INNOVATION FOR THE NETWORK OF THE FUTURE

DOC-030220-FNX

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FOREWORD

ESB Networks' vision for innovation is driven by our purpose to lead the transition to a low-carbon future. For ESB Networks, this means delivering a sustainable, affordable and reliable electricity network for Ireland that connects and accommodates far higher levels of renewable generation and enables the electrification of heat, transport and industry.

With the support of the Commission for the Regulation of Utilities (CRU), ESB Networks developed its Innovation Strategy to support this transition to the network of the future, and strengthened the culture of innovation and collaboration needed to deliver this energy transition for the benefit of customers.

The transition will support Ireland's commitment to the United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement, the EU Clean Energy Package and the Irish Government's National Climate Action Plan (NCAP). The NCAP requires us to reduce CO2 emissions by 40% (relative to 2005) by 2030 and sets out a target of 70% of electricity to be generated from renewable energy by 2030, as well as targets for 936,000 electric vehicles and 600,000 heat pumps in homes across the country.

In ESB Networks, the purpose of our innovation is to develop and implement new ideas with enduring benefits for our customers. We are very clear that the challenge of enabling a low-carbon Ireland powered by clean electricity cannot be delivered without extensive and collaborative innovation. This report describes how ESB Networks, working together with customers, industry (including the Transmission System Operator), technology providers, academics and research institutions, is implementing new ideas, innovative concepts and technologies that will support climate action and provide enduring benefits for our customers and communities.

We are proud to be able to collaborate with local communities on innovation projects in the Dingle Peninsula, Limerick City and the Aran Islands, as we explore the impact and capabilities of new low-carbon and supporting technologies. In these projects, we are testing and trialling solutions which will help us to develop the decarbonised, decentralised and digitised electricity system of the future and we are working with customers and communities to better understand the impact of and interaction with changing technologies and new, developing energy systems.

Through 2019, ESB Networks increased the level of stakeholder engagement on innovation. This included the first public industry consultation on our innovation activities, hosting our first Innovation Forum and conducting a series of targeted engagements with trade associations and industry sectors.

The public consultation on innovation provided us with an opportunity to validate and calibrate our approach and disseminate learnings with key stakeholders. We were delighted to receive submissions from a wide range of stakeholders including renewable energy (both wind and solar), flexibility (both demand response and battery storage), academia, industry equipment/solutions suppliers, industry consultants and utility/TSO. This feedback has helped us to make a number of changes which are summarised in this report. We remain committed to conducting annual public consultations on our innovation activities.

Our initial Innovation Forum proved to be a welcome addition to our engagement channels, providing an opportunity to directly share the consultation feedback we received and respond to the issues/comments raised. It is our intention to hold an Innovation Forum with stakeholders every spring and autumn to share our innovation progress, discuss feedback we have received, and collaboratively consider how we tackle the transition to the network of the future. In fact, the series of workshops and discussion topics selected for the first Innovation Forum were based on the issues raised in the public consultation, and the results of this consultation will inform the next Forum.

Polls taken during the Innovation Forum in November 2019 showed that over 93% of respondents believed their understanding of ESB Networks' innovation activities had increased over the previous 12 months. More importantly, 68% of respondents agreed that ESB Networks was focusing on the right innovation projects to deliver on the transition to a lower-carbon society. While the feedback was encouraging, and showed that we are moving in the right direction, there's more to be done! We look forward to continuing to work collaboratively with our many stakeholders to rise to the future challenge and, to that end, we welcome your comments and feedback on the activities highlighted in this document.

Paddy Hayes

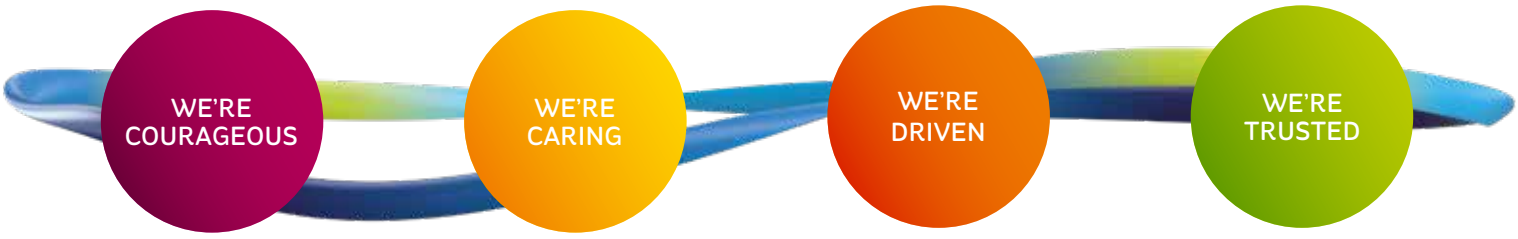
Managing Director
ESB Networks *Feb 2020*

1 INTRODUCTION

1.1 Our Innovation Vision and Values

Our vision is for ESB Networks to continuously innovate towards a sustainable low-carbon energy future for our customers and for Ireland. Our vision and values serve as the foundation of our innovation strategy, informing every new idea and the development of every project.

OUR VALUES



Each of us is prepared to challenge the way we've always done things, stand up for what we feel is right and try better ways of working.

We're putting customers current and future needs at the heart of what we do and we keep ourselves and others safe and healthy.

We bring passion and persistence to what we do everyday, innovating and collaborating to meet the challenges and opportunities ahead.

We each play our part, taking ownership of our responsibilities, seeing the job through and protecting our own health and safety, as well as others'.

1.2 Our Mission

Our mission is to play a leading role in Ireland's transition to a low-carbon economy, and to provide secure, sustainable, reliable electricity in an affordable manner for all customers.

In support of Ireland's commitment to the Climate Action Plan, United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, our Innovation Strategy has been developed to facilitate Ireland achieving its climate change targets to reduce CO2 emissions by 40% (relative to 2005) by 2030.

ESB Networks has been supported by the Commission for the Regulation of Utilities (CRU) through the decision that innovation will be incentivised in the 2016-2020 regulatory period. The CRU incentivises strategic and innovative thinking *"for actively and imaginatively tackling the sizeable challenges associated with the transition to a low carbon energy system"*.

In introducing this innovation incentive mechanism, the CRU reflected that ESB Networks has *"an important role in articulating the variety of commercial and technical challenges, and working with the market participants, the TSO, the TAO and other stakeholders to develop and test practical, workable solutions"*.

1.3 The Role of Innovation in ESB Networks

Our definition of Innovation is to implement new ideas for the enduring benefit of our customers and business.

Consistent application of this principle has been the foundation for one of the most progressive electricity networks in the world – a network that has enabled Ireland to become a world leader in industry and technology, and a location of choice for foreign direct investment. Our innovation activities operate across three broad horizons of innovation:

- Incremental innovation
- Breakthrough innovation
- Radical innovation

We prioritise Technology Readiness Level (TRL) 7 or higher in our innovation projects, as we believe this level of ambition is appropriate to give best value to our customers in view of the scale of resources available within a utility of our size.

ESB Networks does not confine innovation to our "dedicated innovation teams". We are working to develop a culture of innovation which is encouraged across the organisation as we seek to challenge the status quo to find innovative solutions across the range of activities in our business.

2 INNOVATION STRATEGY AND SCOPE

2.1 ESB Networks Innovation Strategy and Framework

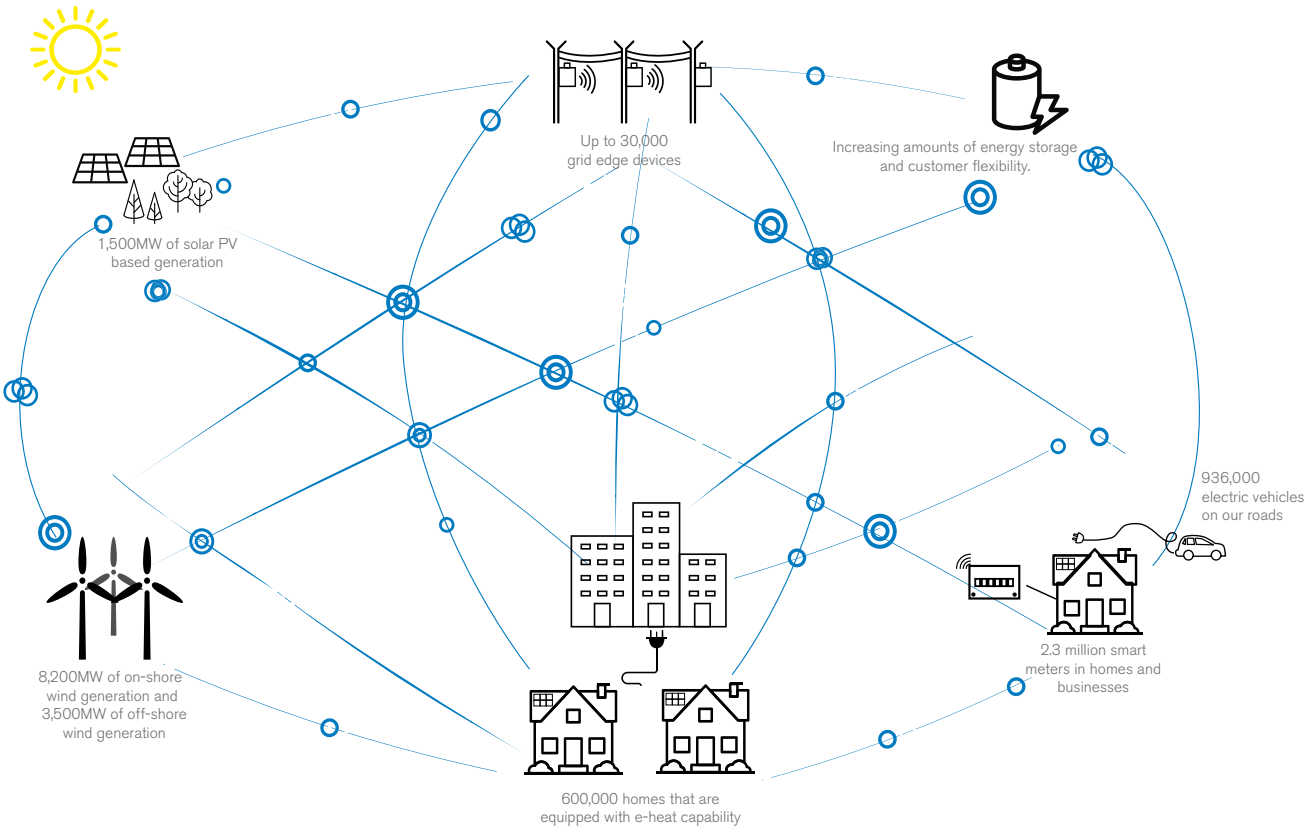
The changing energy environment presents challenges but also offers great opportunities for innovation. The adoption of new materials and technologies, large-scale digital applications and big data analytics will create greater efficiencies, while electrifying the heat and transport sectors will offer a range of new opportunities for our customers. For example, the use of 'non-wires solutions' where feasible could reduce time and cost of providing increased effective capacity for load and generation, and the facilitation of 'non-traditional market arrangements' such as peer-to-peer trading, microgrids, etc. may deliver better value for our customers.

Robust processes associated with the identification of innovative opportunities for our customers and stakeholders are a key part of ESB Networks' Innovation Strategy. This requires us to consider disruptive trends and identify how we see the energy landscape developing, in the next decade and beyond. We anticipate radical changes in electricity generation, consumption and storage, including increasing levels of generation at the domestic level and the emergence of prosumers who will actively participate in the generation of the electrical power system.

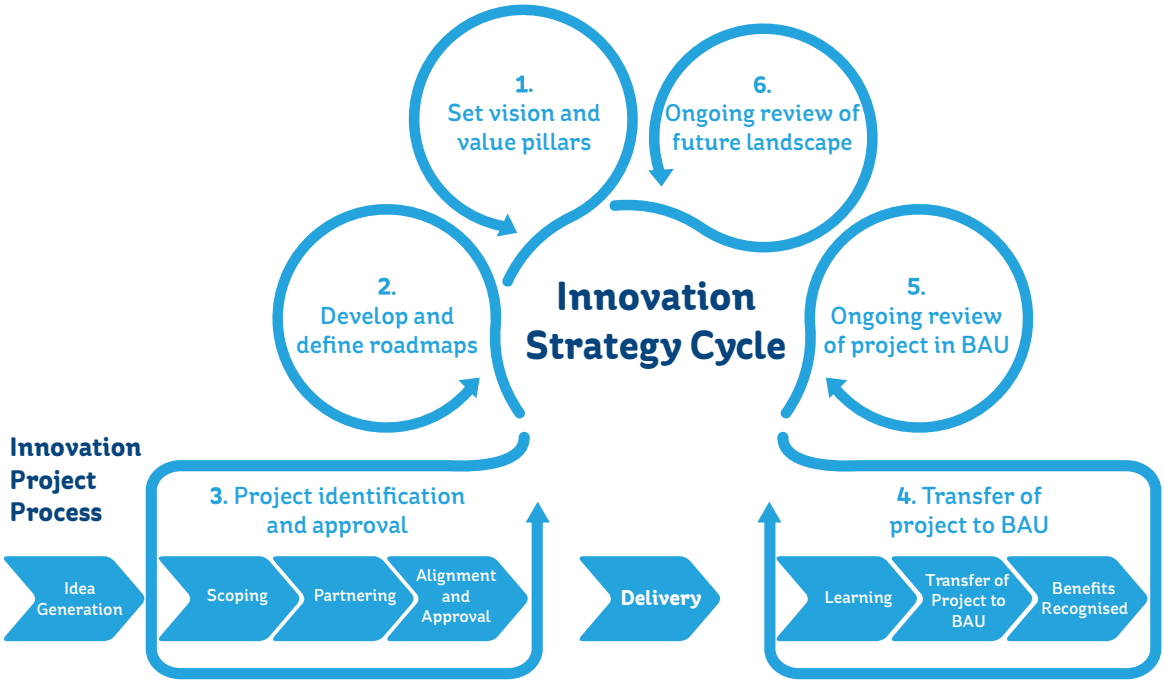
In order to realise our vision of delivering a sustainable, low-carbon energy network that will serve Ireland's future energy needs, we have developed an Innovation Strategy Framework to manage every stage of the development and implementation of strategic initiatives, from setting the vision to establishing business as usual (BAU).

In developing the framework, we reviewed best practice from other jurisdictions, worked with external consultants, and engaged in workshops with representative groups from across ESB Networks and sought feedback from stakeholders to create a solution for our organisation. This framework respects that our customers, who support the cost of these projects, expect efficient and effective dividends from the innovation process. It recognises the risks and uncertainties inherent in investing in untested innovation projects or trials and ensures an appropriate level of oversight.

BY 2030, OUR NETWORK WILL SUPPORT:



ESB NETWORKS INNOVATION STRATEGY FRAMEWORK



2.2 Three Roadmaps: A Progression Plan to 2030 and Beyond

In order to improve focus and align with our new business strategy, and taking into account feedback received from industry and key stakeholders, it has been decided to consolidate the eight roadmaps considered in our previous regulatory period (PR4) into three focussed roadmaps for the next regulatory period (PR5). This is aligned with our innovation strategy framework, which has been designed to be flexible enough to cater for the changing requirements of our business. Furthermore, ESB Networks acknowledges the need to be flexible to address future challenges which may emerge. Therefore, ESB Networks expects to see more adjustments to the projects included in each roadmap as policy priorities emerge, changes in customer behaviour manifest themselves and as forecasts for generation, flexibility and low-carbon load become more certain.

The three new roadmaps aligned with our new business strategy are *Future Customer, Climate Action and Network Resilience.*

Future Customer - Empowering and Supporting Customers and the Economy

Climate Action - Decarbonising Electricity, Heat and Transport

Network Resilience – Efficient, Secure, Reliable Electricity

3 INNOVATION PROCESS

3.1 From Identification to Delivery and Dissemination

To effectively implement our Innovation Strategy, we have developed an end-to-end process for the management of innovation initiatives across our business areas.

Our three Innovation Roadmaps broadly define the scope of work and the areas where we need to deliver new and improved services.

Our strategic framework and ongoing efforts in collaboration and planning allow us to identify a comprehensive number of potential projects. Active engagement with stakeholders and continuous monitoring of the environment we operate in have helped to determine when projects warrant cancellation, expansion or consolidation with projects of similar strategic objectives. This reflects the dynamic nature of innovation and the fact that ESB Networks has developed a high-performing culture of innovation that values the pursuit of new ideas and opportunities.

Governance		
• The Innovation Governance Framework outlines the governance of our Innovation Strategy • Governance is provided through our Connecting Futures Board (CFB) that owns the Innovation Strategy and operates to the terms of reference approved by the Managing Director of ESB Networks • The Innovation Steering Group is responsible for progressing issues that arise at a project level and has delegated authority from the CFB for approval of investment appraisals, certain project decisions, reports and change requests • Each of the three roadmaps has a designated sponsor who oversees the delivery of initiatives under that roadmap		
Pipeline and Scoping →	**Delivery of Innovation Projects** →	**Dissemination of Learnings and Transition into BAU**
Process		
• Scoping, planning and opportunity identification across three Innovation Roadmaps to achieve a balanced portfolio of projects • Impact Assessment across scorecard metrics • Risk assessment and mitigation planning • Validation through active engagement channels and stakeholder engagement	• Ongoing projects assessment process to monitor project status, evolution and outcomes • Risk assessment and mitigation planning as appropriate • Active engagement with partners and wider stakeholders • Progressive project evaluation to determine project continuation, cancellation or merge with others as appropriate	• Identify delivered benefits • Disseminate learnings into BAU operations and/or decision-making • Identify opportunities to extend an innovation project to achieve additional benefits • Disseminate learnings to industry and stakeholders
Reporting		
• Ranking of Ideas Generated • Project Proposal • Investment Appraisal Documentation	• Progress and Close-out reports	• Implementation Plans • Industry Papers and Conferences
Assessment and Tracking Benefits		
• Initial Qualitative Assessment • Cost Benefit Analysis • Measures of Success	• Qualitative Assessment • Cost Benefit Analysis • Measured Data from Pilots • Trial of Methods/Technologies	• Qualitative Assessment • Cost Benefit Analysis • Ongoing Tracking and Assessment of Benefits

3.2 Governance and Risk Management

Risk assessment and mitigation are essential to ensure that ESB Networks delivers value to network users and consumers. An integral part of managing risk and ensuring the operational success of innovation projects is maintaining an appropriate level of governance. This is provided through our Connecting Futures Board (CFB) and the Innovation Steering Group (ISG).

Our new Networks Innovation Governance Framework was finalised and implemented in 2019. The governance of our Innovation Strategy includes oversight of the processes which will allow ESB Networks to effectively identify, assess, monitor, prioritise and deliver the portfolio of innovation projects in accordance with our vision and values. It ensures that innovation is implemented at the right pace, is proportional to both customer and network needs, and realises nett value and benefits for all customers.

The CFB is a cross-functional group of ESB Networks senior managers that provides a common governance structure for the Business, Innovation, Customer and Digital Strategies on behalf of the senior leadership team. In relation to the Innovation Strategy, the CFB is responsible for providing guidance, co-ordination and decision-making regarding innovation roadmap and project portfolio direction, issues affecting delivery and changes affecting key project or roadmap outcomes. A plan is in place for an external advisory group to feed into the innovation governance structure and is expected to be implemented in Q2 2020.

The ISG is made up of a cross-functional group of ESB Networks managers and external advisers and is responsible for progressing issues that arise at a project level. The ISG has delegated authority from the CFB for approval of investment appraisals, project proposals, project initiation documents, significant change requests and close-out/progress reports.

While the membership and structure of the CFB and ISG changed as a result of feedback from stakeholders in 2019, their common aim remains to ensure the collaborative implementation of new ideas that will provide enduring benefits for our customers.

3.3 Strengthening Innovation Expertise and Capacity Building

ESB Networks has already developed one of the world's most progressive and reliable electricity networks, which facilitates changes to how Ireland's electricity is produced and consumed. To ensure that the changing needs of the environment, government and society are met, ESB Networks continues to work towards the model of innovating further and innovating faster. In order to do this, we must ensure we have the right people, with the right skills and expertise, in the right place, at the right time.

To meet this challenge, ESB Networks continues to enhance innovation expertise and capacity building internally through a number of different initiatives. These initiatives provide staff with appropriate training, knowledge and experience, and provide opportunities to learn about and engage on the ongoing innovation projects and international research being collaborated on.

Training and Development Programmes

ESB Networks has devised a comprehensive Graduate Engineering Training and Development Programme to enable new starters to reach their full potential and to develop all aspects of their competencies. The programme includes modules on Innovation, Design Thinking, the Smart Grid, Renewable Technologies and Emerging Technologies.

A large portfolio of technical courses is available at our Networks Training Centre in Portlaoise. Our performance management process ensures staff identify gaps in skillsets and competencies on an annual basis and selects the appropriate internal and/or external training and experience to address those gaps. The innovation team is also in the process of developing proposals where ESB Networks can leverage existing partnerships (such as with the Energy Institute in UCD) to provide relevant training.

These training and development initiatives give our staff the knowledge and skillsets to innovatively build, maintain and operate the electricity network of the future for the whole of Ireland.


SIEMENS
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Innovation Community Forum

In 2019, ESB Networks formed an Innovation Community across the business. In December 2019, we launched our first ESB Networks Innovation Community Forum in the Dogpatch Labs. ESB Networks will hold these Innovation Community Forums every summer and winter, the purpose of which is to facilitate open and on going dialogue with ESB staff members involved in Innovation across the business units. These forums will be used to keep staff informed of ongoing innovation activities and to encourage feedback on potential innovation opportunities arising in different areas in ESB Networks. The Innovation Forum included panel discussions, feedback sessions on ESB Networks' innovation activities and project-specific presentations.

Design Thinking Workshops

During 2019, ESB Networks developed a training programme to introduce its innovation team members to Design Thinking: a customer-focused problem-solving methodology that, when applied to innovation, can drive new ways of identifying solutions. It reinforces the commitment to consider both the problem being solved and the solutions being proposed from the perspective of the customer or end user. The Design Thinking methodology encourages engagement with customers or service users to validate the problem being solved and evaluate, where appropriate, new solutions before they are rolled out.

The Innovation Academy

In 2019, ESB Networks encouraged applications from staff to participate in the UCD-led Innovation Academy training programme, and this collaboration continues in 2020. This programme applies Design Thinking and other innovation techniques to explore new solution options to real business problems facing ESB Networks. Upon completion, proposed solution concepts are considered further by ESB Networks and, where appropriate, these are progressed as projects within the business lines. For example, a team from the 2019 Innovation Academy looked at the challenges associated with forecasting the uptake of EVs in order to be able to target low voltage network constraints and reinforcement solutions. They developed a data analytics approach using publicly available information and made recommendations for follow-on work that is being progressed as the "Electrification Uptake Data Analytics Forecasting Tool" project currently in ESB Networks' project pipeline.

Multi-disciplinary Innovation Initiatives

The innovation team works continuously with colleagues to develop ideas and ensure the innovation projects identified for delivery are the appropriate solutions for the business. This approach acknowledges that the challenges for and objectives of ESB Networks will require innovative multi-disciplinary solutions from across the business.

To enable this, the innovation team leads and participates in regular technology and challenge-specific workshops with staff from across the business to discuss the requirements, solutions and opportunities in areas such as:

1. Electrification of heat and transport;
2. Future DSO/TSO operation;
3. Microgeneration; and
4. Management and utilisation of flexibility.

Educational Videos

ESB Networks has developed a number of educational videos to highlight the challenges and benefits from some of our innovation projects as we develop the network to support the transition to a low-carbon society. Examples of these videos are on the Dingle Project and the RESERVE project.

An electrification video series and support information are under development to inform ESB Networks staff on how we are facilitating the electrification of heat and transport. This will provide staff with relevant information on technologies such as EVs, Heat Pumps and PVs.

Lunch and Learn Programmes

ESB Networks runs a series of "Lunch and Learn" programmes to share information about a range of innovation projects, new technologies and practices. This involves a lunchtime lecture presented by both internal and external experts. Examples of the topics that were included in the 2019 programme were Smart Metering, Electrification of Heat and Transport, Nodal Controller for Reactive Power, Overview of Learnings from the European Utility Week Conference, latest technology developments from equipment suppliers, and a number of Electric Power Research Institute (EPRI)/ESB Network areas of collaboration covering Distribution Planning, Network Hosting Capacity, Advanced Distribution Analytics, Distribution Operations and Operations Protection.

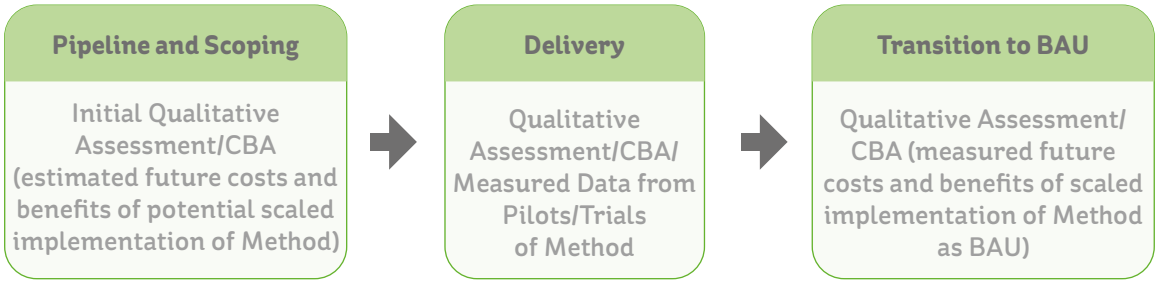
3.4 Project Evaluation and Benefit Assessment

Innovation ideas in the project pipeline are initially assessed and prioritised for further investigation and scoping against five criteria: Lifecycle Savings Potential; Time Frame/Complexity; Core Competencies; Strategic Fit and Innovation Type; and Customer Need and Demand.

As projects move from pipeline to scoping, an Impact Assessment Framework is applied to evaluate the impact across six strategic areas: Safety; Network Reliability and Resilience; Facilitating Growth and New Connections; Customer and New Market Services; Environment; and Social and Sector Learning.

The identification, assessment and monitoring of benefits provides ESB Networks with the justification to support innovation projects and establishes clearly defined measures of success. One of the key drivers to the successful delivery of our innovation project portfolio is the continuous assessment and tracking of benefits throughout the project lifecycle. ESB Networks carries out qualitative and quantitative benefit assessment (where possible) at each stage of the innovation process; this is detailed in the Benefits, Learnings, Impact and Opportunities section later.

Assessing and Tracking Benefits Throughout The Project Lifecycle



3.5 Assessing Innovation Beyond Business-As-Usual (BAU)

The innovation framework that ESB Networks has put in place requires those proposing innovation projects, and in particular incremental innovation, to reflect on whether their idea is over and above BAU and would not be done by the business in the normal course of events.

The framework works off the definition that innovation is "*the implementation of new ideas with enduring benefits*". This includes any changes to our existing techniques and processes that result in net benefits.

The project proposers/sponsors assess their innovation idea using standard templates, e.g. Project Proposal, Investment Appraisal templates, and as such are required to consider the following:

1. What are the benefits/savings potentially associated with the project? These benefits may, where appropriate, consider benefits in a broader whole system perspective;
2. What options or alternatives exist?;
3. What are others in industry doing about the same issue; and
4. What are the risks associated with not pursuing it?

The assessment process and appraisal of the innovation idea, including reflecting on these four questions, provides ESB Networks with the confidence that the approved innovation projects have exceeded an appropriate hurdle threshold and are beyond simple business-as-usual. It also enables us to prioritise our innovation projects.

A poll taken during the Innovation Forum in November 2019 showed that 68% of respondents agreed that ESB Networks were focusing on the right innovation projects to deliver on the transition to a lower-carbon society. While the poll's sample size may impact its statistical significance, the result does offer some positive insight into stakeholders' views on whether ESB Networks are moving in the right direction.

3.6 Strategic Validation Through Collaboration with Stakeholders and Third Parties

As we transition to a low-carbon future, we have an important role in understanding the variety of commercial and technical challenges facing the energy industry. These challenges will require us to collaboratively implement new ideas to provide enduring benefits for our customers. Our Innovation Strategy is evolving to reflect the rapidly changing energy landscape. Ongoing stakeholder engagement to consider consumer and industry foresight, as well as third party collaboration to share knowledge, identify opportunities and validate our innovation plans, are all features of implementing our Innovation Strategy.

In addition to our customers, key partners include the CRU, national and EU government departments, local communities, the TSO, academia and industry. In 2019, collaborations with national industry bodies included discussions on a range of innovation topics as well as engagements with customers and their representatives. These included the Irish Wind Energy Association (IWEA), the Irish Solar Energy Association (ISEA), Demand Response Aggregators of Ireland (DRAI), the Irish Farmers Association (IFA), the Irish Wind Farmers Association (IWFA), the Irish Bio Energy Association (IrBEA), demand response and energy storage stakeholder groups, and the Distribution Code Review Panel (DCRP).

3.7 Validation Case Study: Smarter HV and MV Customer Connections

The objective of this project (previously referred to as Planning and Security of Supply Standards Review) is to evaluate existing and new innovative approaches to distribution network development, including the connection of new demand and renewable generation. This will explore the use of flexible connections and flexibility services to maximise the use of existing network assets, reducing the levels of network reinforcement required wherever possible. Such non-wires alternatives should facilitate the lowering of connection charges and costs, and the shortening of connection times. These innovative approaches to network planning should enable Ireland's energy policy objectives in a more cost-effective manner while ensuring that the security of supply is equal to, or where appropriate even greater than, what is delivered today.

However, it is acknowledged that delivering the most cost-effective operation and design of a future distribution network, and thus the development of these innovative planning policies by ESB Networks, cannot be done in isolation. To support this activity, a number of engagement activities have been completed with stakeholders to validate the objectives and proposed solutions in this project. Crucially, we have collaborated with industry through workshops and meetings held with the distribution generators stakeholder group (e.g. IWEA, ISEA, Meitheal na Gaoithe (IWFA), IrBEA), the demand response stakeholder group (DRAI), and the energy storage stakeholder group (IESA).
These engagements were used to define the project terms of reference, project plan and associated stakeholder plan for the project, which were published on our website in early 2019.

Collaborative work throughout 2019 with our appointed technical consultancy support (EA Technology), and a workshop with the Distribution Generator group in June 2019, led to a detailed consultation document being prepared, outlining proposals for fundamentally more innovative ways of connecting customers to the distribution HV and MV systems. A public industry consultation was held in winter 2019.

During the consultation period, as part of the Innovation Forum in November 2019, a breakout workshop was held, giving attendees an opportunity to discuss in detail the main Smart HV and MV Customer Connections consultation proposals with the project team.
The collaborative engagement, both workshops and the consultation all provided the project team with further opportunities to validate proposed solutions and listen to feedback from stakeholders.

Continuing the consultative process to validate the project's activities, regular updates were delivered over the course of 2019 via the Distribution Coder REVIEW Panel (DCRP) which has a range of industry stakeholders, with details published quarterly on the ESB Networks website.

4 INNOVATION PROJECT PORTFOLIO AND ROADMAPS

4.1 Project Prioritisation and Initial Assessment

New innovation ideas are sourced from a variety of channels, e.g. from the innovation team's activities, more broadly from staff within the business, from potential collaborators and partners contacting ESB Networks directly, and from stakeholder engagements including responses to the innovation public consultation. These ideas form the innovation project pipeline.

In order to carry out an initial assessment and preliminary ranking of projects, prior to more detailed consideration, a simple set of criteria outlined below is used to score the projects. The process is intended to provide clarity to the assessors and allow a common evaluation method for projects across all roadmaps and areas. During subsequent consideration, other requirements may emerge which change the ranking e.g. one project may have little direct benefit itself, but may be an enabler of other projects with significant benefits.

The projects which emerge from this screening process are then subjected to a detailed Cost Benefit Analysis (CBA) to confirm that they will provide long-term value to our customers and/or our other stakeholders.

Initial Assessment Criteria

Lifecycle Savings Potential	The potential for a project to generate revenue/cost savings within 5 years. In general, the revenue/cost savings are to ESB Networks on the basis that ESB Networks represents customer's interests, but significant savings to other stakeholders within the electrical energy system from innovations/changes in practice by ESB Networks would also be considered if they provide an overall societal benefit.
Time Frame / Complexity	How soon can we get the product/service out in the market, or how complex/difficult will the project be?
Core Competencies	What capabilities can be leveraged internally; processes, assets and values?
Strategic Fit and Innovation Type	Horizon 1, considered to be core strategy. Horizon 2, natural evolution of services that ESB Networks could offer in adjacent areas (called out in strategy). Horizon 3, products or services not traditionally associated with ESB Networks and transformative (not explicitly called out in strategy).
Customer Need and Demand	How relevant is the product/service potentially and is there known demand within 5 years?

4.2 Pipeline Projects

Projects that have come through the initial assessment and are currently in ESB Networks' pipeline of possible future innovation projects are listed below. These projects have been proposed as they address the challenges identified by our Innovation Strategy and provide benefits to customers. However, they have not yet been formally evaluated or approved as innovation projects. ESB Networks would welcome comment and feedback from stakeholders on their view of the projects as proposed or variations that might be worthwhile considering. If there are alternative/additional projects which stakeholders would consider as having greater potential benefits, or for which there is a more urgent requirement, then ESB Networks would welcome such suggestions for consideration.

Table of Pipeline Projects

Pipeline Project	Project Description
Novel Use of Drone Technology and Artificial Intelligence for Line Patrolling	A pilot is being progressed in Dublin South that will use drones for quick response damage assessment during fault hunting/fault follow up, investigation of intermittent faults on overhead lines and follow up quality checks on timber management contracts. Data (photographs) will be captured as part of the project and will be used for comparison reviews against traditional methods. The expected benefits of this trial are continuity (reduced customer minutes lost and continuity improvement), reduction in crew patrolling times and improved safety. This project will have a second phase where drones will be flown Beyond Visual Line of Sight (BVLOS) and artificial intelligence (AI) will be used to assess the data captured to optimise the patrolling process.
Identification of network configurations for Active Network Management (ANM)	Using existing infrastructure and enabling quicker connections for generation are critical in enabling the targets set in the Climate Action Plan for electricity generation from renewable resources. Active Network Management has been identified as having the potential to achieve the objectives cost-effectively with limited impact on the volume of renewable generation produced. This project will seek to understand which network configurations could be implemented through Active Network Management (ANM) so as to maximise use of available capacity for both generator and demand customers whilst maintaining appropriate levels of system security.
Development of Robust Low Voltage (LV) models for the Future Network Planning and Operations required to facilitate active energy citizens	ESB Networks, in common with most utilities worldwide, does not have a detailed, accurate geographical or electrical model of its LV networks. Furthermore, it has limited knowledge of customer distribution at LV other than numbers of customers per transformer. LV circuit loading data is unavailable. The challenges of decarbonising heat and domestic transport and requirements for larger quantities of microgeneration on the distribution network drive the need for access to improved LV data and development of appropriate network models. ESB Networks proposes to develop an innovative framework that will assist in the creation of LV models and assess the potential of a variety of sources of data that might be used to inform and populate the LV models.
Leveraging enhanced LV monitoring to optimise targeted network reinforcement	The LV system has not been designed with the level of electrified heat, transport, and microgeneration being targeted to meet our climate change targets in 2030. It is anticipated that clustering of EVs and/or heat pumps may cause constraints on the current system. ESB Networks must ensure LV network readiness for increased uptake of low-carbon technology to support the decarbonisation to enhance customer continuity. New solutions to provide additional capacity in the LV network must be developed including physical reinforcing and flexibility. Targeting deployment of enhanced monitoring equipment on LV/MV substations will reduce uncertainty on the location of constraints, and help focus reinforcing investment decisions in a more cost-effective way than broad stroke application across existing infrastructure.

Pipeline Project	Project Description
Developing and trialling novel approaches to manage LV flexibility	ESB Networks is currently collaborating with the Transmission System Operator (TSO) on planning trials for LV-connected flexibility. Significant volumes or clusters of flexibility in LV networks will trigger local congestion in these networks. An ideal system for managing LV flexibility would enable all the flexibility connected at LV to be available all the time. To enable this, two high-level options could be considered: - Reinforcement of existing LV infrastructure - Smart solutions that enable maximum use of the infrastructure Each of these options have costs and benefits associated with them. Costs are dependent on the deployment location and delivering an optimum solution in all cases is complex. In order to understand the capability of smart management solutions, trials will be carried out to assess their capability and practical implementation.
Framework for the optimal coordination of Network Management Systems (NMS) and Distributed Energy Resources (DER)	Network capacity is a finite resource and should be used to maximise societal benefits. The scope for innovative connection methods, demand-side response and flexibility will strongly depend on the access rights of loads/generators being optimal and delivering the greatest benefit to the overall energy system. This is a complex challenge. For example, a device which is operated for 15 minutes a year to provide a system service might risk sterilising access to the electricity network for another customer (e.g. demand/generator) operating continuously in either consuming or producing renewable generation. Similarly, 'capacity' needs to be defined – it is the 'right' to use a network for a given load over a given period, but should not entitle users to prevent others using the same network. This project would consider these principle and what might be applied in other areas, such as in the allocation of hybrid connections or in peer-to-peer trading.
Congestion Management and Capacity Allocation using Operational Management System (OMS)	Demand-Side Units (DSUs) are aggregated market players, and they comprise a portfolio of Individual Demand Sites (IDSs), which are usually distribution connected. They use demand reduction or on-site generation, or combinations of these, to act in the wholesale markets. In 2015, it became apparent that the activation of these IDSs, as part of the market activity, had the potential to cause local congestion issues on the distribution network. To give effect to the first stages of this understanding, manual studies are carried out once a year and the output from these studies is a list of so-called "Red" sites. These are communicated to the relevant DSUs and they are instructed to refrain from activating these sites for the summer months. However, this approach results in some Individual Demand Sites (IDSs) being unavailable for long periods during the summer months. To reduce these periods of unavailability, a new assessment approach is being evaluated to address the limitations. ESB Networks and NIE Networks have agreed a joint use case and are collaborating with an OMS vendor. There would be a trial programme involving the procurement and testing of the Distributed Energy Resource Management System (DERMS) module, together with a phased transition from the current connectivity model, to a fully populated electrical model with loadflow and state estimation.
Development of optimised LV design framework to enable a unified mobile support application	To best deliver designs, ESB Networks staff use a number of tools and applications to extract data from the organisation's databases and make assessments of key planning metrics such as voltage drop and transformer capacity. Providing an application that unifies and simplifies these processes should ensure consistency of approach and enable them to complete the design more efficiently and accurately. Providing this support to ESB Networks staff will become more critical in the future as the challenges in LV design become more varied (electrification of heat and transport, microgeneration and flexibility) and the solutions become more numerous and complex (both physical and flexibility solutions such as new transformer options, DSR, new connection options etc.).

Pipeline Project	Project Description
Developing 400MHz Spectrum Use for Smart Grid Applications	ESB Networks has acquired licence for the use of the 400MHz spectrum to deploy private, secure, resilient communications at a national level using cost-effective radio equipment to facilitate the roll-out of Smart Grids. As a result, ESB Networks can now leverage benefits from the use of this secure spectrum in terms of standardised communications interfaces and modules on ESB Networks infrastructure. An earlier innovation project provided learnings as to how this enabling infrastructure might support Smart Grids. This project aims to investigate this further and develop solutions for implementation, including power quality monitoring, non-secure network access, active network management, MV/LV substation load and generation monitoring, active coordination of EV charging, and microgeneration.
Network Flexibility - Non-wires solution to replace conventional network reinforcement	This project will trial a non-wires solution to replace conventional network reinforcement using flexibility solutions. An assessment of locations which require conventional reinforcement will be carried out as part of the project, and the approach proposed in the Smarter HV and MV Customer Connections project will be trialled. This will consider what will be required across the business to implement this new approach to reinforcement including procurement, economic assessment, and operational requirements.
Electrification Uptake Data Analytics Forecasting Tool	By analysing the demographic data from the CSO database, and if appropriate, other public sources of data, with ESB Networks GIS data the project aims to develop a forecasting tool for the uptake of EVs and heat pumps in order to predict future network upgrade requirements and better target investment for LV networks with large concentrations of electrified heat and transport.
Novel Protection for Public Lighting LED programme	To reduce the electricity usage and light pollution from public street lighting, local authorities have a replacement programme to replace 480,000 lamps across the country with efficient LED lamps. To facilitate this programme, a new in-line LV fused plug socket for public lighting is proposed. This will enable local authorities and their contractors to carry out the upgrades with increased safety and efficiency, and at a reduced cost.
Develop a novel slim unit substation to replace Magnefix substations >200kVA	To facilitate the electrification of heat and transport, this project aims to develop a newly designed slim unit substation that can be retrofitted into the existing LV Magnefix footprint. This will avoid the impact to the customer and environment of installing a standard unit substation, which is a larger size, in a new open space location.
Development of modularised metering and control for RES connections	ESB Networks will consider a number of possible designs for the provision of modularised arrangements at Renewable Energy Resources (RES) in which necessary metering equipment can be accommodated. Locating metering in prefabricated modules may have a number of advantages in terms of costs and speed of delivery.
Provision of Enhanced Levels of Reactive Power	A previous innovation project (Nodal controller) sought to use centralised and automated intelligence to allow as much reactive power support as possible to be delivered from specific type of wind generators to the TSO-DSO interface, while at the same time respecting voltage and thermal limits on the distribution network. This project looks to further develop the benefits of the Nodal controller and the provision of reactive power from other types of wind generators (other type B windfarms and potentially type C windfarms) and examine operational issues raised in the original trial.
Optimised design for 38kV Arc Suppression Coil (ASC) to support RES connections	This project aims to investigate different modifications to the design of the Arc Suppression Coils and the changeover switch for wind farm connections in order to facilitate a reduced cost of connection and improve system protection for our generation customers.

Innovation pipeline ideas that have been received from a variety of sources and that are under consideration by ESB Networks but have not yet gone through the initial assessment filter are listed below:

- Modelling and impact assessment of microgeneration operational scenarios
- Microgeneration curtailment trial at (a) high distribution voltages and (b) high export levels
- Trial of export limiting schemes
- Developing operation models for community energy/peer-to-peer trading
- Investigating new use cases for smart meter data
- Flexibility access rights for customers – trials of active network management
- Electrical Energy Storage (EES) – use of long-term storage to support increased integration of renewable energy
- Investigate the use of low impedance 33kVA pole-mounted transformers - support increased uptake of low carbon technology on the network
- Trial of fused mini-pillars - improve continuity of supply for the electrification of heat and transport
- Investigate the use of kW droop on EV charging - minimise voltage drop and negative impacts on the quality of supply
- Investigate the use of managed EV charging as contract option in certain connections
- Consider the use of >244V and <253V as output voltage on new 15kVA transformers - improve quality of supply on rural networks due to the electrification of heat and transport
- Investigate the potential system operation benefits of converting the LV rural network to operate at voltage levels higher than 230V - minimise voltage issues and negative impacts on the quality of supply for electrification of heat and transport
- Wide area voltage control to tighten MV voltage regulation and minimise the need for LV voltage driven network reinforcement
- Novel MV/LV unit substation designs to support fast EV charging
- Investigate climate change adaptation approaches
- Strengthening the resilience of future networks
- Network impact assessment of microgrids
- Assess and monitor harmonic levels on LV distribution networks for low-carbon technologies
- Using average windspeed measurements to increase real-time line ratings nationally
- Assessment of LV infrastructure to 1000V

4.3 Fast Follower Approach

Towards the end of 2019, ESB Networks began a 'Fast Follower' approach to review new solutions/ technologies that have been trialled by other utilities and may be feasibly transferred for use by ESB Networks in Ireland. For example, ESB Networks commenced a review of smart grid projects funded by Ofgem (to Q4 2019). This list is publicly available at www.smarternetworks.org/. This review is in progress.

This tactic seeks to leverage research and innovation that has been done by others and offers opportunities to be adopted and/or adapted for Irish circumstances, cognisant of the fact that the Irish electricity network has characteristics that are not necessarily replicated elsewhere, including the challenges associated with having almost six times as much overhead line rural network per capita as most other European countries, and substantial amounts of non-synchronous generation on the system that is less interconnected than many other jurisdictions. As such, a simple "Plug and Play" approach to innovation outcomes successfully achieved elsewhere may not always be applicable on our system. Nevertheless, given the size of our organisation in the global innovation context, ESB Networks believes it worthwhile to leverage successful innovation outcomes from others wherever possible and that it should offer value for money for our customers.

Adoption requires that the associated documentation and business case is assessed with respect to its suitability for implementation on the Irish distribution system. Where applicable, a feature of such assessments is consistency with results from ESB Networks' trial e.g. the Dingle Project, where a wider variety of technologies are under trial. If the desktop assessment suggests that the proposal is sound in an Irish electricity system context, and, if applicable, the results are consistent with learnings from ESB Networks' trials in Dingle, then subject to normal risk review, it should be possible to transition findings from these studies into ESB Networks BAU operations. In some situations, ESB Networks may still be required to trial the solution due to particular characteristics of the Irish system, but in doing so should be able to leverage the successful outcomes of others in order to significantly reduce the trial scope and timeline for ESB Networks, thereby making best use of our innovation resources.

4.4 Impact Assessment Framework

As part of the investment appraisal process, ESB Networks has developed an impact assessment framework. This is a set of scorecard metrics used to evaluate the impact of the proposed initiative across six strategic areas: Safety; Network Reliability and Resilience; Facilitating Growth and New Connections; Customer and New Market Services; Environment; and Social and Sector Learning.

Project Impact Scorecard Metrics	Description
➢ **Safety**	Safety to staff, contractors and general public
➢ **Network Reliability and Resilience**	Improved continuity, reduced outages and Customer Minutes Lost (CML)
➢ **Facilitating Growth and New Connections**	Growth in electricity consumption and additional connections to system
➢ **Customer and New Market Services**	Consumer, prosumer, cost of supply, future peer-to-peer trading, facilitating future market services and models
➢ **Environment**	Climate change and climate change adaptation, external impacts
➢ **Social and Sector Learning**	Customer service, public policy, ESB Networks' role in leading transition to lower-carbon economy

Each innovation opportunity is assessed against the six strategic areas above as either Significant, Moderate, Minor or Non-Applicable. The summarised results of this impact assessment framework on projects that were ongoing or closed in 2019 are presented in the table overleaf.

Roadmap	Project	Safety	Network Reliability and Resilience	Facilitating Growth and New Connections	Customer and Retail Market Services	Environment	Engagements and Social Obligation
Future Customer	+CityxChange						
	SERVO Increased Capacity for Individual Demand Sites						
	RE-SERVE – Customer Flexibility						
	StoreNet Customer Side Energy Storage						
	Superhomes 2.0 – Flexible ASHP Customers						
	Dingle Electrification Project						
	Exploration of ASHP for Ireland's Residential Heating Needs						
	Frequency Response and Voltage Control - DSO Investigation for Service Capability and Operation (DISCO)						
Climate Action	Smarter HV and MV Customer Connections						
	Big Data Analytics for Wind Farm Connections						
	Wind Farm Reactive Power Optimisation Trial						
	Introduction of Sidewalk Transformers						
	Introduction of MV.LV Tap Changing Transformers						
	Introduction of 1MVA Unit Substation Transformer						
	Introduction of Alternatives to Creosote Wood Poles						
	Wildlife OHL Contact Prevention						
	Heat Pump Cluster Impact Assessment						
	Intelligent Secondary Substation Monitoring (Winter Peak)						

Legend: Not Applicable | Minor | Moderate | Major

Roadmap	Project	Safety	Network Reliability and Resilience	Facilitating Growth and New Connections	Customer and Retail Market Services	Environment	Engagements and Social Obligation
Network Resilience	Smart Network - National Radio Access Network Project						
	Development of Dynamic Line Ratings						
	Fault Location, Isolation, Sectionalisation and Restoration (FLISR)						
	DistriHost Mapping Network Capacity						
	Data Analytics to Temperature Correct Loads						
	Nodal Controller for Reactive Power						
	Inspection of OHLs Using Drones and Image Processing Analytics						
	Leveraging Fibre Infrastructure for Smart Network Management						
	Storm Resilience for Overhead Networks						
	SOGNO – Smart Monitoring for Increased Resilience						
	Weather Forecasting and Network Damage Prediction						
	HV Stations Health Index						
	New Core and Aggregation IP Network						

Legend: Not Applicable | Minor | Moderate | Major

4.5 Innovation Projects Overview

Our Innovation Strategy was launched in late 2017 which presented the Innovation Roadmaps. A brief overview of each of our current 31 innovation projects, which includes five projects completed in 2019, are outlined under their respective roadmaps *(pages overleaf)*. In the course of the year, further ideas and suggestions were submitted to the innovation team, and these are and continue to be considered by the Innovation Steering Group for delivery and transition into the organisation.

4.6 Future Customer Innovation Roadmap

Empowering and Supporting Customers and the Economy: This roadmap focuses on delivering the innovation that will meet the requirements of future customers in a cost-effective manner. For example, enabling active energy citizens to provide flexibility for system services to support the operation of the electricity system.

The following outlines the portfolio of projects undertaken by ESB Networks under the Future Customer roadmap.

Positive City Exchange (+CityxChange)

Status: Ongoing **Project Timeline: Q4 '18 – Q3 '23**

Key partners / stakeholders: Limerick City and County Council, Trondheim Municipality, IES and MPower

Overview: Through active citizen engagement, the Positive City Exchange project is developing a series of demonstration projects on how today's cities can become smart, positive energy cities of the future. Positive City Exchange (+CityxChange) is a European Union (EU) Horizon 2020 Smart City Lighthouse project. The consortium consists of 32 partners, led by the lighthouse cities Limerick and Trondheim in Norway and five other follower cities, Alba Iulia (Romania), P'isek (Czech Republic), Sestao (Spain), Smolyan (Bulgaria) and Võru (Estonia). This is the first such award to an Irish city.

In Limerick, a community energy concept will be trialled with the use of intelligent meters, innovative new renewable generators (including hydrokinetic energy), electrical energy storage, digital tools and citizen participation to create a Distributed Positive Energy Block and District (DPEB). The focus of ESB Networks activities will be to support the integration of the DPEB in the distribution network and provide the regulatory and technical advice and guidance to enable concepts such as peer-to-peer energy trading and the Energy Community Utility (ECU) to be trialled.

SERVO Increased Capacity for Individual Demand Sites

Status: Ongoing **Project Timeline: Q4 '17 – Q1 '20**

Key partners / stakeholders: ESB Networks Asset Development

Overview: The aim of the project is to allow Demand Side Management (DSM) aggregators the greatest possible freedom to control load without compromising network performance and integrity using a database system to represent network capacity and other parameters. It will operate as a mechanism ensuring that 100% of network availability is exposed to customers and aggregators without incurring unavoidable increases in electrical network costs. The project will also introduce a mechanism capable of autonomously appraising network conditions, flagging parts of the network for replacement or upgrade on a reactive basis.
An additional benefit of the project will be the ability to monitor asset condition and lifecycle, informing asset health and maintenance.

RESERVE – Customer Flexibility

Status: Complete **Project Timeline: Q3 '16 – Q3 '19**

Key partners / stakeholders: 10 Horizon 2020 Consortium Partners from across the EU

Overview: ESB Networks engaged in the EU H2020 funded RESERVE project with 10 other consortium partners to develop solutions capable of enabling 100% renewable generation on electricity networks. As the sole Distribution System Operator (DSO) in the consortium, ESB Networks focused on voltage control techniques which utilise inverter-based technologies to provide voltage support to the distribution network.

In order to validate the voltage control concepts developed in the RESERVE project, ESB Networks led the co-ordination and management of the disparate range of tasks and activities required to deliver and validate field trials on the Irish distribution network. This required the mapping of control techniques, ICT architectures and renewable technologies to suitable trial sites. ESB Networks succeeded in procuring,

permitting and commissioning operational renewable and storage technologies at a total of six DER trial sites which included;

- Solar PV Array at ESB Networks' National Training Centre, Portlaoise, Co. Laois
- Vehicle to Grid (V2G) Charging System at ESB Networks, Leopardstown, Co. Dublin
- Air Source Heat Pump at Youghalarra National School, Newtown, Co Tipperary
- Domestic Scale Battery Systems at locations in Cork and Tipperary.

ESB Networks' successful delivery of the RESERVE Project Field Trials demonstrated that a Voltage Control technique solution can be implemented in real world scenarios, is inherently scalable, can be integrated with additional external monitoring devices, and is capable of positively contributing towards the resolution of constraints encountered by the distribution network.

StoreNet – Customer Side Energy Storage

Status: Ongoing **Project Timeline: Q2 '16 – Q1 '20**

Key partners / stakeholders: IERC, Solo Energy and Electric Ireland

Overview: StoreNet is a project which is led by IERC, who formed a consortium of project partners which include ESB Networks, Solo Energy and Electric Ireland, to validate the performance of 20 no. 10kWh 4kW battery energy management systems on the distribution network.
The batteries are installed in residential premises in the townland of Ballyferriter, west of Dingle town, Co. Kerry.

The aim of the StoreNet project is to develop and deploy a pilot Virtual Power Plant (VPP) network of distributed batteries to store and effectively manage renewably generated electricity, whether generated onsite or elsewhere on the local distribution system. The StoreNet VPP will provide a buffer between electricity generation and demand and will facilitate a shift from the current status quo of supply (from fossil fuel power plants) responding to demand, toward a smart-grid system of demand responding to intermittent renewable supply. Ultimately, this will help pave the way for the creation of a carbon-free energy system supplied by indigenous renewable resources.

The project is seeking to validate the following benefits:

- Maximising self-consumption of onsite renewable generation
- Matching customer demand to times of low-carbon supply
- Facilitating increased renewable penetration through the delivery of ancillary services to grid operators
- Reducing reliance on fossil-fuel-based electricity
- Encouraging a prosumer driven low-carbon alternative to existing electricity suppliers
- Enabling increased electrification of heat and transport from sustainable sources

Superhomes 2.0 – Flexible ASHP Customers

Status: Complete **Project Timeline: Q3 '17 – Q2 '19**

Key partners / stakeholders: International Energy Research Centre (IERC), Tipperary Energy Agency (TEA), Limerick Institute of Technology, and Electric Ireland

Overview: The mass adoption of eHeat is a key pillar of Ireland's national decarbonisation strategy. The installation of Air Source Heat Pump (ASHP) based technologies has traditionally been very limited in Ireland with negligible impact on the electricity networks. Understanding and predicting the impact of heat pumps on the electrical distribution network is key to enabling ESB Networks to understand and design a network capable of efficiently hosting the mass deployment of such technology.

ESB Networks engaged in the IERC Co-ordinated Superhomes 2.0 Project with four Irish-based consortium partners in order to develop an understanding of the impact on the distribution network and electrical demand in general of heat pumps in newly retrofitted residential dwellings. In delivering the project, ESB Networks installed Advanced Metering Infrastructure at 20 diverse premises located throughout the country and leveraged this technology to gain an in-depth understanding of the seasonal and climate factors that impacted these premises' energy requirements. Working with our consortium partners, we combined this data with ASHP performance metrics in order to inform an understanding of the relationship between ASHP energy requirements and latent electricity demand.

Working in co-operation with data science specialists, these data sets were cleansed, error checked and correlated with additional meteorological records in order to identify trends and dependencies with regard to energy consumption by heat pumps. The output of this analysis is a deeper, data-driven understanding of the impact of eHeat installations on the distribution network, learnings which are now underpinning our plans to optimise the design and delivery of our networks to accommodate eHeat solutions.

The Dingle Project

Status: Ongoing **Project Timeline: Q1 '18 – Q4 '20**

Key partners / stakeholders: MaREI, Molteic (Dingle Creativity and Innovation Hub), and the Tipperary Energy Agency

The Dingle Project was launched in April 2018. This 3-year project aims to demonstrate residential scale Demand-Side Response technologies which utilise behind the meter assets such as Heat Pumps, EVs, Immersions, Solar PV, and Batteries. The trials will provide the customer with knowledge of the data, systems, customer adoption considerations and economic value in order for such services to become a reality.

There have been many discrete implementations of how different technologies might assist in a decarbonised future, however this project seeks to cluster viable technologies in a defined geographical area creating a sandpit for solutions, to demonstrate a working implementation of an electrical network capable of delivering Ireland's future energy needs.

Through demonstration, the Dingle Project aims to examine the following challenges:

1. The additional electrical load which will materialise through the adoption of EVs and Heat Pumps will need to be furnished by electricity produced from renewable sources if Ireland is to meet its commitments to reduce carbon emissions
2. Unlike thermal generation, renewable generation is not dispatchable. Hence, in order to maintain network stability, the load will need to be more flexible to align with available renewable generation
3. As customers move to using electricity for heat and transport, the reliability of the network to be "always on" becomes ever more important

There are four project objectives, as detailed below;

Project Objectives	Description
Understanding the behaviours and mechanisms required to transition to the Active Energy Citizen	There is a need to understand what mechanisms drive the desire to transition from a traditional consumer to an active citizen. Services such as peer-to-peer, virtual power plants, community scale developments and flexibility will be offered with a view to appreciating levels of adoption, utilisation and acceptance among all customers. Studies and structured reporting will allow for understanding of incentives required to ensure optimal adoption of services.
Assessment of how Distributed Energy Resources (DERs) can offer flexibility as a service for a non-wires solution to network reinforcement	It is forecast that the rate at which customers adopt electric vehicles and heat pumps will increase. As a consequence, in some instances, the MV and LV electrical network will become constrained. This objective will deliver demonstrations which will compare conventional network reinforcement approaches with a non-wires solution to accommodate the additional load. The non-wires solution proposed for trial assumes loads (such as smart EV chargers, smart heat pumps, smart immersion controllers) can be controlled to provide diversification, in tandem with resources such as batteries to offset grid constraints. Upon demonstrating and verifying the realities of this, it will then be possible to definitively report the feasibility to defer a conventional network upgrade and/or provide operational and reliability increases through these services.
Peer-to-peer services and Data Platforms to enable the Active Energy Citizens and Energy Communities	Residential generation and demand technologies are changing, creating an environment where customers can trade electricity. The electrical industry is aligning to decentralised generation at distribution level, driving the need for sector coupling (the idea of interconnecting or integrating the energy consuming sectors – heating and cooling, transport, and industry, with the power producing sector). Peer-to-peer accounting is needed to enable this. This objective will develop, document and disseminate an understanding of how the DSO can facilitate new services facilitating peer-to-peer, and ensure smart meters and platforms capture this into the future. The demonstrations delivered as part of this objective will allow ESB Networks to understand the role peer-to-peer has to play in enabling the Active Energy Citizen and Local Energy Communities.
Increasing reliability on the MV and LV network	As electrification proliferates across Ireland, electricity begins to displace very robust delivery mechanisms for other fuel sources. The reliability of the overall electrical network will need to be ever more robust due to additional utilisation, exposure and changing customer expectations. This objective will establish and deliver demonstrations of viable measures required to make the network resilient by reducing Customer Interruptions and Customer Minutes Lost, as well as improving the efficiency of operations by decreasing van rolls, fuel usage, and hence reducing carbon emissions.

Exploration of ASHP for Ireland's Residential Needs

Status: Ongoing **Project Timeline: Q1 '19 – Q4 '20**

Key partners / stakeholders: University College Dublin, and the Tipperary Energy Agency

Overview: Air source heat pumps are a suitable domestic heating alternative, particularly to replace oil-fired systems. However, consumers may need to be convinced of their effectiveness and usability if they are to be widely adopted. A clearer understanding of heat pumps will help policymakers and governmental agencies define policy in the overall energy balance challenge. This project aims to provide the basis for evidence-led policies on the electrification of heating in Ireland by conducting a field study and attitudes survey. The project aligns with SEAI's vision to secure a sustainable, efficient, clean energy future for Ireland. This project follows on from work carried out by ESB Energy Analytics, Future Networks, Smart Networks and Tipperary Energy Agency (TEA) using data from the Superhomes project earlier in 2018.

Frequency Response and Voltage Control - DSO Investigation for Service Capability and Operation (DISCO)

Status: Complete **Project Timeline: Q3 '19 – Q4 '19**

Key partners / stakeholders: NIE Networks

Governments in Northern Ireland and Ireland have ambitious renewable energy targets, with both jurisdictions aiming to achieve 40% 'Renewable Energy Sources of Electricity' (RES-E) by 2020. To ensure the safe and secure operation of the power system whilst delivering on the RES-E targets the Transmission System Operators (TSOs) in Ireland have established the DS3 programme (Delivering a Secure Sustainable Electricity System). Within DS3 a need has been identified to procure services from customers to help the TSOs manage the system; these services are known as DS3 System Services.

While DS3 system services have traditionally been provided by customers, the potential for the distribution network to offer services to the TSO has been trialled by Electricity North West Limited (ENWL) in GB through their Customer Load Active System Services (CLASS[1]) project. Importantly, the CLASS project has demonstrated that these services can be provided without compromising the customer's security or quality of supply if managed correctly by the DSO.

The aim of this project was to determine the potential volume of frequency response and voltage control that could be offered to the TSO by both NIE Networks and ESB Networks. As part of the project, a number of trials were carried out on the distribution networks in Northern Ireland and Ireland to validate models and understand the practical implications for the provision of these services using distribution network assets.

The project concluded that both NIE Networks and ESB Networks currently possess substantial capability within their existing network assets to deliver system support services for both Frequency Response and Voltage Control, with only minor adjustments required to fully unlock this potential. However, a more comprehensive study will be required to understand completely what risks, if any, providing these services pose to the security, safety or quality of supply.

[1] www.enwl.co.uk/class

4.7 Climate Action Innovation Roadmap

Decarbonising Electricity, Heat and Transport: This roadmap focuses on delivering the innovations that will ensure that ESB Networks cost-effectively delivers the right infrastructure at the right time for a decarbonised energy system supporting the integration of significantly increased levels of renewables and electrified heat and transport on the system.

The following outlines the portfolio of projects undertaken by ESB Networks under the Climate Action roadmap.

Smarter HV and MV Customer Connections

Status: Ongoing **Project Timeline: Q1 '17 – Q1 '20**

Key partners / stakeholders: CRU, ISEA, Meitheal na Gaoithe, IWEA, IrBEA, DRAI, IESA

Overview: The most fundamental issue regarding the future evolution of our planning and security standards is whether it prescribes economically efficient investments, given the many changes affecting the energy market at present. These changes include the large-scale deployment of non-network technologies such as Demand-Side Response (DSR), energy storage and the changing role of the customer. This gives rise to the need for a fundamental review of the baseline philosophy of distribution network planning, operation and design to deliver new, innovative approaches to distribution network planning that ensure that Ireland's energy policy objectives can continue to be met economically and sustainably, while ensuring that the security is equal to or, where appropriate, even greater that what is delivered today.

Phase 1 of the project is a comprehensive stakeholder engagement and consultation process, and consists of research, analysis and modelling.

Phase 2 will take forward the learnings and recommendations from Phase 1 and will begin the process of bringing these changes into business as usual, while also outlining any associated implementation timelines. This will take the form of codification and approval of these changes into our Distribution System Security and Planning standard and where necessary, in our other codes and approved regulations.

Big Data Analytics for Wind Farm Connections

Status: Ongoing **Project Timeline: Q4 '18 – Q2 '20**

Overview: Currently, wind farm connections are deterministically assessed on the basis that they will never cause breaches of our Distribution Planning and Security of Supply Standards. In order to assess the impact of wind farms on the network, a set of 'worst case' conditions are assumed under which the system is modelled. These assumptions are maximum system demand, maximum generation and connection point voltage at its maximum.

Our current planning approach assumes that these worst-case conditions occur simultaneously. Using big data analytics and probabilistic analysis, it may be possible to more accurately evaluate and understand the probability of these worst-case conditions occurring. Understanding and quantifying these risks will allow us to understand the current risk we have on our network and quantify the financial and risk implications of new methods of connecting customers to the network.
The learnings of this project should also feed into the Smarter HV and MV Customer Connections project.

Wind Farm Reactive Power Optimisation Trial

Status: Ongoing **Project Timeline: Q1 '18 – Q4 '20**

Key partners / stakeholders: UCD and Enterprise Ireland

Overview: ESB Networks has collaborated with UCD and Enterprise Ireland to develop a device which modulates the reactive power produced by a wind farm to minimise losses on a designated circuit of the distribution network. This can be immediately adjacent to the wind farm in question, or to a designated circuit further upstream.

Key outputs from the project will be insights into the benefits this device may bring to the overall energy system that could be used to inform what regulatory changes might be required to achieve these benefits. The changes may have operational ramifications that need to be understood before any regulatory changes are considered.

Introduction of Sidewalk Transformer

Status: Ongoing **Project timeline: Q3 '17 – Q2 '20**

Overview: The electrification of heat and transport will lead to increased demand loads and potentially congestion on LV networks, as network design did not consider the proliferation of low-carbon technologies.

Thermal capacity limits can be effectively overcome with conventional reinforcement, e.g. upgrading cables and upgrading or installing additional transformers. This often proves to be an economic long-term solution; however, practical issues, for example finding a site for a new secondary substation, can limit our ability to deliver this solution in existing housing estates.

Miniature secondary substations, known as sidewalk transformers, are a solution to such spatial restrictions on narrow streets in densely populated city areas. For example, this technology is already in use in Tokyo, Japan. ESB Networks is developing an Irish trial of these units to use this technology to increase capacity for electrification on our LV networks for housing schemes.

Introduction of Medium/Low Voltage Tap Changing Transformer

Status: Ongoing **Project Timeline: Q3 '17 – Q1 '20**

Overview: ESB Networks' investment planning standards provide for defined voltage drop on the MV and LV systems. 10% of this is allocated upstream of the LV bus bar and the balance is allowed for on the LV network.

As LV load increases due to installation of heat pumps and EVs, the voltage drops on the LV network will increase. Ensuring that this does not impact customers' quality of supply would normally require substantial conventional reinforcement. ESB Networks is investigating innovative alternatives which may provide more economic solutions. One approach is to regulate the sending LV voltage using MV/LV on load tap changing transformers. These would allow for larger voltage drops and greater voltage variation on the LV network, without compromising customer's received voltage.

Pilots in Ireland will allow us to:

1) evaluate the operational implications of their use on the Irish system which has its own technical characteristics compared to other jurisdictions;
2) identify and design for the practical issues regarding their installation on the Irish system; and
3) determine how best to integrate them with our existing network technologies and with Irish customers' usage patterns

Introduction of 1MVA Unit Substation Transformer

Status: Ongoing **Project Timeline: Q2 '18 – Q2 '20**

Key partners / stakeholders: CG Power Systems Ireland Ltd

Overview: This project is trialling small compact transformers which can be retrofitted into smaller spaces to provide extra capacity for the electrification of heat and transport. A modern unit substation design has been made to accommodate either a 440 kVA or 630 kVA transformer. It has two limitations - the available footprint for the transformer, and the ability of the unit substation housing to vent excess transformer heat to allow operation at full load.

This project seeks to develop a 1MVA compact transformer solution whose heat output is no greater than those transformers used in existing unit substations that could be retrofitted into the available footprint of an older unit substation design.

If successful, this would allow existing unit substations in over-developed locations to be uprated to 1MVA and for new 1MVA unit substations in new housing estates to be installed using the existing unit substation design.

Introduction of Alternatives to Creosote Wood Poles

Status: Ongoing **Project Timeline: Q3 '16 – Q3 '20**

Overview: ESB Networks has installed over 2.2 million poles across the LV and MV networks. These poles have traditionally been creosote wooden poles, however the Department of Communications, Climate Action and Environment (DCCAE) banned the use of 'A oil' poles in 2000 and has granted derogation for the continued use of 'B oil' and 'C oil' creosote wood poles up to May 2021. Therefore, there is a requirement for ESB Networks to find an alternative for creosote wood poles.

The first part of this incremental innovation project will examine materials application using fibreglass composite poles, steel poles, concrete poles, laminate poles and hybrid poles. The second part of this project aims to investigate alternative treatment types that could protect wooden poles once the use 'B oil' and 'C oil' creosote allowance expires.

Wildlife OHL Contact Prevention

Status: Ongoing **Project Timeline: Q1 '19 – Q1 '20**

Overview: The project aims to identify and trial novel measures to prevent wildlife contact with live conductors and OHL network equipment in general (pole attack by woodpeckers, insects etc.). The project aims to use technology to allow technicians to report issues caused by wildlife and to allow workable solutions to be shared. The benefit to the customer will be an improved service (reduced CML).
The benefits will also accrue to the wildlife, who will be deterred from causing themselves damage also.
Project outputs will feed into line design incorporating any measures at the outset, informing upgrades and alterations to account for local conditions. Another project benefit relates to how existing standard materials can be cost-effectively modified to incorporate risk mitigation during manufacturing.

Heat Pump Cluster Impact Assessment

Status: Ongoing **Project Timeline: Q3 '17 – Q2 '20**

Overview: The uptake of heat pumps in domestic dwellings will represent significant load growth, driving the development and update of our LV planning standards and designs. These changes must be evidence-based, and as such, in this project we are monitoring a number of new build locations with clustered ASHP installations. The data gathered will be analysed to develop robust models informing revised planning standards and designs. Building on our current research work around MV/LV transformer monitoring, ESB Networks will install transformer monitoring devices in both unit substations and pole mounted transformers feeding estates with ASHP installations.

Winter Peak – Intelligent Secondary Substation Monitoring

Status: Ongoing **Project Timeline: Q1 '17 – Q1 '20**

Overview: The anticipated increase in new LV technologies such as EV chargers, heat pumps and PV – based microgeneration, battery storage and renewable microgeneration could cause electrical effects or impacts on the LV distribution system. These network impacts are not fully understood yet by ESB Networks. They could cause power quality problems by affecting a range of electrical parameters such as voltage, phase angle, current, active and reactive power as well as harmonics. The LV network needs to accommodate the new lower-carbon technologies while ensuring it does not exceed its technical design capabilities.

This project is about the design, development, installation and operation of a standardised MV/LV monitoring device that is able to gather electrical parameter data on the LV distribution system. Analysing that data will assist ESB Networks in integrating new technologies onto the network, ensuring that the network does not become an obstacle to deployment of DER.

4.8 Network Resilience Innovation Roadmap

Efficient, Secure, Reliable Electricity: This roadmap focuses on delivering the innovations to provide an efficient, resilient and reliable future network supporting increased electrification in a low-carbon future.

The following outlines the portfolio of projects undertaken by ESB Networks under the Network Resilience roadmap.

Smart Network - National Radio Access Network Project

Status: Complete **Project Timeline: Q3 '17 – Q4 '19**

Overview: The existing telecoms infrastructure on ESB Networks' Telecoms network is designed to support connectivity to primary substations from 38 kV to 400 kV. Connectivity beyond the substations is primarily supported by third party offerings currently. The deployment of a Smart Grid greatly enhances ESB Networks' ability to meet its objectives regarding decarbonisation, reducing faults and their durations, electrification of heat and transport and many other key issues. The development of a highly available cyber-secure national radio access network is needed to meet the demand for machine-to-machine data communication for the control, protection and management of utility assets.

ESB Networks was approved funding in the PR4 period to plan for the deployment of this network and carry out necessary trials. ESB Networks conducted two trials of LTE equipment in the 410 MHz spectrum range in 2019. Based on the success of these trials, ESB Networks participated in ComReg's spectrum award process in Q4 2019. ESB Networks was successful in acquiring a radio spectrum licence for 15 years, beginning in November 2019.

The development of a highly available cyber-secure national radio access network is needed to meet the demand for machine-to-machine data communication for the control, protection and management of utility assets.

ESB Networks is now in a position to plan, design and deploy a dedicated Smart Grid network to meet the business needs. This will involve the development of a dedicated wireless network for the reliable transport of data for future smart grid applications. This network will enable the replacement of many of the current systems dependent on public networks such as distribution automation, fault passage indicators and energy meters, and will also provide new systems with their communication needs. The network will also enable large scale connection to individual devices for asset management purposes.

ESB Networks will begin a tendering exercise in 2020 to enable the procurement of the relevant equipment and services to support a national radio network.

Development of Dynamic Line Ratings

Status: Ongoing **Project Timeline: Q1 '17 – Q2 '20**

Key partners / stakeholders: The TSO

Overview: A meteorologically-driven increase in cooling effect on overhead lines would allow for an increase in transmission and distribution line ratings.

This project is about the development of a model that accounts for ambient meteorological parameters changes such as temperature, wind speed and wind direction, allowing increased line rating that leads to a greater operational flexibility. This project would look to build on learnings from other jurisdictions and look to identify the appropriate innovation solution to the Irish system and environment.

Fault Location, Isolation, Sectionalisation and Restoration (FLISR)

Status: Complete **Project Timeline: Q3 2019 – Q4 2019**

Key partners / stakeholders: NIE Networks

Fault Location, Isolation, Sectionalisation and Restoration (FLISR) is a software solution to enable automated devices to communicate through a central system and isolate faults. FLISR is utilised in several states in America, reducing CIs by 55% with automation or 35% with manually validated automation. In this project, two sites – one in Northern Ireland and one in Ireland, – were studied to evaluate the impact that FLISR systems could have on faults on the system. Based on this limited study, the project recommended that ESB Networks and NIE should consider further investment in SCADA and automated devices to enable a full FLISR system in the future. This would drive toward a future of improved network reliability and continuity for both companies.

DistriHost: Mapping Connection Capacity

Status: Ongoing **Project Timeline: Q1 '17 – Q3 '21**

Key partners / stakeholders: ERPI

Overview: As we connect more DER such as large-scale renewables, microgeneration and energy storage onto our distribution network, we need to ensure this is done in the most cost-effective way while maintaining a safe, secure and stable system. This can only be done by first determining what capacity is available on our network to connect DER.

The DistriHost project is an EPRI collaboration to develop a set of tools that will evaluate the capacity on our network to accommodate DER, without adversely impacting power quality or reliability under current network configurations and without required infrastructure upgrades.

The aim of the project is to equip our network planners with tools to quickly visualise and understand the impact of DER across our distribution network. This will be done by using EPRI's hosting capacity method to analyse large numbers of MV feeders.

The tools developed should enable areas where there is capacity available to connect renewables onto the distribution system to be easily identified. This should aid network planners to quickly evaluate the Least Cost Technically Acceptable (LCTA) connection method to connect DER to the electricity system.

Data Analytics to Temperature Correct Loads

Status: Ongoing **Project Timeline: Q1 '17 – Q3 '20**

Key partners / stakeholders: Met Éireann

Overview: This project is using data analytic techniques to enable temperature correction of network loads. This is important to provide network planners with the most accurate load information on which to base their planning studies.

The relationship between load and temperature for each circuit is different, as the response of load to temperature on each circuit depends on the proportion of temperature sensitive load (% Domestic, % Commercial, % Industrial). A correlation between temperature and load for each MV feeder would be required based on SCADA load data and temperature data from Met Éireann. Load, temperature and weather conditions for each MV circuit can be used to set an appropriate temperature correction factor for each. This will result in a baseline temperature corresponding to realistic worst-case conditions being set and all loads temperature corrected to this reference temperature.
Special Load Reading (SLR) reports can then be corrected to these levels, and the accumulation of such loads would then form the input data to planners.

Nodal Controller for Reactive Power

Status: Ongoing **Project Timeline: Q1 '16 – Q2 '20**

Overview: To facilitate the transfer of reactive power to the transmission system, ESB Networks has developed a sophisticated control system called a Nodal Controller.

The Nodal Controller is a new concept and seeks, for larger DSO connected wind farms, to use centralised and automated intelligence to allow as much reactive power support as possible to be delivered to the TSO-DSO interface, while at the same time respecting voltage and thermal capabilities of the distribution network. The DSO-connected wind farms can be used to provide valuable reactive power support to the transmission network and in some cases, obviating, reducing or deferring investment in transmission infrastructure such as STATCOMs and capacitor banks.

To test this concept, a pilot of this technology was carried out at the Cauteen wind cluster in Co. Tipperary. The pilot was carried out on Topology B wind farms to deliver transmission support functionality at the TSO-DSO interface whilst ensuring that all distribution voltages and current limitations were maintained and protected. It has now been proposed that this solution be considered for other types of wind farms e.g. Topology C.

Inspection of Overhead Lines Using Drones and Image Processing Analytics

Status: Ongoing **Project Timeline: Q3 '16 – Q2 '20**

Key partners / stakeholders: University of Limerick and the TSO

Overview: Currently, line inspections on ESB Networks' overhead transmission lines are carried out manually. To carry out these inspections, the lines need to be switched out and then the inspectors are deployed to carry out visual inspections on all structures and equipment associated with the line by climbing the structures. Some drawbacks associated with this traditional means of inspection are: limited range of visibility for inspections; dependence on accessible locations on the structures; outages are required to carry out the inspections. This project aims to explore the application of new drone technology and associated analysis as an innovative alternative to the traditional line inspection approach.

A specification will be produced to engage a service provider to inspect all transmission lines using drones. The service provider will have at their disposal Corona, UV, Radiometric Thermal and Infrared cameras, and the survey work will also include:

- Recording galvanising thicknesses on steel structures – to indicate whether the tower needs to be painted;
- Tower Footing Resistance measurements – to indicate whether extra Potential Control rings etc. are required; and
- Soil Resistivity measurements – to indicate whether extra Potential Control rings etc. are required.

Leveraging Fibre Infrastructure for Smart Networks Management

Status: Ongoing **Project Timeline: Q1 '15 – Q4 '20**

Key partners / stakeholders: SIRO

Overview: SIRO intend to deploy fibre to the building (FTTB) services to over 300 urban locations in Ireland. The roll out of this service involves the deployment of fibre optic cables which pass close to primary and secondary substations.
ESB Networks has reserved a single pair on all SIRO fibre for operational use.

The fibre will run alongside existing ESB Networks equipment. The objective of this project is to identify the best method of deploying ducting to attain a viable fibre route between SIRO Point of Isolation (POI) and primary / secondary substations.

ESB Networks intends on delivering communication services over operational fibre to backhaul information and potentially control secondary substations. This project will also trial different types of use cases over different technologies.

Storm Resilience for Overhead Networks

Status: Ongoing **Project Timeline: Q4 '17 – Q2 '20**

Overview: Overhead line assets are vulnerable during extremely high wind speed events, particularly where there are large trees growing within falling distance of the electricity network. ESB Networks carries out cyclical planned maintenance and timber clearing programmes to maintain the performance of the network and to ensure public safety.

The concept of 'Hardening' the overhead network has been implemented in North America where targeted actions increase the resilience of overhead networks to storm conditions. This project will trial a number of 'Hardening' initiatives on an MV outlet and its continuity performance will be tracked. The Project scope includes:

- selection of a line on the Western Seaboard with a history of timber and storm-related outages;
- establishment of a larger than standard vegetation exclusion zone on the three-phase backbone line; and
- trialling of smart reinforcement techniques for vulnerable areas of the network

SOGNO – Smart Monitoring for Increased Resilience

Status: Ongoing **Project Timeline: Q3 '17 – Q2 '20**

Key partners / stakeholders: EU Horizon 2020 partners

Overview: An increase in renewable energy penetration on the distribution system is a challenge that drives the need for greater network visibility and performance monitoring.

This EU Horizon 2020 project will address this challenge by trialling combinations of data analysis and visualisation tools, advanced sensors, an advanced power measurement unit and 5G based ICT to provide greater visibility and control of both MV and LV power networks, using end to end automation in a virtual environment.

SOGNO aims to trial solutions that may increase resilience of existing systems and reduce customer minutes lost (CML).

Weather Forecasting and Network Damage Prediction

Status: Ongoing **Project Timeline: Q4 '17 – Q2 '20**

Overview: Climate change is predicted to lead to more frequent extreme weather events. To help increase ESB Networks' network resilience and adapt to climate change, this project looks to introduce a system that achieves the following objectives;

- A localised multi-day ahead weather forecast with a set of ESB Networks customised and specified weather metrics (wind, lightning, rain, snow etc.). This system will supplement the existing Met Éireann system (national and regional basis for forecasting general weather impacts)
- This localised weather forecast will then be used to create an outage and damage prediction model by using previous weather events and local continuity data in conjunction with the look ahead forecast
- The system will be used alongside the existing Operational Technologies to forecast damage and outage numbers to relevant stakeholders and will feed into the ESB Networks' response to major weather events

Development of High Voltage Stations Health Index

Status: Ongoing **Project Timeline: Q1 '18 – Q2 '20**

Overview: This project will develop the first phase of a functioning Health Index for all HV Substations. A project is currently being developed to widen the application of this project to other asset categories. The project will involve reviewing current end to end maintenance activities and mapping current business processes to allow a specification document to be produced for tender enquiry purposes.

ESB Networks is looking for a solution that facilitates the collation of asset-related data via mobile device deployment in the field and capturing executed maintenance activities via mobile devices with associated work order management. The solution also should update the Asset Health database with said activities, generate reports and performance review dashboards, as well as analyse gathered data to allow Health Index computation. The project will also involve the piloting of a current vendor offering to demonstrate 'proof of concept', thus enabling the above specification/tender enquiry process.

Smart Network - New Core and Aggregation IP Network

Status: Ongoing **Project Timeline: Q3 '16 – Q1 '21**

Overview: ESB Networks' telecommunications networks consists of multiple platforms over various mediums and is the main means of providing connectivity for system critical services for the electricity network. The range of critical services that will require connectivity on the telecommunications network is predicted to grow significantly, with the bandwidth requirements per service also increasing.

ESB Networks is investing in the installation of a scalable new fibre optics-based core and aggregation network spanning ten core sites (HV stations) and four aggregation sites. This new core and aggregation IP network will be a fundamental building block in fulfilling the existing and future communications requirements of the electricity network, and will act as a key enabler of smart network operations.

5 COLLABORATION, ENGAGEMENT AND DISSEMINATION

5.1 Collaboration and Engagement

As discussed in Section 3.6, stakeholder collaboration and engagement are features of implementing our Innovation Strategy, and this holds true throughout the validation, delivery and dissemination of our innovation activities. ESB Networks collaborates with a wide range of stakeholders including academic institutions, government entities and organisations, industry trade associations, electricity suppliers and generators, as well as new energy actors such as demand-side aggregators and battery storage providers. 2019 saw a step change in the level of ESB Networks stakeholder engagement and publication of information on innovation, including our first public industry consultation on our innovation activities; hosting our first Innovation Forum; revamping the Innovation section on our website; and conducting an increased number of targeted engagements with trade associations and industry sectors.

The impact of the increased activity was anecdotally confirmed by a poll taken during the ESB Networks Innovation Forum in November, where 93% of respondents believed their understanding of ESB Networks innovation activities had increased over the previous 12 months.

We also polled Innovation Forum participants on their views as to how ESB Networks should better disseminate learnings from our innovation activities from a list of four options. The anecdotal results showed that 50% of respondents preferred the Innovation Forum, 34% preferred the ESB Networks website, 14% selected the public industry consultation and 4% thought Conference Papers and Trade Articles were a better way to disseminate our learnings.

5.2 Collaboration and Engagement with Academia and Research Organisations

ESB Networks has extensive engagements with academia and research across all areas of innovation. To fully appreciate the values and choices of our customers today and into the future, we have been working with UCD and UCC MaREI conducting socio-demographic projection models and customer engagement campaigns within the Dingle Project. To understand the digital services and platforms of the future energy system, we have been working with TU Dublin and WIT. To understand the future tools and services that we could use to enhance reliability on our networks, we are working with UL on Autonomous Drone Technologies. To understand the capabilities, services and roles of customer sited DER, we are working with UCD's Energy Institute in the Integrated Energy Laboratory and with partners from across the EU on the EU Horizon 2020 RESERVE project. To fully appreciate the role of the community and future energy needs of islands, we are working with NUIG within the Renewable Energy for self-sustAinable island CommuniTies (REACT) EU Horizon 2020 project. Other academic institutions that ESB Networks collaborates with include:

- International Energy Research Centre (IERC)
- ETIP SNET (European Technology and Innovation Platform – Smart Network for Energy Transition) WG1 Reliable, economic and efficient smart grid system
- EU Commission Working Group on "Grid System of the Future"
- Polito - Politechnico di Torino - Polytechnic University of Turin, Italy
- Universitatea Politehnica Din Bucuresti - Technical University of Bucharest, Romania (UPB)
- Rheinisch - Westfaelische Technische Hochschule Aachen - German Research University (RWTH)
- University of Bologna
- Vrije Universiteit Brussels
- University of Oxford
- Technical Research Centre of Finland Ltd (VTT)
- DIW - German Institute for Economic Research
- Trinity College Dublin
- Istituto Superiore Mario Boella
- Teeside University, UK
- Uppsala University, Sweden
- Austrian Institute of Technology
- Institute Mihajlo, Serbia

5.3 Collaboration with Irish and International Organisations

ESB Networks also undertakes significant external collaboration with Irish suppliers, generators and other external international parties/companies. The majority of our projects feature an element of industry involvement and various levels of collaboration. Illustrative examples of collaboration with Irish suppliers and generators in 2019 include:

- ESB Networks held regular meetings in 2019 with industry representative groups to garner insights and feedback on our activities. These groups included IWEA, IWFA, DRAI, Solar Energy development organisations including representatives from ISEA and bio energy groups (e.g. IrBEA)
- ESB Networks has collaborated with SSE (Retail) on the RealValue EU Horizon 2020 funded project and has also worked with SSE (Generation) on the Wind Farm Reactive Power Optimisation project
- ESB Networks is collaborating with M-Power, Irish ESCO, on the +CityxChange project
- ESB Networks is collaborating with Solo Energy, Irish ESCO, and Tipperary Energy Agency on the Dingle Project
- ESB Networks has given a number of innovation updates and engagement presentations to Irish industry representatives via the Distribution Code Review Panel (DCRP). Representatives of the following bodies were present at these sessions:
  - Embedded generators (solar)
  - Synchronous generators
  - Embedded generators (wind)
  - Major customers
  - PES (Public Electricity Suppliers) / Independent Suppliers
- Other EU working groups and committees that ESB Networks have representatives on include: the Electricity Association of Ireland (EAI); the UK's Electricity Network Association (ENA); the International Council on Large Electric Systems (CIGRÉ); Eurelectric (Union of the Electricity Industry in Europe); and the International Smart Grid Action Network (ISGAN Part of IEA Technology Collaboration Framework)
- Utility-to-utility specific sessions were also held with other European utilities such as EDF and Iberdrola to share learnings and knowledge from our innovation activities

Another key collaborative partner for ESB Networks is the Electric Power Research Institute (EPRI) which, while international, has a large home base in the USA.

Our advisory role on EPRI's steering committee allows us to inform its research and development programs and identify critical and emerging electricity industry issues. This level of thought leadership has ensured we adopt industry's best practices and solutions to deliver the most suitable solutions for our customers at the most optimal time.

In 2019, ESB Networks collaborated with ERPI on a number of project sets. These include projects pertaining to energy storage and distributed generation, end use energy efficiency and DSR, DER integration, and distribution operations and protection.

5.4 Collaboration Case Study: the Dingle Project

One of the objectives of the Dingle Project is to assess peer-to-peer services and data platforms to enable Active Energy Citizens and Energy Communities. This trial aims to achieve the following outcomes;

- **Learnings on the impact on the LV and MV network**
- **Learnings on the data, technology, and processes required to undertake peer-to-peer trading**
- **Learnings on how peer-to-peer might integrate or align with existing ISEM trading processes and how settlement could take place**
- **Regulatory changes which will be required to enable peer-to-peer trading**
- **Understanding of economic value and benefit to society**
- **Learnings on the optimal peer-to-peer trading model to maximise customer adoption to support activation of the Active Energy Citizen**

ESB Networks recognises that collaboration with industry, regulation and policy owners, and undertaking the trial in close partnership with key stakeholders, is required in order to achieve the above outcomes. For example, at the Innovation Forum in November 2019, the Dingle Project team held a breakout workshop giving attendees an opportunity to discuss and debate in detail the potential peer-to-peer trading element of the project, what should be included in the scope and what might realistically be achieved in the ESB Networks trial.

Workshop attendees included representatives from academia, energy suppliers, energy agencies, technology and platform providers, SEAI and DCCAE. The collaborative workshop gave the project team further opportunities to validate proposed solutions and listen to feedback from stakeholders as to what they thought should be in the scope of the trial.

In addition, ESB Networks' Dingle Project is planning to issue an Expression of Interest in March 2020 to seek a project partner for the peer-to-peer trial. The Project partner will bring their knowledge of the energy market, ISEM trading processes, and will work with the ESB Networks Dingle Project and a digital platform provider partner to simulate peer-to-peer trading with trial participants acting in the prosumer role. Throughout the trial, ESB Networks and our trial partners will conduct user feedback through interviews and focus groups with trial participants in order to ensure that the solution is designed with the end-user in mind.

The trial will model the regulatory and policy changes needed to make peer-to-peer trading a viable service in the future. The learnings of this trial will be documented and disseminated for the benefit of the customer and the wider energy industry.

5.5 Dissemination of Knowledge and Learnings

We engage with key stakeholders who were either impacted by our innovation activities or who may have had an influence on our activities. The purpose is varied, ranging from seeking feedback to inform terms of references and project approaches, to sharing updates on project progress and plans to disseminate knowledge and learnings from projects to the wider industry. These engagements include:

- ESB Networks launched their Innovation Forums in 2019. See Dissemination of Learnings Case Study below
- Project-driven engagement such as with the Dingle Project; the Smarter HV and MV Customer Connections; Planning Future LV Networks for Electrified Heat and Transport; and the Wind Farm Reactive Power Optimisation project
- Industry engagement which includes us hosting and participating in a range of industry events. This was critical to effective consultation on the energy future and to the sharing of ideas and insights. By working with policy makers, the Liaison Group, working groups and expert panels, we can provide insights and leadership to the sector
- Publication of substantially more information on the revamped and updated innovation section of our website. This information includes our Innovation Strategy, project progress reports, project close-out reports and information on the Dingle Project. The 2019 website improvement initiative aligns with the Innovation Forum poll results mentioned in 5.1, where 32% of respondents preferred the website as a route for the dissemination of information on our innovation activities
- Participation in a number of public dissemination events where ESB Networks shared plans, outputs and findings of the Innovation Strategy and projects as appropriate, for example the National Ploughing Championships and the SEAI Energy Show
- Participation, by way of presentations or panel discussions, in a number of industry conferences and seminars that provided an opportunity to share details of our innovation activities. Examples include the IIEA Live Electric conference, ESIPP Annual Symposium, Utility Week Annual Conference, 3rd E-Mobility Integration Symposium, and 9th Solar and Storage Integration Workshop
- We have also had papers published in a number of conference publications: - 8th DACH+ Conference on Energy Informatics. 2019, Salzburg, Austria, 9th Solar Integration Workshop 2019. Dublin, Ireland, CIGRÉ Chengdu Symposium 2019. Chengdu, China, 3rd E-mobility Power System Integration Symposium. 2019, Dublin, Ireland.

  And academic journals:
  International Journal of Electrical Power and Energy Systems.
  Applied Energy.

5.6 Dissemination of Learnings Case Study: ESB Networks Innovation Forum

In November 2019, we launched our first Innovation Forum. ESB Networks will hold these Innovation Forums every spring and autumn, the purpose of which is to facilitate open and ongoing dialogue with customers and stakeholders. These forums will be used to keep industry informed of ESB Networks' innovation activities and to encourage feedback, ensuring ESB Networks is focused on the right innovation projects to deliver on the transition to a low-carbon society. The Innovation Forum included panel discussions, feedback sessions on ESB Networks' innovation activities and break-out sessions on topics concentrated around our three new roadmaps - Future Customer, Climate Action and Network Resilience. ESB Networks received positive feedback on this event, and an example of an online review can be found at www.irishevowners.ie/esb-networks-innovation-event/

Feedback from the event included the following comments:

"It was interesting to hear about the breadth of different activities"

"Liked the high level of audience participation"

"The mix between presentation, participation and discussion worked well."

"Constructive" "Good speakers with interesting content".

6 BENEFITS, LEARNINGS, IMPACT AND OPPORTUNITIES

6.1 Assessment of Benefits Against Costs

ESB Networks carries out qualitative and, where possible, quantitative analysis of the costs and benefits for all innovation projects. This provides the justification and analysis to support innovation projects and establishes clearly defined measures of success. Cost benefit analyses (CBA) are used by project managers for our innovation initiatives where possible. However, the nature of the innovation activity is that in some cases, it is difficult to monetise benefits. In such situations, ESB Networks considers qualitative assessments only.

Recognising the challenge of monetising benefits on certain innovation projects and in response to stakeholder feedback, ESB Networks strengthened our CBA methodology to include a CBA tool which improves the way we monetise non-financial benefits. A standardised CBA tool was developed, similar in structure and components to the UK industry-approved CBA tool (Ofgem RIIO EDI CBA template) used by UK DNOs to undertake CBAs in a consistent and transparent manner. ESB Networks has adapted the CBA tool to reflect Ireland's context and its industry's characteristics. The CBA tool is based on discounted cashflow principles to assess the networks and societal costs and benefits.

6.2 Transition to BAU

In 2019, ESB Networks went through an organisational restructuring. One of the key objectives of the new structure was to drive innovation at every level across ESB Networks and have clearer innovation roles and a centralised innovation function identifying and trialling innovation projects before transitioning to BAU. ESB Networks identified that the area of transition to BAU needed to be strengthened, and as a result, a dedicated Innovation Portfolio and Transition Team was established in 2019 to focus on improving the transition process and to enhance how we disseminate learnings.

Since the establishment of the new team, a systematic methodology and implementation process has been developed to ensure that a consistent approach to transition and dissemination is maintained. This framework is being applied to current and future projects transitioning to BAU.

In 2019, the Innovation Portfolio and Transition Team investigated best practices in other organisations and jurisdictions for transitioning innovation project portfolio outcomes to BAU. The team have engaged with UK Power Networks, Western Power Distribution (WPD), NIE Networks and SSE Networks to share learnings in this area in relation to the innovation process, governance, project reporting, transitioning projects to BAU, assessing benefits, measuring success and disseminating learnings. The output of this ongoing investigation is a set of ESB Networks-specific recommendations that will be implemented in the business in order to make the approach to transition to BAU and the dissemination of learning more efficient and effective.

ESB Networks' innovation projects will deliver quantifiable benefits by successfully embedding the new knowledge, processes, solutions and technologies into our BAU practices to improve the way we work and serve our customers. The integration of innovation sponsors at a senior level for each Innovation roadmap is an important part of this process. Their senior roles give them an in-depth understanding of the working practices, challenges faced and opportunities arising across the business; therefore, they are best placed to drive the company through change. The governance framework for the innovation programme was revised in 2019, with the Connecting Futures Board and Innovation Steering Group given clear and transparent responsibilities and decision-making roles. This will ensure that the most appropriate innovation projects with the greatest benefit to the customer make their way through the innovation process and transition into the business.

6.3 To BAU and Beyond: Learnings and Outcomes from 2019

One of the key priorities of our strategy is ongoing collaboration and communication of project results and insights with stakeholders who are impacted by, interested in, or have influence on our innovation activities.

In 2019, our engagements were varied and ranged from soliciting feedback and suggestions, to sharing updates on project progress, to disseminating learnings via a range of industry events, the ESB Networks' website and research groups in Ireland and abroad. As this update has outlined, ongoing collaborations include working with international research and development organisations such as EPRI, EU-funded working groups such as EU Horizon 2020, and numerous academic institutions, as well as participating in a variety of industry conferences and events.

A number of projects that delivered benefits and learnings in 2019 and are transitioning into BAU are summarised in the following table *(right and overleaf)*.

Innovation Roadmap	Innovation Project Name	High Level Benefit	Specific Learnings and Outcomes
Future Customer	Intelligent Secondary Substation Monitoring (Winter Peak) **To view report click here.**	Supporting electrification of heat and transport by using innovative monitoring and control systems to facilitate eHeat and EV's.	Informing future LV visibility strategy by developing a functional specification for an MV/LV monitoring device.
	Planning Future LV Networks for Electrified Heat and Transport **To view report click here.**	Designing LV Networks for the electrification of heat and transport.	LV standards and planning tools to change After Diversity Maximum Demand (ADMD) from 2.5 to 5.5 to accommodate new power flows from electrification of heat and transport.
	RESERVE **To view report click here.**	Demonstrating Voltage Control solutions that can be implemented in real world scenarios utilising multiple types of Distributed Energy Resource (DER) technologies.	Validated in the field all elements required for the delivery of system services by customer sited DERs.
	Superhomes 2.0 **To view report click here.**	A deeper, data-driven understanding of the impact of eHeat installations on the distribution network.	Identified trends and dependencies in relation to energy consumption by ASHPs.
	Servo Flex - Increased Capacity for Demand Sites	Enabling a Smart Grid to create a future ready network and facilitate future electricity market models.	Learnings on Smart Grid architecture and how to implement new cloud solutions in utility applications.
Climate Action	New Rate of Change of Frequency (RoCoF) settings for Distributed Generators **To view report click here.**	Supporting improved continuity of supply for distributed generation such as wind and solar farms.	New protection settings to ensure the system remains stable during grid-wide frequency events and high wind dispatch scenarios while providing adequate islanding protection.
	Facilitation of Fast Frequency DS3 Services **To view report click here.**	Facilitate frequency and voltage stability on the transmission system supporting more DER for a low-carbon future.	Developed innovative automated planning tools to simplify network connection studies and reduced time to issue connection offers.

Innovation Roadmap	Innovation Project Name	High Level Benefit	Specific Learnings and Outcomes
Network Resilience	Smart Network – National Radio Access Network Project (Spectrum) **To view report click here.**	The successful acquisition of radio spectrum will facilitate the secure reliable communication deployment for the smart grid.	Successful spectrum approved and acquired from ComReg on the 400 MHz spectrum. Technical capabilities of Long-Term Evolution (LTE) technology as well as Interface and deployment capabilities with Network equipment for smart grid communications.
	SigFOX Demonstration Trial **To view report click here.**	Enabling a Smart Grid to create a future ready network and facilitate future electricity market models.	Benefits and limitations of low power narrowband IOT communications capabilities.
	Amorphous Core Transformers **To view report click here.**	Implementing innovative asset solutions to ensure we minimise losses.	Reducing distribution losses. Total cost of ownership model for Amorphous Core Transformers versus Transitional Transformers.
	Improved Continuity for 20 kV Earth Faults **To view report click here.**	Improving safety and continuity of supply for the network by reducing interruptions and their duration.	Implementation of the new Sensitive Earth Fault (SEF) settings on networks reclosers has shown to lessen the number of SEF operations by 5%, reducing outages and improving the continuity of supply.
	Data Analytics Meter Fraud Detection **To view report click here.**	Developing innovative solutions to ensure improved safety for staff, emergency services and the public.	Using machine learning algorithms to identify meter anomalies and tampering, reduce distribution network losses and improve safety.
	Wind Farm Reactive Power Optimisation	Supporting more renewables and DER for a low-carbon future.	Allowing wind generation to provide system support services to maintain system stability.
	SCADA Digital Polling Radio **To view report click here.**	Enabling a Smart Grid to create a future ready network and facilitate future electricity market models.	Secure, Reliable and Cost-Effective Smart Grid Communications. Improved resilience, capacity, throughput and real time response for SCADA control.
	DistriHost	Supporting more renewables and Distributed Energy Resources (DER) for a low carbon future.	Developing innovative automated planning tools to simplify network connection studies and reduced time to issue connection offers.

6.4 BAU Case Study: Planning Future LV Networks for Electrified Heat and Transport

Emerging low carbon technologies and DER such as EVs, heat pumps, energy storage and domestic PV generation are changing the ways customers are using the network. As these changes gather momentum, they will become more significant and will put greater requirements on the electricity infrastructure. To accommodate these changes ESB Networks carried out research which derived new metrics, values and design tools based on academic and utility research and analysis which will enable us to plan LV networks for the future.

To ensure best practice in terms of implementation into BAU the project also comprehensively reviewed and critiqued existing LV planning standards and approaches both here in Ireland and internationally. Critically we have implemented into BAU increased values for After Diversity Maximum Demand (ADMD). This will ensure that the LV networks designed today will cater for the greater demand imposed on the system required by a low carbon energy system underpinned by EVs and domestic electrified heat.

To implement these changes, we have changed our system planning standards, our implementation guides and developed new learning tools. Our new interactive eLearning module, covering these new design standards, procedures and tools, has been developed to enable our field staff to understand the changes to the design and planning of our LV networks. 80% of Engineering Officers will have completed the e-Learning module by Q1 2020, with the remainder to have completed the training in Q2 2020.

We are exploring approaches to ensure that the practical application of the new design standards and processes are monitored in terms of quality assurance and are consistently aligned with best practice.

7 FEEDBACK ON INNOVATION IN ESB NETWORKS 2019

ESB Networks published an update on innovation activities in August 2019 and invited feedback from interested parties. Feedback was received from the following sectors.

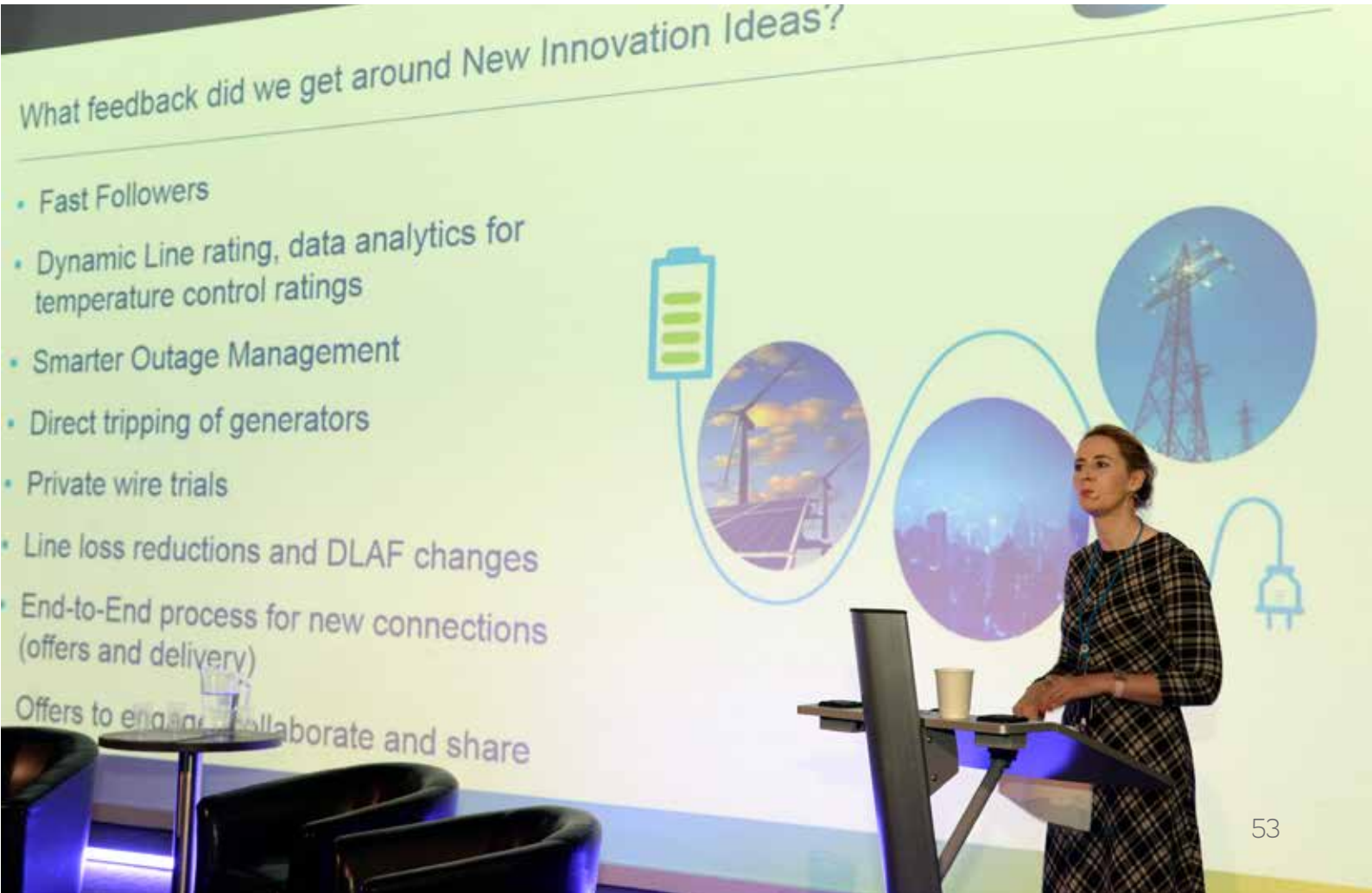
Sector	
RES Wind	√
RES Solar	√
Flexibility - Demand Response	√
Flexibility – Storage	√
Academia/Research	√
Utility / TSO	√
Equipment/Systems Manufacturers	√
Industry Consultants	√

Summary of Innovation Consultation Responses

The feedback provided in the submissions fell within three broad categories:

1. Suggestions to improve the Innovation Strategy Framework employed by ESB Networks
2. Suggestions to enhance innovation projects which are currently being conducted by ESB Networks
3. New ideas/proposals for innovation projects which are not in the current innovation portfolio

ESB Networks has drafted responses to this feedback in the following tables, with each table covering one of the three categories.



7.1 Improve the Innovation Strategy Framework employed by ESB Networks

Several responses focused on the Innovation Strategy Framework employed by ESB Networks and suggested modifications to the innovation process itself and the scope of projects considered. These included:

Feedback Received	ESB Networks Response
Requests for more expansive definition of ESB Networks' interpretation of the term 'innovation'.	ESB Networks' definition of innovation was shared and discussed with our stakeholders at the Innovation Forum in November 2019 – 'Innovation is to implement new ideas for the enduring benefit of our customers and business'. It was clarified that the benefits assessment, described earlier in section 3.4, included societal and whole system-type benefits where appropriate. This is reflected in our project impact appraisals that take into account a variety of societal impacts including safety, facilitating growth and new connections, customer and new market services, environment, and social and sector learning. In addition, we believe that an organisation of our size and resource capability should be focused on projects with a Technology Readiness Level (TRL) of 7 or above, as this delivers best value to our customers.
A number of responses suggested a consolidation of the roadmaps tracked by the Innovation Strategy Framework and highlighted the need for a balanced portfolio of projects across all sectors.	In order to improve focus, align with our new business strategy and taking into account the feedback received, the eight roadmaps used up to the end of 2019 have been consolidated into three focussed roadmaps: 1. Future Customer 2. Climate Action 3. Network Resilience
More information was looked for on the assessment and prioritisation of the innovative ideas. Suppliers who attended the supplier session in November also requested that ESB Networks publish our pipeline projects.	Innovation ideas are initially assessed and prioritised against five criteria: Lifecycle Savings Potential; Time Frame/Complexity; Core Competencies; Strategic Fit and Innovation Type; and Customer Need and Demand. The purpose of this is to give a simple initial assessment of projects and a preliminary ranking, prior to more detailed consideration. An Impact Assessment Framework is also applied to each project to ensure there is a balanced portfolio of projects across all six strategic areas: Safety; Network Reliability and Resilience; Facilitating Growth and New Connections; Customer and New Market Services; Environment; and Social and Sector Learning. The summarised result of this impact assessment is presented in the Innovation Project Portfolio Section above. ESB Networks' pipeline projects are listed in the Innovation Project Portfolio Section; feedback from stakeholders on these projects is requested.
There was a desire for more published project information to be made available including project timelines and deliverables, the status of innovation delivery projects, benefit assessment and measures of success.	In Q4 2019, ESB Networks updated the innovation section of its publicly accessible website to increase transparency of its innovation activities. A new section was added on ESB Networks innovation projects, and 21 close-out and progress reports were published for industrywide consumption. Project reports will now be published on an ongoing basis under the relevant roadmaps as they become available. In the Innovation Project Portfolio section, project timelines have been added. Project benefits and learnings are also detailed in the latter part of this document. The purpose of sharing this information is to continually disseminate the learnings and benefits from our completed and ongoing innovation projects to industry and stakeholders. The development of another new website section on electrification also started during the year. This will inform the public on how ESB Networks is facilitating the electrification of heat and transport.

Feedback Received	ESB Networks Response
Suggestions relating to external membership of the Innovation Governance Board included appointing a member of the academic community to the Board.	ESB Networks developed a new Innovation Governance Framework in 2019 as illustrated in sections 3.1 and 3.2. Under this new framework, the members of the Connecting Futures Board and Innovation Steering Group provide governance to the Innovation Strategy in ESB Networks. The Connecting Futures Board is made up of a group of cross-functional ESB Networks senior managers. A plan is in place for an external advisory group to feed into the innovation governance structure and is expected to be implemented in Q2 2020. Following feedback from stakeholders, the Innovation Steering Group now has external members who bring industrywide expertise to the group. In appointing external advisors on to the Innovation Steering Group, ESB Networks did not consider members who were part of organisations that were receiving funding/co-funding/sponsorship from ESB Networks.
Respondents indicated their openness to engage in further collaborative projects and highlighted a desire for more active engagement by ESB Networks with external stakeholders during the initial stages of project development.	Following feedback from stakeholders, ESB Networks launched the bi-annual Innovation Forums and stakeholder group sessions (See Dissemination Case Study) to enhance engagement, encourage collaboration and to keep industry up to date on ESB Networks' Innovation Activities. The workshop sessions reflected the areas of interest highlighted in the feedback from stakeholders on ESB Networks' consultation in August/September. Topics covered were: • Opportunities for Flexibility in HV Network Development • Optimising the Network for the Electrification of Heat and Transport • Active Energy Citizens and Peer-to-Peer Services
The opportunity to consider innovation from an All-Island perspective was proposed, given the current existence of an All-Island Electricity market with requests to work more collaboratively with NIE Networks.	In 2019, ESB Networks signed a Memorandum of Understanding on Innovation with NIE Networks. This reflects our commitment to working more collaboratively with the DSO in Northern Ireland. We have carried out two collaborative projects during 2019: • DSO Investigation for Service Capability and Operation (DISCO) • Fault Location Isolation Sectionalisation and Restoration Another set of projects are being planned for this year.

7.2 Enhance innovation projects which are currently being conducted by ESB Networks

Most of the respondents provided detailed analysis of specific innovation projects which are currently in progress. Suggested enhancements included:

Feedback Received	ESB Networks Response
Interest expressed in the SERVO project and a desire to collaborate in its development.	ESB Networks is evaluating a number of options including SERVO to facilitate the provision of flexibility. As these innovation projects progress, we will look for external stakeholders to collaborate on trials of these concepts. We are committed to having more public calls and expressions of interest once the scope of the projects are more fully defined. To date, we have held a number of stakeholder engagements to inform the development of the projects e.g. Innovation Forum, electricity supplier session and DRAI session.
Increased emphasis to be placed on non-wires distribution reinforcement solutions.	ESB Networks has recently published a public industry consultation paper, as part of the Smarter HV and MV Customer Connections project, where our proposed approach to non-wires connections and criteria for assessing their application on the distribution system is presented. A dedicated workshop on the proposed approaches outlined in the public consultation was held during the November 2019 Innovation Forum to discuss the proposed approach with stakeholders. A final recommended approach, taking consultation stakeholder feedback into account, will be submitted to the CRU at the end of Q1, 2020 for approval. We also have the following projects where we are evaluating different aspects of non-wires solutions: • RESERVE – Customer Flexibility • StoreNet – Customer Energy Storage • Smarter HV and MV Customer Connections • Network Flexibility – Non-wires solution to replace conventional network reinforcement
Increased focus on the facilitation of microgeneration.	Domestic customers generating their own electricity for self-consumption will be an important element in the decarbonisation of the built environment. ESB Networks is looking at a number of initiatives that facilitate wide-scale adoption of microgeneration. Furthermore, ESB Networks is delivering on its commitments of the Climate Action Plan. As per Action 30: Develop an enabling framework for microgeneration which tackles existing barriers and establishes suitable supports within relevant market segments, ESB Networks delivered a report assessing the 'potential implications for distribution network of defined higher penetrations of distributed generators' in Q4 2019.
Enhanced TSO/DSO collaboration.	The TSO is a key partner for ESB Networks as the DSO/TSO interface evolves in response to distributed energy resources (DER) become more prevalent. We are currently developing a joint project proposal with the TSO to explore how both organisations can optimally operate the transmission and distribution systems from a whole system point of view, including the use and procurement of flexibility services. In addition, ESB Networks is a key partner in the TSO's Flextech programme.

Feedback Received	ESB Networks Response
Expedited transitioning of projects to Business as Usual (BAU).	As part of the recent reorganisation, the innovation units in the business have been realigned to expedite transitioning of projects to BAU (*see section 6.2*). This included the establishment of a dedicated team within innovation for transition to BAU. We are also looking to use learnings from other jurisdictions in this field to expedite transition to BAU. This will be part of the Fast Follower approach.
Request to broaden the definition of the term prosumer to include services and the facilitation of same.	This was discussed at the Innovation Forum and it was agreed that this broader definition is more appropriate. This is reflected in the projects that are now included in the Future Customer roadmap, which includes projects that consider customer flexibility.
Support expressed for hybrid RES distribution network connection trials.	ESB Networks, in conjunction with the TSO, has been actively considering the restrictions that have been previously identified and that currently prevent the deployment of more hybrid connections on the system. A consultation process has been completed as part of the FlexTech programme which has included a specific workstream dedicated to Hybrid connections, and which identified and clarified the main issues that will need to be resolved. ESB Networks and the TSO submitted a joint paper to the CRU to assist in the completion of the initial action under the Climate Action Plan action 18. In 2020, ESB Networks and the TSO will seek to provide solutions to the key hybrid issues.
Numerous offers for enhanced engagement, suggestions for collaborative projects and opportunities for information sharing with ESB Networks.	ESB Networks see's that collaboration on projects and information sharing is key to it delivering relevant innovation projects that enable the transition to a low-carbon economy. In 2019, there was a step change in the level of innovation-related engagement that ESB Networks did and this is discussed in more detail in Sections 3 and 5. Indeed, on the back of specific feedback from stakeholders we held dedicated workshops at the innovation forum on electrification and flexibility to provide an opportunity for more in-depth discussion with stakeholders on the topics, sharing learnings and perspectives with each other. ESB Networks will continue to collaborate and in 2020, is moving to open calls for expressions of interest from potential partners on specific projects, e.g. peer-to-peer on the Dingle Project and flexibility solutions as an alternative to conventional distribution reinforcement. We have decided to pause involvement in further partnerships in EU H2020-type projects at present and focus our resources on the more immediate and higher priorities. To deliver best value for our customers given the resources a utility of our size has at its disposal, we decided to prioritise projects that are TRL7 and above. EU H2020 projects tend to consider and evaluate concepts at a lower TRL. We will focus on completing our existing H2020 projects, e.g. REACT, +CityXChange and reassess at that point. Nevertheless, we have provided Letters of Support to a number of Irish-led consortia bidding for such EU projects (e.g. in areas of smart local community energy and the integration of renewable energy in island communities) where we have expressed a willingness to participate in the Advisory Board should the projects be successful in winning funding. We recognise that there is value to both ourselves and the potential project partners in sharing our distribution utility perspectives with the project and learning about the projects' recommendations and outcomes.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7.3 New ideas and proposals for innovation projects which are not in ESB Networks' innovation portfolio

In addition to feedback on ESB Networks' portfolio of existing innovation projects, respondents put forward ideas for new innovation projects which ESB Networks might pursue.

Proposals Received from Stakeholders	ESB Networks Response
ESB Networks to adopt a Fast Follower approach, expediting specific solutions and trials which have been successfully implemented by other utilities in similar jurisdictions.	In late 2019, ESB Networks completed a review of UK DNO innovation projects from **www.smarternetworks.org** to assess whether they are likely to be applicable on ESB Networks infrastructure and to assess them against results from the Dingle Project where applicable. Recommendations for particular Fast Follower projects will be agreed by the ISG by the end of Q1 2020.
Investigation of Dynamic Line Rating and associated data analytics for overhead lines.	We are not aware of any jurisdiction where DLR has transitioned successfully to BAU on a distribution network. The Dynamic Line Rating project is listed under ESB Networks' pipeline project list (Section 4.1); however, we are also looking to the Fast Follower approach (outlined in section 4.3) if applicable to leverage innovation completed elsewhere instead of trialling a bespoke solution. There are different forms of DLR approaches. In general, DLR is more applicable on HV lines at higher heights which are less affected by local terrain ground effects. Also, whenever the line changes direction, there is a significant impact on wind cooling, so extra sensors are needed on each such segment. As the system is designed as a whole, it may be that increasing the rating of one component means that other components are now the limitation. Once DLR increases rating, it is also likely that voltage rise from increased loading will then become the issue, so DLR is not necessarily a 'silver bullet'. As the thermal time constant of the line is about 5-10 minutes at most, there would also be a need to reduce generation if limits were being approached – this also requires another set of control technology.
Smarter outage management and the co-ordination of same between both DSO and TSO.	We have shared this feedback with the relevant teams who are working with the TSO on ensuring better coordination on such issues.
Private wires.	Private wires is the subject of Climate Action Plan action 22 and ESB Networks will work with DCCAE and other stakeholders to develop policy options as required under this action.
Line losses reduction proposals including associated alterations to the method for calculating DLAFs.	In collaboration with UCD, we have completed the project titled Wind Farm Reactive Power Optimisation Trial. The project demonstrated that optimising reactive power export from a wind farm can reduce system losses. In order to realise the possible benefits from this technology, it is critical to understand how the operation of these systems would increase value to society from actions which decrease losses by using simple adjustments to existing DLAF methodology. Furthermore, the assessment would also need to consider that there are no unexpected impacts on existing/ future customers from the operation of such systems.
Reformed end-to-end process for new generator connections incorporating both the offer process and the delivery of infrastructure	The Lean Connections project is an ESB Networks process improvement initiative. This has developed in response to stakeholder feedback and renewable industry engagement in recognition that a more innovative approach is required to connect the increasing volumes of generation connections forecast for Enduring connection Policy (ECP) and Renewable Electricity Support Scheme (RESS) auctions out to 2030 and for targets set in the NCAP. Lean Connections will examine the entire end-to-end process to reduce overall connection times for new generation, adopting relevant best practice methodologies and increasing standardisation across the administrative and design processes, as well as for the physical connection technologies used. The project commenced in Q4 2019 and continues throughout 2020 and beyond to deliver process improvements and introduce "Lean" as an approach for the PR5 price review.

8 WORK WITH US ON THE INNOVATION JOURNEY

8.1 Tell Us What You Think

We are very clear in ESB Networks that the challenge of enabling the transition to a low-carbon Ireland cannot be delivered without extensive and collaborative innovation. ESB Networks is committed to leading the transition and knows we must continue to innovate further and faster to increase the volume of renewable generation connected: to increase the speed with which new generation is connected; to support the timely implementation of the National Climate Action Plan and the European Clean Energy Package; to facilitate the wholesale electrification of transport and heat; to improve network resilience; to manage intermittency; to support energy communities, microgeneration and active customers; and to move the dial on the many fronts required to make an increasingly low-carbon grid a reality.

We must build on our history of innovation, maintain an agile mindset and ensure the processes we have in place and the solutions we implement are capable of responding to a rapidly changing world. This report has summarised how ESB Networks is collaboratively implementing new ideas, innovative concepts and technologies that will provide enduring benefits for our customers. We have shared our approach to innovation including our overall framework, strategy, governance, processes, dissemination, feedback and progress.

Polls taken during the Innovation Forum in November 2019 showed that 68% of respondents agreed or strongly agreed that ESB Networks is focusing on the right innovation projects to deliver on the transition to a lower-carbon society. The feedback was encouraging, showing that we are moving in the right direction, but ESB Networks understands that there is more to be done.

Join us on the journey, this transition to the network of the future, by telling us what you think and how we might improve. We want to hear your views on how ESB Networks delivers innovation and whether we are focusing on the right innovation projects.

We welcome any feedback you may have via innovationfeedback@esbnetworks.ie.