the unique situation in Ireland where the majority of wind farms are connected to the Distribution System, a proactive partnership approach to the connection and operation of renewable generation is essential to maximising the benefits. This has already been shown through the adjustments to quotation and

connection processes to date. Co-operation on research of innovative operational techniques will deliver benefits for both generators and demand customers.

Partnering Manufacturers, Designers and Innovators

ESB Networks is committed to ongoing partnership with the innovators and manufacturers who will shape the networks of 2027. Close collaboration with technology developers has seen state-of-the-art distribution technology fit for Irish networks improve the efficiency and robustness of Irish networks.

It is vital that we continue to work to ensure that our systems evolve in an integrated manner to reduce costs and improve performance.



The delivery of a smart network is not about technologies alone, the collective smartness of its users and operator is fundamental to leveraging the full benefit

Smart Network Operations

BY 2027:

>> ESB Networks will have increased its visibility and control of its network by increasing its 1,400 controllable devices to 13,000

ESB Networks will have reduced customer interruptions for planned and fault work to:

- >> less than one interruption per year (over 55% reduction on 2005 levels)
- >> less than 100 outage minutes per year (over 80% reduction on 2005 levels)
- >> ESB Networks distribution losses will be reduced to below 6.35% of network end user load

BY 2027:

customer power loss due to faults will be reduced to less than 100 minutes per year –

an **80%** reduction on 2001-2005 levels

Over 1,400 remotely operable devices are already deployed on our rural network. By 2027, this will increase to over

13,000 devices.

Over 7,000 of the above devices will act as network sensors

99% of networks will be within voltage standard

Through innovation and excellence in operations, electricity consumption will be reduced by up to 3% independent of customer action



Active network management will revolutionise the nature of electricity distribution and will have huge implications for network planning and operations

ESB NETWORKS STRATEGY:

ESB Networks must manage an increasingly complex system, integrating high levels of distributed generation, while delivering the highest security and quality of supply to all customers.

Increasingly, local automation must be integrated with centralised monitoring and control – our 1,400 remotely monitored and controlled devices will increase to 13,000, providing vital protection and supply quality and security capabilities.

Delivering this introduces a range of challenges – integrating this level of network

intelligence and data from 2.3m smart meters requires the overlay of a robust IT and telecommunications infrastructure which reaches even the most remote networks.

With an exponential increase in measurement data coming from network sensors nationwide, improved forecasting and environmental monitoring, ESB Networks will be equipped to meet the challenges and realise the full benefits of dynamic network management, variable generation, strict network standards and flexible customer demand.

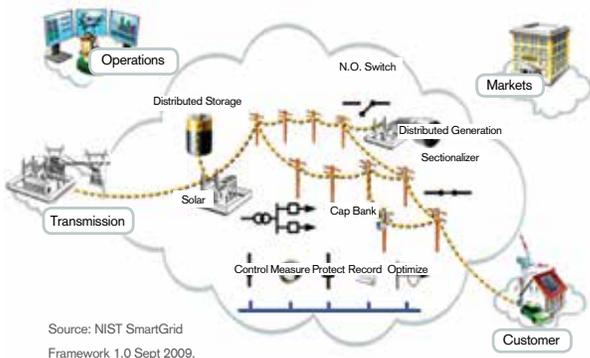
BY 2027 ESB NETWORKS WILL:

- » develop communications infrastructure to enable dynamic control and monitoring
- » extend and develop IT System to support active customer involvement and dynamic network optimisation
- » deploy self-healing MV networks nationwide
- » reduce load by 3% through network operation innovation and excellence
- » effectively integrate data from 2.3m smart meters to benefit operation optimisation

CONTINUAL INNOVATION IN NETWORK OPERATION: INCREASING EFFICIENCY AND IMPROVING RELIABILITY

Real-time information and control will be vital to ensure secure integration of distributed generation, while also meeting the evolving energy needs of customers, suppliers, renewable generators, storage and all industries – vital to rebuild the Irish economy.

NIST SMART GRID CONCEPTUAL MODEL



Source: NIST SmartGrid Framework 1.0 Sept 2009.

Self-Healing Networks, Automation and Innovative Protection

High penetrations of distributed renewable generation offer unique opportunities in efficiency and security, but without active monitoring and control, the full benefits can not be harnessed.

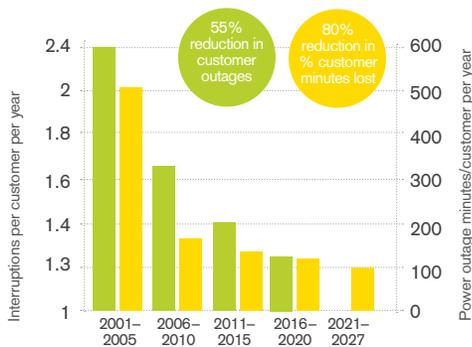
Investment in the deployment of several thousand networks sensors and Distribution Automation (DA) devices enables remote control and sectionalisation to pre-empt faults and minimise customer impact when they do occur. Remote monitoring and control down to each large distribution transformer in the country and integrating

smart meters as network sensors will ensure that trends in supply quality can be monitored and pre-emptive switching or upgrades can be carried out on any network before it sees a problem.

ESB Networks are now testing systems including self-tuning arc suppression coils at 20kV, single phase reclosers for spurs, state-of-the-art fault passage indicators providing high-spec system measurements and developing DA device capabilities as remote current and voltage sensors.

In 2010, ESBN installed its first self-healing network on the Iveragh Peninsula, Co. Kerry. Self healing networks use advanced technology and systems, which do not rely on human intervention, to locate and restore power to as many customers as possible following a fault. Leveraging the full capabilities of our DA technology, this groundbreaking development required all our planning and operational technical expertise to realise.

While this operation is completely communications independent, remote communications integrate these operations into our central SCADA system. Based on marked continuity improvements, this and other forms of self-healing configurations will be extended to all overhead networks



CUMULATIVE REMOTE CONTROLLED DEVICES

	2010	2015	2020	2027
Smart Fault Indicators	0	300	1,200	2,000
MV Rural Automation	1,200	1,950	2,500	2,800
Urban Automation		700	2,300	3,900
Automate Triple Pole Switches		5	1,200	3,600
38kV Load Break Switches		50	70	70
Automate Voltage Regulators		25	500	600
TOTAL 2027				12,970

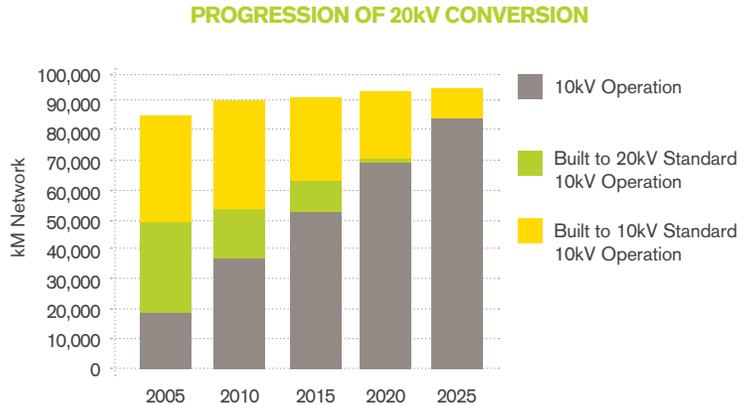
from 2011-2027. Requiring advanced, network-specific designs, this will require our full engineering and operational expertise and experience.

Telecoms

Delivering a smart and secure Network, leveraging new technologies and control capabilities, places many challenging requirements on the communications infrastructure to support it. A multi layered architecture is needed, that can prioritise traffic and deliver the data speeds and capacity required. Our communications network must have the geographical reach to supply robust, secure communications for the electricity system, reaching every corner of the network and of the country.

Today we have an extensive fibre, microwave and power line carrier network that provides thousands of links to both transmission and distribution stations. A significant expansion is planned that will eventually see hundreds of thousands of connections. Far higher data speeds to all transmission and distribution stations are increasingly required, as well as a greater reach, beyond the stations to field area networks for downline sensing and control.

The challenge is to select the optimum media and systems that meet the specific operational requirements of security, speed, capacity and availability. Applications such as protection and



dynamic network management require real time high speed links, while remote maintenance and Smart metering are more tolerant to delays.

Advances in communications and IP internet technologies, are enabling us to connect vast numbers of intelligent devices across a communications network seamlessly. By 2027 the communications infrastructure will be far more extensive, utilising the existing fibre network as well as new operational fibre on the distribution network. This will be supported by microwave radio and new 4G wireless communications that will extend our reach to all parts of the network and country at the data speeds required. An advanced highly secure operational IP network will provide the routing intelligence, applying the necessary prioritisation and re-routing capability to deliver the robust

communication links required.

Efficiency Improvements – Dynamic Sectionalisation and Voltage Optimisation

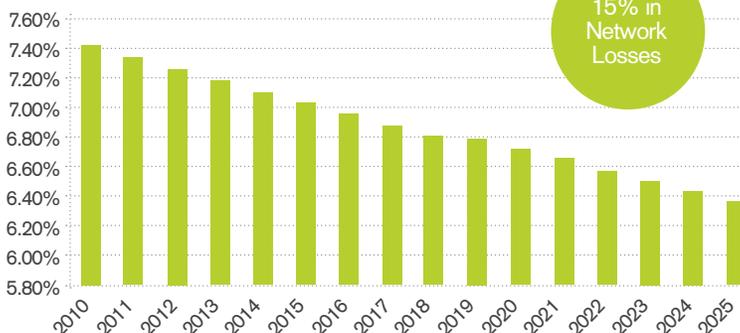
The lowest losses are achieved where the electricity is given the smartest path from generator to customer. Active network management will revolutionise the nature of electricity distribution and will have huge implications for network planning and wind connections for customers.

Through continuing our 20kV conversion scheme and integrating the ultra-low loss network technology which we are now testing, ESB Networks will ensure environmental sustainability. Innovative systems, including conservation voltage reduction, offer the potential to reduce losses and passively improve customer efficiency – extending the benefits and savings to all network customers.

Optimised Asset Management

A 99% accurate asset register will be in place. This, combined with first class design and increased affordable sensor technologies, will enable optimised asset management, reliable communications and IT systems to analyse condition, duty and operational data will be essential for this delivery.

NETWORK LOSSES REDUCTION TARGETS



15% in Network Losses

Customers and New Technology

BY 2027:

- >> ESB Networks will install smart meters in homes and businesses in Ireland, with a gateway giving the customer instant energy use information
- >> Support the electrification of transport in Ireland, delivering the vital electricity infrastructure for electric vehicles, light rail and all new transport technologies
- >> Empower customers, delivering the smart metering infrastructure and networks to let industry develop active demand management services
- >> Build a customer satisfaction level of 95%

By 2027:

Install over
2.3 million
smart meters in Irish homes and businesses

Help Irish customers reduce consumption by
2.5% by using smart meters real-time information

Facilitate Government target of
10%
EV penetration by 2020



Customer needs are at the core of all network development, delivering secure, high-quality electricity to meet the changing needs of customers and vitally support the Irish economy

ESB NETWORKS STRATEGY:

By 2027, ESB Networks will facilitate an electricity grid that will enable the customer to be in complete control of their consumption in terms of how, when, why, at what cost and even at what carbon intensity, energy is used. With an ESB Networks smart meter providing real-time electricity usage information in their home, customers will have the opportunity to minimise their electricity costs, while also playing a major role in meeting Irish climate change targets.

ESB Networks values not only the right of the customer to a secure, high-quality electricity supply, but will enable customers

to take on a wider active role in the electricity market of the future. As distribution system operator, we will embrace all new communications platforms to keep customers up-to-date on faults and outages in their area, while continuing to reduce outage times.

Engaging customers and ensuring they can take control, is central to developing the system of 2027. The Smart Meter Programme being rolled out by the CER, will integrate with the technology which shapes our lives by using mobile communications and in-home technology and is a vital step in this process.

BY 2027 ESB NETWORKS WILL:

facilitate customer engagement through:

- » Working with CER, the electricity industry and customers to install a smart meter system meeting the needs of every home, and business in Ireland
- » Building on existing research – to investigate:
 - > customer and utility active demand management
 - > technology trials on the operation of active demand and new loads
- » Advancing customer interface services from network operation centre to provide real-time network fault information
- » Supporting the economy with robust, secure, high-quality power supplies

ENABLING THE CUSTOMER

The customer is at the centre of our business and we develop our networks to reflect this. ESB Networks' goal is to provide a secure, high quality supply which will enable all customers to play an active role in the management of their energy use in the future.

Smart Metering and New Technologies

Smart metering is the key to empowering customers to minimise their electricity costs and participate in the electricity market. Under the mandate of the CER, ESB Networks will install the smart metering infrastructure in Ireland and play a key role in providing the technology, telecommunications and management required.

In the future, customers will be able to avail of offers to reduce their maximum import capacity – saving money and reducing societal investment costs in higher capacity lines and stations.

Data Security

ESB Networks will continue to ensure that systems are designed, and managed to deliver the highest security standards, ensuring data is safe and protected. This is a number one priority for the company.

Connecting with the Customer – Real-Time Fault Information

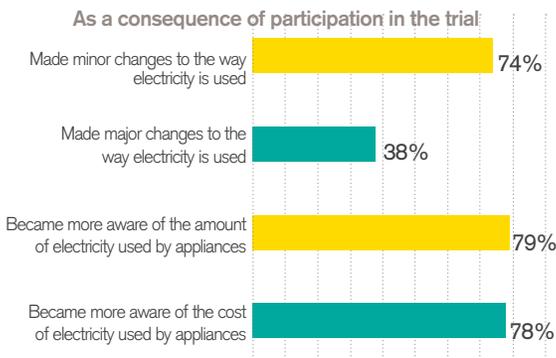
Improving the service for customers is central to the electricity system.

Real-time updates on faults, outages and power quality will be available to all through the quickest and most convenient channels. Local information, vital to residential customers and businesses will be available in text messages, online, or through any new technologies, letting people plan and prepare, knowing that any problem is being addressed.

ESB Networks' industry leading National Customer Contact Centre is already playing a vital role in connecting the customer and network operator to ensure that outages are quickly and effectively dealt with. By integrating customer calls into our Operations Management System immediately, we can restore supply and keep our customers up-to-date.

Demand Response

ESB Networks, through smart meters, will enable the customer to avail of innovative electricity products and services offered by their supplier or energy management companies. With improved system optimisation and smart meters providing accurate, real-time data, the customer will become an active participant in the market



Smart metering trials implemented by ESB Networks in conjunction with the CER, SEAI and industry suppliers in 2009-2010 showed that with smart meters and time of day rates, residential customers reduced their energy use by up to 2.5%, and their peak demand (when energy costs the most) by up to 8.8%.

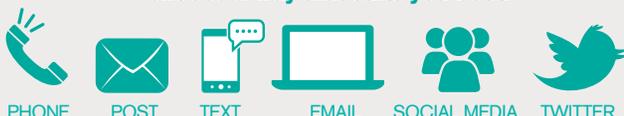
Smart metering was shown to save Irish residential customers a total of up to €200m and Irish society up to €282m. CO₂ emissions could be reduced by 100,000 to 110,000 tonnes of CO₂ each year and annual SO₂ emissions could be reduced by 117-129 tonnes.

Being Easy To Deal With

...when you need to talk to us

We understand that our customers communicate in different ways. We will continue to offer you a wide range of options for communicating with us.

When you need to talk to us choose a way that suits you best:



Our customer Contact Centre answers 1.4 million of your calls each year within set regulatory performance targets.

We also commit to taking special care when communicating with elderly customers. In conjunction with Age Action we are introducing a communication programme to pro-actively contact older customers with information and important updates.

When you do get in touch we will respond to you as quickly as possible and listen carefully to what you have to say. If you have any suggestions for how we can do things better, we'll take them on board.

...when we need to talk to you

When power cuts do occur, we know you want information on the status of the repair as quickly as possible. We have introduced a PowerCheck app which provides you with live updates on our phone or computer on the status of power cuts.

and will have the tools to take control of their own energy use. By heating water, washing clothes/dishes, charging electric cars or smarter heating at off-peak times, customers will see a reduction in their bills and carbon footprint.

Already hundreds of mobile apps are being developed to allow people to control their electricity use remotely. All of these developing services will be integrated with smart metering to deliver flexibility, control and financial benefits to customers.

Market Opening

Since the electricity retail market has been opened to competition, it

has been the responsibility of ESB Networks to manage all change of supplier requests, regardless of the old or new supplier. To date we have quickly and effectively managed over 700,000 changes.

Microgeneration

Microgeneration in homes or businesses which allows users to fulfil their personal energy requirements and sell excess energy into the market has become a major feature of low voltage networks across Europe. In Ireland, ESB Networks has put incentives in place to research the take-up and the impact of microgeneration on the

electricity network – facilitating the connection of over 600 sites. Through advanced metering, research and continual development of infrastructure and operations, ESB Networks is fully supporting the development of microgeneration.

Communications Technology Challenges

The delivery of the full benefit of smart meters is dependent on having secure communications and IT systems, giving the timely information that is required to deliver the services to the customer. This is a particular challenge for Ireland, as over 800,000 customers live in non-urban locations. ESB Networks has extensively researched the options available and will ensure that the communications infrastructure that will be implemented with the smart meter roll-out will deliver to the standard required.





Delivering on Price and Regulation

ESB Networks is committed to maintaining a competitive price of electricity to the customer in delivering the networks of 2027, through best practice asset management investment strategy, informed and educated investment strategy and adapting our policies in line with economic, technological, social and environmental changes.

ESB NETWORKS WILL KEEP IRELAND ON A COMPETITIVE FOOTING THROUGH:

- » meeting challenging regulatory cost effectiveness targets
- » facilitating the reduction of future carbon penalties
- » innovation in network management to improve customer and network efficiency
- » maximising wind integration, reducing dependence on imported fuel

Regulated Network Investment – Five-Year Price Control Process

Investment in Irish electricity networks is made by ESB Networks to meet growing and changing energy needs. This investment is funded through Use of System (UoS) charges, paid by customers through their supplier. The Commission for Energy Regulation (CER) has the responsibility of approving ESB Networks expenditure and thereby setting the Distribution Use of System (DUoS) charges.

For every five-year cycle, ESB Networks produces highly detailed development plans, based on measured energy usage, development needs, infrastructure, age and reliability for the coming years. Infrastructure replacement is risk assessed to consider the age, reliability, condition, safety risks and cost of replacement of each asset. Based on this information, the CER approves investment plans that are required and will deliver value for customers.

By 2027:

- » ESB Networks will invest up to €10bn in further developing the electricity system
- » ESB Networks will enable energy savings of over €1bn through smart investments in our system
- » ESB Networks will pass on the benefits – economical, environmental and those which affect our quality of living – to all our customers

ESB Networks consistently delivers on these plans – the CER continually monitors progress and demands clear, transparent evidence and results on an ongoing basis.

Smart Investment – Leveraging Technology to Deliver in More Economic and Effective Ways

For ESB Networks, ‘smart networks’ means developing our networks to improve efficiency, reduce losses and integrate high levels of renewables without any compromise in power quality.

Through innovation in developing new operations and control using telecommunications and monitoring technology now available, we can reduce network losses and increase hosting for renewable generation. Other ‘smart’ methods include optimising network voltages to improve demand efficiency and



reduce distribution losses.

Through monitoring our assets we can implement ‘condition-based maintenance’ – scheduling asset maintenance to meet actual priorities rather than based on estimated or manufacturer suggested lifetimes. It is uniquely challenging to predict the savings smart investments will deliver – as with all revolutionary developments, there are few precedents to base calculations on

beyond our own dedicated field trials and pilots.

Competitively Meeting Environmental Targets

Meeting Ireland’s renewables integration and carbon reduction targets need to be achieved cost effectively to best serve the Irish economy. Through smart network management, we are designing wind connections that integrate wind generation more efficiently, encouraging and supporting investment in wind generation.

The cost benefit analysis conducted by the CER indicated that smart metering will mean direct savings to the customer of up to €207m through energy efficiency and new variable tariffs.

ESB Networks is developing electricity infrastructure to enable the electrification of transport and heating. These energy requirements being fuelled through zero carbon energy will remove the carbon cost from these sectors for which Ireland is responsible into the EU Emissions Trading Scheme sector.

POSSIBLE CUSTOMER SAVINGS DUE TO SMART NETWORKS INITIATIVES



- Energy reductions due to Conservation Voltage Reductions, high efficiency assets and dynamic network sectionalising
- Network loss savings due to voltage conversions 10kV - >20kV
- Smart metering (including network savings)
- Value to customer of reduced network outages
- Energy reductions due to facilitation of active demand response and efficiencies in renewable Integration



Future Networks

Over the lifetime of the organisation, ESB Networks has strived to be at the leading edge of engineering excellence in developing our electricity networks. Our aspiration is to provide all customers with world class electricity networks with high energy efficiency and reliability. This continues as we embrace a low carbon future.

THE FUTURE OF NETWORKS

- » **Convergence of Electricity & Telecommunications** – The electricity networks of the future will be critically dependant on telecommunications. ESB Networks will continue to develop its existing telecommunications infrastructure to deliver this vision.
- » **Real-Time Customer Interaction** – Online and mobile interaction will open the electricity network up to customers, allowing a free and empowered role in the electricity market
- » **Intelligent Network** – Smarter systems will improve our visibility and control of the networks. This enhanced awareness will allow ever greater renewable generation penetrations while improving the quality of supply to all users.

Transformed Networks

ESB Networks is recognised as having one of the most advanced networks in the world. We will continue to lead the way in network transformation. Instrumented, interconnected, intelligent networks will be fundamental to sustainable growth in Ireland.

Instrumented: Accurate monitoring and control of power flows and power quality on our networks through the co-ordination of advanced sensing and automated control capability.

Interconnected: Joined up thinking, using the same resources and capabilities to improve sustainability, safety, efficiency and give transparency and control to our customers.



By 2027:

» ESB Networks will deliver real value by developing our expertise in two of the greatest developments of the past century – Electricity & Telecommunications.



Intelligent: Smarter thinking and systems will improve the operation of the electricity system and cater for future changing user needs. ESB Networks is already developing asset monitoring and adaptive protection systems and a remote network configuration capability in partnership with leading industry partners.

Accessible Network

New technologies, energy costs and the hope of a more sustainable, greener future are ever more important to energy consumers. In the future energy customers can be far more involved in managing their energy use, while electricity networks will become more accessible and responsive to customer's demands.

With smart metering in Irish homes and increasing in-home energy management systems, customers can be a key player in the electricity

market. This will enable consumers to avail of financial savings, through altering how and when they use electricity, with time of use rates and demand response contracts. This could allow for smoother or dynamically responsive load profiles, allowing for more efficient generation and smarter network investments.

Online Customer Interaction

The online world plays a huge part in society today and as this continues to grow, ESB Networks business processes will grow with it.

ESB Networks will ensure that all customers are able to interact with us easily through all channels. Real-time information on new connections, energy usage and fault notifications will be available to our customers. Excellent customer service is core to what we do and

we will continue to expand on the range of options for communicating with us and the services we provide.

Active networks

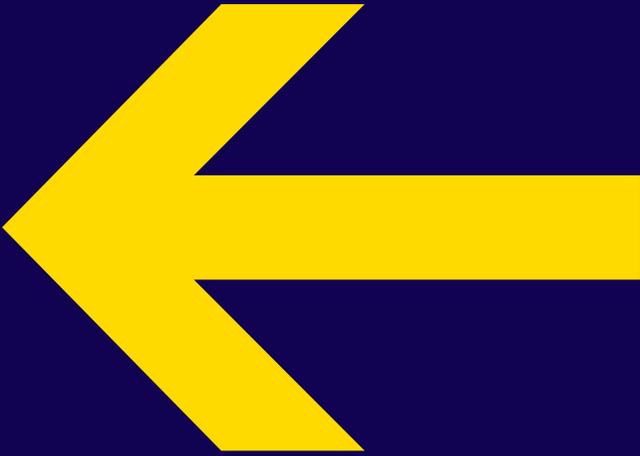
Active networks do not mean new networks, they mean new thinking and capabilities to manage them. This will see our customers benefit from new technologies, increased control and more freedom, while aiding sustainable communities. Active network management demands innovation, smart technologies, centralised control, local automation, flexibility and expertise in system operations. ESB Networks is already pioneering this change internally and working with Irish SMEs to make it a reality. The capabilities and resources we are developing will reduce the requirement for investment and deliver a safer, more secure and more efficient power system.

Summary



**ESB NETWORKS WILL DELIVER,
AND WORK WITH OTHERS TO DELIVER**

**ESB NETWORKS >>
2027**



BY 2027 ESB NETWORKS WILL:

THROUGH RD&D AND COLLABORATION WITH INDUSTRY



» continue to play a leading role at home and abroad, working with all of our national and international partners to develop the distribution system along the most efficient, effective and economical path.

RENEWABLES

» Enable over 5,000MW of wind generation capacity to supply the Irish grid – with over

2,500MW

on the distribution system

» Help Irish industry develop

OCEAN & TIDAL

energy projects, enabling technology development, connection and demonstration



LOW CARBON ECONOMY

» deliver one of the most environmentally sustainable systems in the world, reducing distribution losses to below

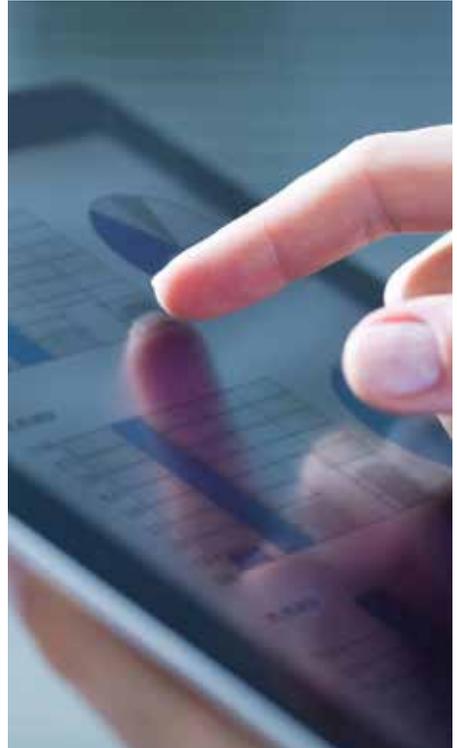
6.35%

of end user load, delivering massive savings in CO₂ each year. The environmental and economic sustainability of this is key to ESB Networks strategy as a modern DSO.

CUSTOMERS AND NEW TECHNOLOGIES



- » Install **SMART METERS** in homes and businesses in Ireland, with a gateway giving instant energy use information
- » Support the **ELECTRIFICATION OF TRANSPORT IN IRELAND**, delivering the vital electricity infrastructure for electric or fuel cell vehicles, and all new transport technologies
- » **EMPOWER CUSTOMERS**, delivering the smart metering infrastructure and networks to let industry develop active demand management services
- » Build to a customer satisfaction level of **95%**
- » Expand the customer interface to allow us **PROACTIVELY INFORM AND UPDATE CUSTOMERS** on fault information and network outages through multiple communications channels



SMART OPS AND TELECOMS

- » Increasing remotely controlled devices by 650% to **13,000** giving real time centralised control of networks nationwide
- » Improve reliability of supply to all customers, reducing outages, planned or fault, to
 - » one interruption per year (over **55%** below 2005 levels)
 - » 100 outage minutes per year (over **80%** below 2005 Levels)
- » **EXTEND OPTICAL FIBRE TO EACH OF OUR 600 HV STATIONS ACROSS IRELAND**, reaching beyond the cities and larger towns, to more remote regional towns, this will enable high speed broadband penetration nationwide
- » Deliver on safety, ensuring robust networks which can deal with extreme weather conditions going forward, reducing line drops:
 - » **42%** on 2008 levels at LV
 - » **17%** on 2008 levels at MV
 - » **70%** on 2008 levels at 38kV

DELIVERING ON PRICE AND THE ECONOMY

- » Invest up to **€10bn** in maintaining and developing the electricity system
- » Even with the substantial investment already made by ESB Networks, network charges have been reduced by 20% in the last 10 years. ESB Networks will continue to maintain competitive pricing
- » Deliver over **€1bn** of savings through smart investments in our system
- » Pass on the benefits, economical, environmental and those which affect our quality of living, to all of our customers

