ESB NETWORKS

INNOVATION TO CONNECT A CLEAN ELECTRIC FUTURE 2022

DOC-091121-HFC

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EFQM

EFQM Excellence Model Innovation Lens

FOREWORD

ESB Networks has a pivotal role in Ireland's energy transition to a low carbon future.

The energy transition will support Ireland's commitment to the United Nations' Framework Convention on Climate Change (UNFCCC), COP26 commitments, the EU Clean Energy Package, and the Irish Government's Climate Action Plan (CAP).

It is through innovation that ESB Networks will develop a future electricity network which empowers our customers, delivers value for money, and provides a sustainable energy system for us all. Our network must accommodate higher levels of renewable generation and enable increased electrification, so that clean electricity can displace carbon from heat, transport, and the economy. This includes ensuring our network will support the adoption of at least 945,000 Electric Vehicles (EVs); 600,000 heat pumps; and enable up to 80% of renewable electricity generation.

With the support of the Commission for the Regulation of Utilities (CRU), ESB Networks has developed its Innovation Strategy to support this transition to the network of the future, strengthening our culture of innovation with 3 key pillars around which our portfolio of projects is based: Future Customer; Climate Action and Network Resilience. Our current portfolio has 29 active innovation projects with combined potential life cycle benefits of more than €60 million.

We are clear that the challenge of enabling a low carbon Ireland requires extensive and collaborative innovation and throughout 2021 were active with over 80 organisations on a range of innovation initiatives. We are proud to collaborate with local communities on innovation projects in the Dingle Peninsula and on the Aran Islands, as we explore the impact and capabilities of new low carbon and supporting technologies to continue to develop our network to connect a clean electric future together. Our flagship innovation project in Dingle, which was launched in 2018, will be completed in 2022 and has achieved some significant milestones, learnings and outputs with our community partners and ambassadors which we have begun to share.

ESB Networks continued to leverage a variety of channels to engage with stakeholders including public consultations, our spring and autumn innovation webinar series, our Innovation Stakeholder Panel and dissemination/showcase demonstration events. A stakeholder survey carried out in October 2021 showed that 94% of respondents believed their understanding of ESB Networks innovation projects and activities had increased over the previous 12 months.

Our annual innovation consultation is an important opportunity for us to ask our stakeholders what they think of our approach to innovation. This report describes how ESB Networks, working together with customers, communities, industry, the Transmission System Operator, technology providers, academics, and research institutions, is implementing new ideas, innovative concepts, and technologies as we innovate to connect a clean electric future together and deliver enduring benefits for customers.

This consultation is an opportunity for you to tell us where we are getting things right and where we need to improve.

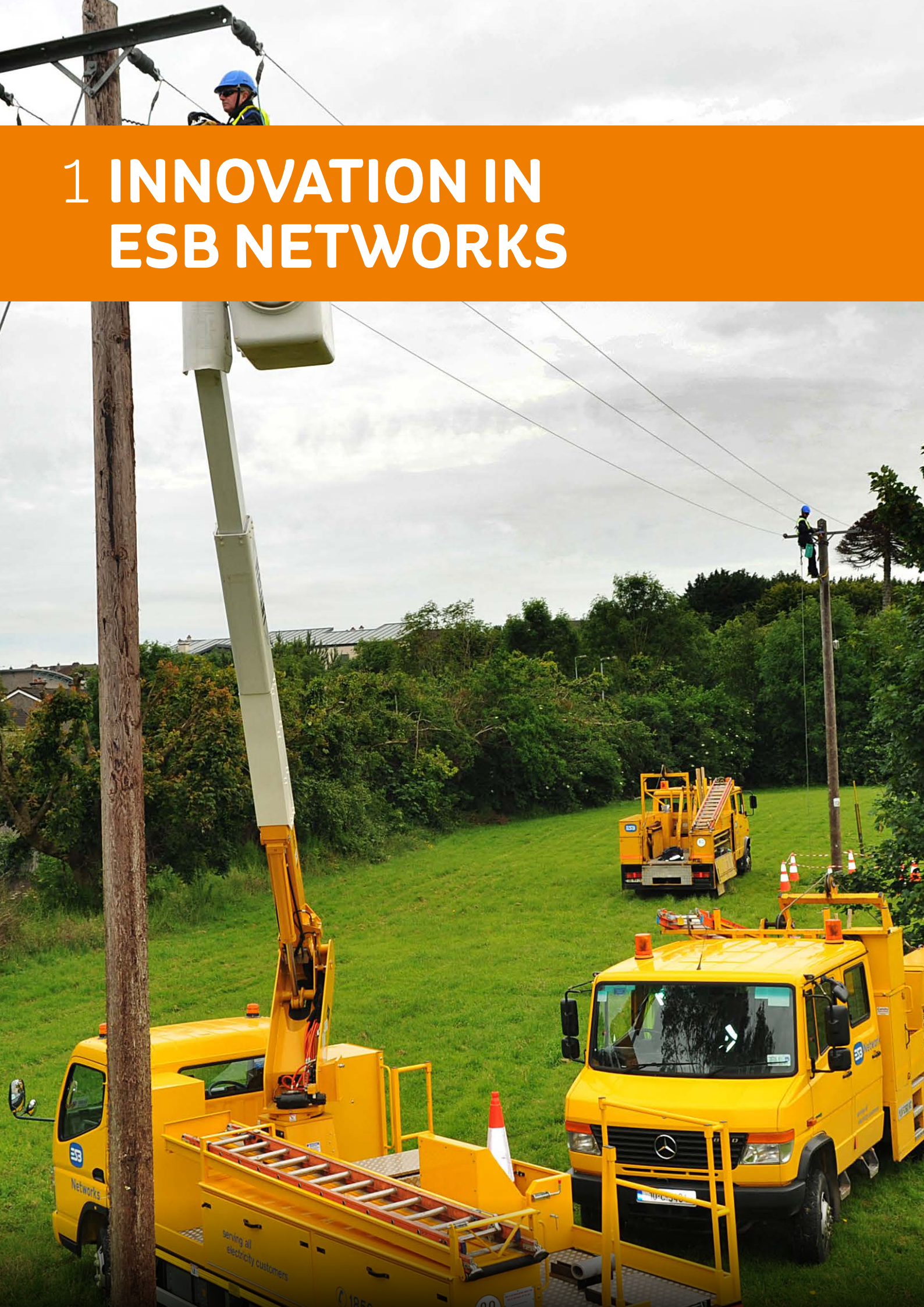
We welcome your comments and feedback to help shape how ESB Networks innovates to support our customers connect to a clean electric future.

Nicholas Tarrant

Nicholas Tarrant

Managing Director
ESB Networks *Jan 2022*

1 INNOVATION IN ESB NETWORKS



1.1 INTRODUCTION

ESB Networks ensures electricity gets to the homes and businesses of our 2.4 million electricity customers in a safe and efficient manner. As the Distribution System Operator (DSO) ESB Networks is responsible for the operation, maintenance, and development of a safe, secure, reliable, economical, and efficient electricity distribution network and the Transmission Asset Owner (TAO). We recognise that the environment in which we operate is changing rapidly driven by new policy and regulation, the advancement of technology and the changing needs and expectations of our customers and stakeholders. This means the role of electricity is also changing, creating new challenges and opportunities.

Innovation in ESB Networks is a key enabler to our 2030 business strategy and Price Review 5 (PR5) objectives as we continuously innovate to connect a clean electric future together. This report describes how ESB Networks, working together with customers, communities, industry, the Transmission System Operator (TSO), 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.

Throughout this document, as part of our annual consultation, we will share our approach to innovation including our overall innovation framework, strategy, governance, processes, dissemination, feedback and progress. We will give you an insight into our innovation project portfolio that spans across our three innovation pillars and report on actions undertaken by ESB Networks over the last 12 months in response to stakeholder feedback.

ESB Networks published our last annual consultation, 'Innovating to Transform the Electricity Network' in February 2021 and invited feedback from interested parties. We welcomed our stakeholder feedback from the 15 respondents across 8 sectors. We received positive feedback and support from the respondents in relation to many of our ideas, pipeline projects and active projects. We also received support for new or enhanced initiatives we implemented in 2020 and proposed plans for 2021 such as the establishment of our Innovation Stakeholder Panel, support for our well-structured innovation process and strategy framework, recognition of increased stakeholder engagement with positive feedback on our innovation webinar series. Many respondents acknowledged the efforts by ESB Networks to externally assess/audit its innovation functions and activities and our transparency in dissemination with increased visibility of dashboards and metrics/Key Performance Indicators (KPIs).

ESB Networks published a response paper to the feedback on our consultation Innovating to Transform the Electricity Network. The response to stakeholder feedback covered four broad categories across our innovation strategy framework, approach to dissemination and engagement, suggestions to enhance innovation projects and new ideas/proposals for innovation projects. Many of the actions committed in this response paper have been covered in the content of this report. In 2021 as part of PR5, the National Network, Local Connections (NNLC) Programme was launched as a standalone programme to innovatively transform how we manage and operate the electricity system. As a separate programme within ESB Networks with extensive collaboration and engagement, including separate reporting to the Commission for Regulation of Utilities (CRU), areas covered by NNLC Programme will not be detailed in this report.

Throughout 2021 ESB Networks has extensively collaborated, engaged and disseminated the learnings and benefits of our innovation projects and activities with our stakeholders (see Section 2). The purpose of this consultation is to continue to encourage our stakeholders to share your ideas with us, to challenge our approach and in turn to continue to hold us to account. We want to hear your views on how ESB Networks delivers innovation and whether we are focusing on the right innovation projects.

Please send your comments and feedback to **innovationfeedback@esbnetworks.ie**

Innovation KPIs Dashboard

ESB Networks' innovation efforts are broad-ranging and involve collaboration with several organisations. In order to provide our internal strategic board and stakeholders with information about the extent of our innovation efforts a set of KPIs has been developed. Our KPIs are updated quarterly and in response to stakeholder feedback are regularly published on our website.

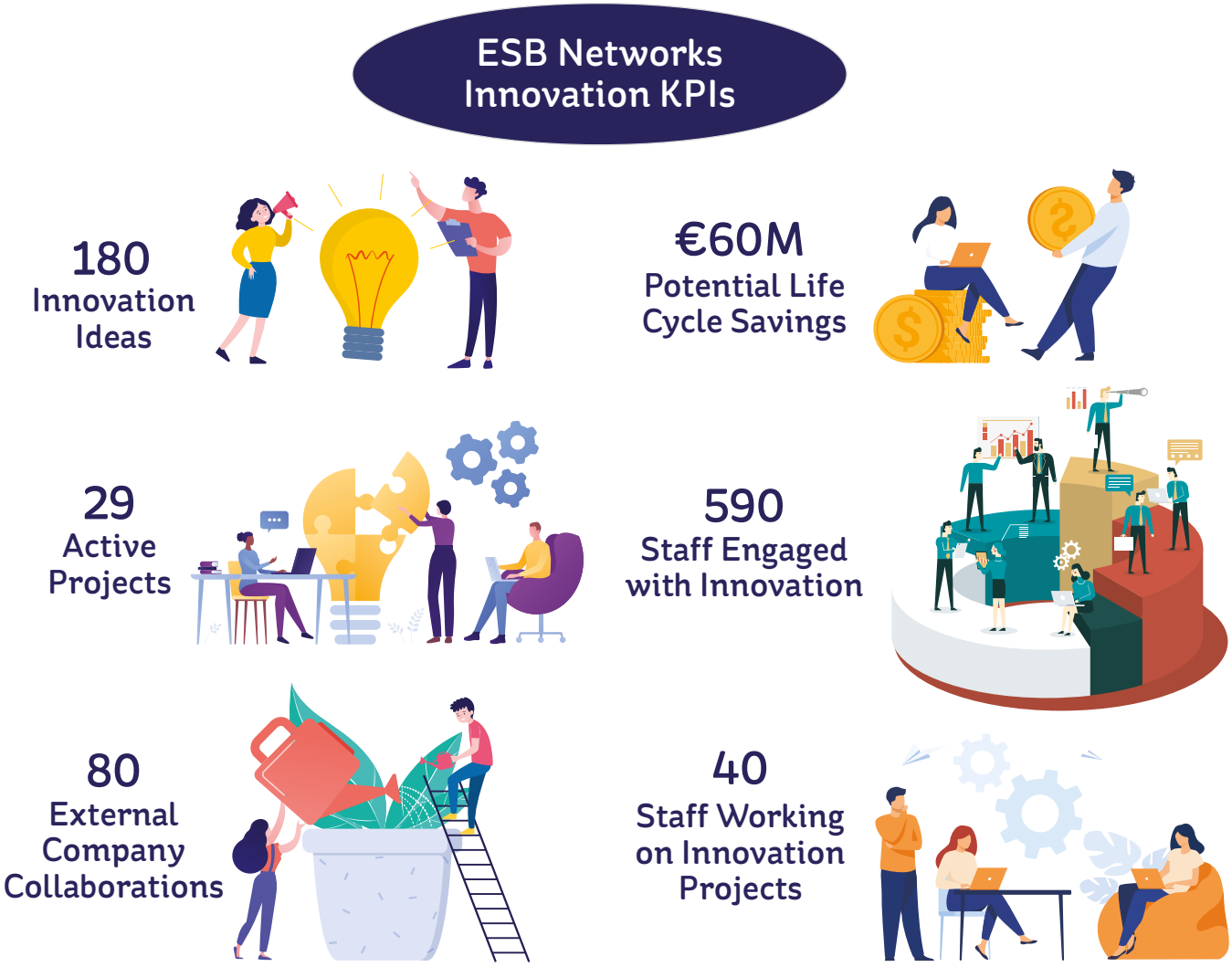


Figure 1.1: Innovation KPIs Dashboard

- Of the **180** innovation ideas examined in 2021, 29 projects are in active delivery, see Section 4 for further details.
- **80** external collaborations – a review of project and engagement records show that ESB Networks is actively collaborating or partnering with 80 organisations across a wide range of industry sectors and research organisations.
- **40+** Staff are working directly on Innovation projects across ESB Networks with over 590 engaged across our broader internal innovation community.
- **€60m** – this figure is compiled from the potential life cycle savings calculated by each project.

1.2 OUR INNOVATION VISION, VALUES AND MISSION

At ESB Networks, our vision is to continuously innovate towards a clean electric future together with our customers who will be at the heart of the transformation towards a low carbon energy future. Our ambition is to build, maintain, operate, and develop the electricity distribution network to meet the needs of our customers, today and tomorrow. Our vision and values serve as the foundation of our innovation strategy, informing every new idea and the development of every project.

Figure 1.2: ESB Networks' Values

Our mission is to play a central 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 Climate Action Plan (CAP), the Programme for Government and the CRU's PR5 objectives, our Innovation Strategy has been developed to facilitate Ireland achieving its climate change targets for 2030 and beyond to net zero by 2050. This means that low carbon electricity will provide Ireland with an opportunity to decarbonise other sectors of our economy such as transport and heat through the adoption of electric vehicles (EVs) and heat pumps.

ESB Networks looks to embed innovation across the business and is not confining innovation to our "dedicated innovation teams". We're driven to continue to develop a culture of innovation which is encouraged across the organisation as we seek to challenge the status quo to find new and innovative approaches to how we carry out our business and operate our systems. This will ultimately benefit all our customers, irrespective of how or where they interact with the energy system.

Our definition of innovation is to implement new ideas for the enduring benefit of our customers and business. Our innovation activities operate across three broad horizons of innovation:

- Incremental – the innovation builds on existing systems, equipment or processes.
- Breakthrough – the innovation potentially provides new systems, equipment or processes.
- Radical – business-altering innovation.

We prioritise Technology Readiness Level (TRL) 7 or higher in our innovation projects. We have received feedback particularly from the research stakeholder sector challenging the preference for TRL7 and above however on balance and based on overall feedback we continue to 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 is able to leverage research carried out in academic/research institutions, which includes research at lower TRL levels, and we will continue to support academic research in Ireland through funding and sponsorship such as our support of Marine and Renewable Energy Ireland (MaREI) and University College Dublin's (UCD's) Energy Systems Integration Partnership Programme (ESIPP). This research has a role in Ireland's transition to a low-carbon economy and is key to building the necessary skills in Ireland. While we prioritise innovation projects with a TRL7 or higher, this does not preclude lower TRL levels should a relevant project be proposed. In response to feedback from stakeholders we have introduced a new assessment criterion for breakthrough and radical projects. In Q2-Q3 of 2022 we aim to have a public call/Expression of Interest (EOI) on proposals for more radical projects, as detailed in Section 3. We have sought to provide advance notice to stakeholders as published in 2021 in our 18-month programme plan and presented in our Autumn innovation webinar series.

1.3 OUR INNOVATION STRATEGY AND SCOPE

1.3.1 Innovation Strategy Framework

Our Innovation strategy is aligned to and supports ESB Networks 2030 strategy and delivery of our PR5 objectives by employing innovation and innovative means to lead the transition to a low carbon economy in which the electricity network enables and facilitates that transition. The fundamental challenges posed by climate change to our society pose significant challenges for the operation of the distribution system but also present new opportunities to innovate and continually review how we plan, develop and operate the distribution system to deliver the network for a clean electric future. By 2030, the network will support the adoption of 950,000 EVs, and 600,000 heat pumps as well as the integration of up to 80% renewable electricity generation.

The adoption of new materials, technologies and concepts, digitalisation and big data analytics have the potential to create greater efficiencies, while electrifying the heat and transport sectors will offer a range of new opportunities for our customers to engage with the energy system. Comprehensively understanding the capabilities and limitations of these new technologies and concepts through a combination of trials and analysis will ensure that ESB Networks will be able to deliver the electricity distribution network of the future.

Robust processes associated with the identification of innovative opportunities are a key part of ESB Networks' Innovation Strategy[1]. This requires us to consider the disruptive trends and identify how we see the energy landscape developing in the next decade and beyond. We have developed an Innovation Strategy Framework (see Figure 1.4) to manage every stage of the development and implementation of our strategic initiatives, from setting the vision to establishing Business-As-Usual (BAU) . In developing this Framework and our Innovation Strategy Cycle (See Figure 1.5), we reviewed best practice from other jurisdictions, worked with external consultants, 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 trialling untested innovation ideas and ensures an appropriate level of oversight.

[1]ESB Networks, Innovating for a Brighter Future - ESB Networks' Innovation Strategy 2017

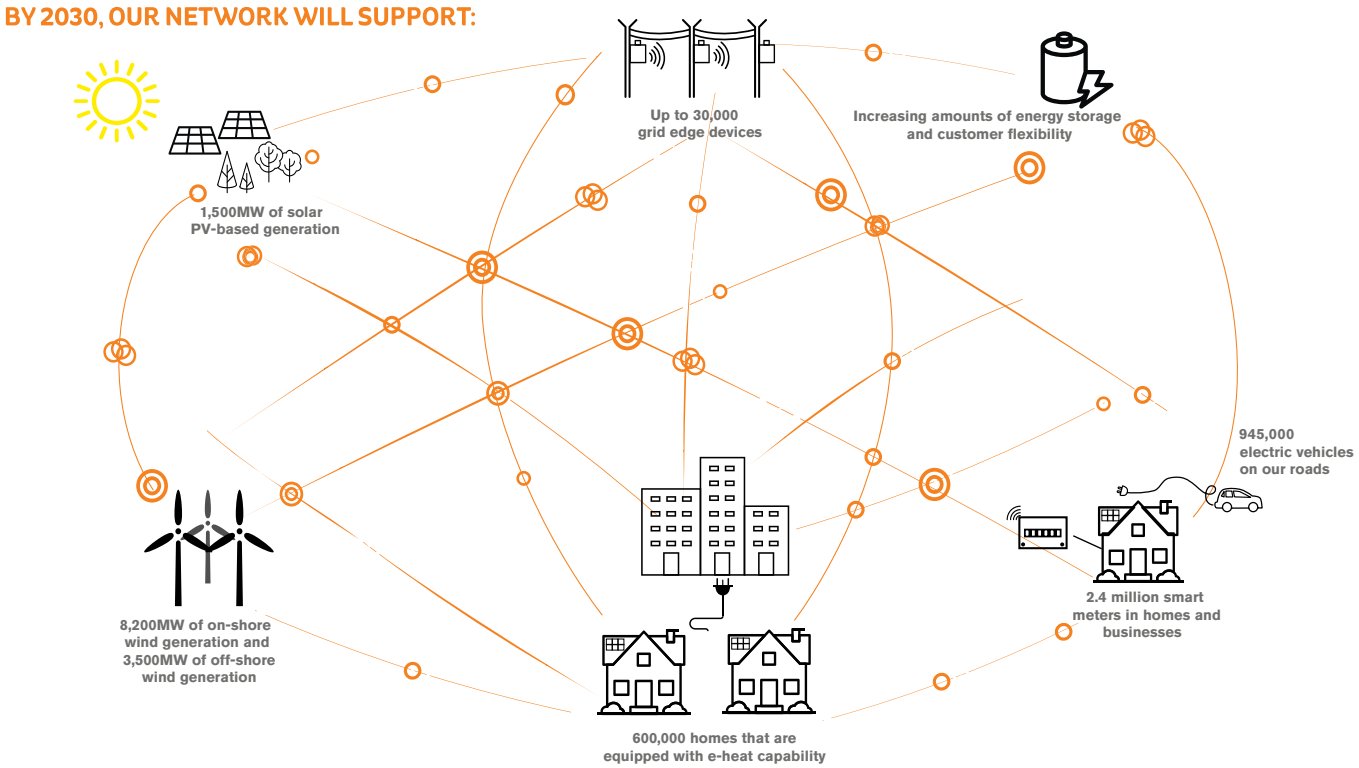


Figure 1.3: Network of the Future 2030

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		
Project Identification and Evaluation →	**Delivery of Innovation Projects** →	**Transition to BAU and Dissemination of Learnings**
Process		
• Identifying project ideas beyond Business-As-Usual • Project prioritisation and initial assessment • Impact assessment framework • Detailed project evaluation, benefit assessment, scoping and objective setting • Strategic validation through collaboration with stakeholders and third parties	• Ongoing project 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	• Develop and monitor transition plans to completion • Identify opportunities to extend an innovation project to achieve additional benefits • Disseminate learnings into BAU operations and/or decision-making • Disseminate learnings to industry and stakeholders
Reporting		
• Ranking of Ideas Generated • Project Proposal • Investment Appraisal • Webinars/Public Consultations	• Progress and Close-Out Reports • Hand-Over Pack • Webinars/Public Consultations	• Transition Plans • Industry Papers and Conferences • Webinars/Public Consultations
Assessment and Tracking of Benefits		
Creation	**Delivery**	**Transition to BAU**
• Qualitative and Quantitative Benefit Assessment • Cost Benefit Analysis • Measures of Success	• Qualitative and Quantitative Benefit Assessment • Cost Benefit Analysis • Measured Data from Pilots • Trial of Methods/Technologies	• Transition of Qualitative and Quantitative Benefits to BAU • Ongoing Tracking and Assessment of Benefits

Figure 1.4: Innovation Strategy Framework

1.3.2 Our Innovation Process

To effectively implement our Innovation Strategy, we have developed an end-to-end process for the management of innovation initiatives across our business areas. This process is part of our Innovation Strategy Cycle (See Figure 1.5) and has three main stages:

1. Project identification and evaluation;
2. Delivery of innovation projects; and
3. Transition to BAU and dissemination of learnings.

The structure of our innovation framework and ongoing efforts in collaboration and planning allow us to identify a comprehensive number of potential projects. Proactive 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.

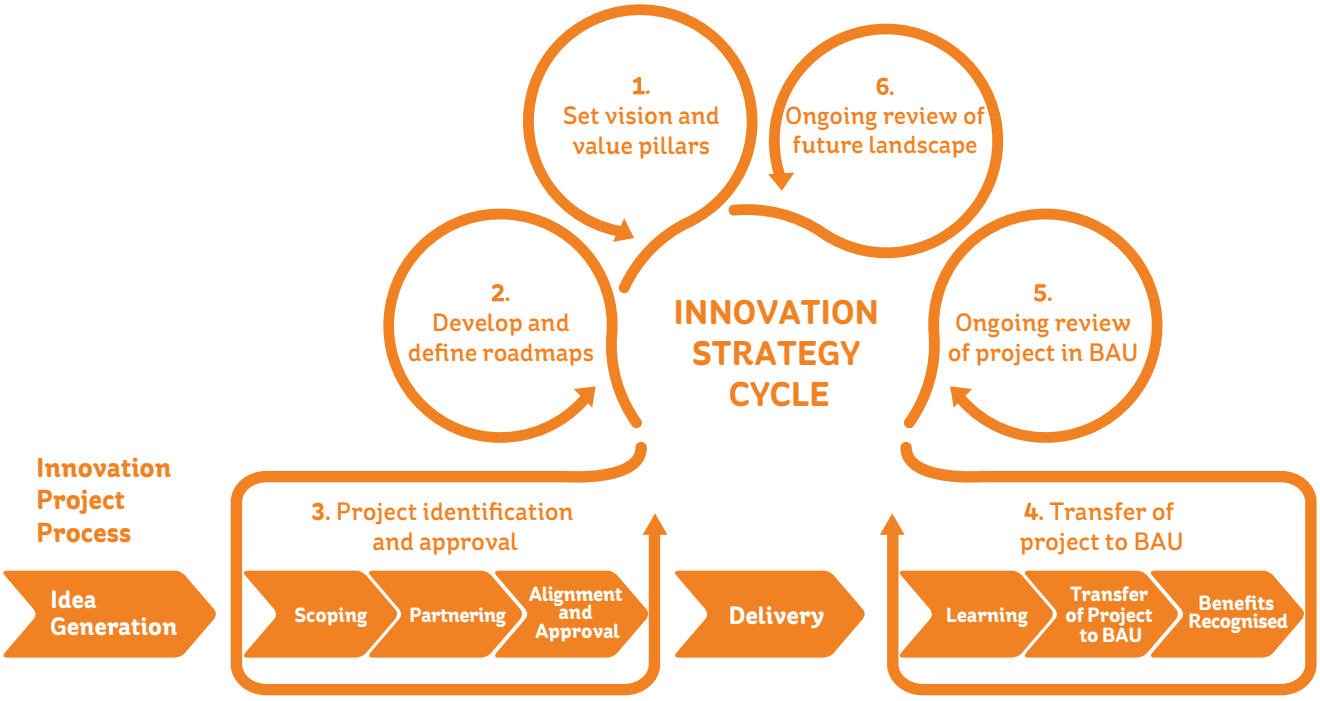
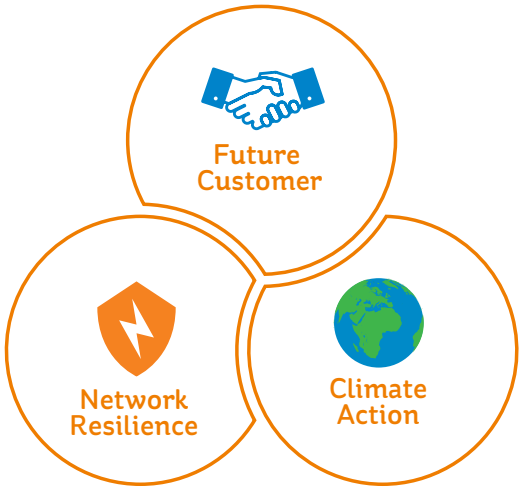


Figure 1.5: Innovation Strategy Cycle

1.3.3 Three Innovation Pillars: A Progression Plan to 2030 and Beyond

Our innovation strategy framework has been designed to be flexible enough to cater for the changing requirements of our business and society. Our people and values are at the heart of delivering on our innovation strategy which is reflected in how we implement our innovation framework. The innovation framework has been applied to a balanced portfolio of projects covering three Innovation Pillars:



Future Customer: Empowering and Supporting Customers and the Economy

Climate Action: Decarbonising Electricity, Heat and Transport

Network Resilience: Efficient, Secure, Reliable Electricity

Figure 1.6: Innovation Pillars

The Innovation Pillars align with our new 2030 business strategy, and our PR5 objectives as agreed with the CRU. ESB Networks acknowledges the need to be flexible to address future challenges which may emerge. We expect to see refinements to the projects included in each Innovation Pillar as policy priorities emerge, changes in customer behaviour manifest themselves and as forecasts for generation, flexibility and low-carbon load become more certain.

1.4 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 CFB and the ISG (see Figure 1.4). 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. Our Innovation Governance Framework document sets out the roles and responsibilities of individuals that are part of the innovation governance structure as illustrated in Figure 1.7 below. It also defines the communication channels that are expected, so that the members and Chairs of the CFB and the ISG are provided with comprehensive documentation that details project status and information.

The Sponsor of our Innovation Strategy is the Managing Director of ESB Networks, who is a member of the Senior Leadership Team. The Sponsor has ultimate accountability to ESB Networks' organisation for the successful delivery of the innovation project portfolio.

The CFB is a cross-functional group of ESB Networks senior managers that provides a common governance structure for the Business, Innovation, Customer, Electrification and Digital Strategies on behalf of the Senior Leadership Team. The CFB is accountable for the overall success and governance of the innovation project portfolio. The CFB owns the Innovation Strategy and operates to the terms of reference approved by the Managing Director of ESB Networks. The CFB is responsible for providing strategic guidance, coordination and decision-making regarding innovation pillar and project direction, issues affecting delivery and changes affecting key project or innovation pillar outcomes.

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 an operational level. Throughout 2021, the ISG drew upon the advice and views of two external advisors - Lisa Vaughan, Business Development Director at Engineers Ireland and Jonathon Pollock, Network Development Manager at NIE Networks - in relation to projects or issues that arise. 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.

The common aim of the CFB and ISG is to ensure the collaborative implementation of new ideas that will provide enduring benefits for our customers and our business.

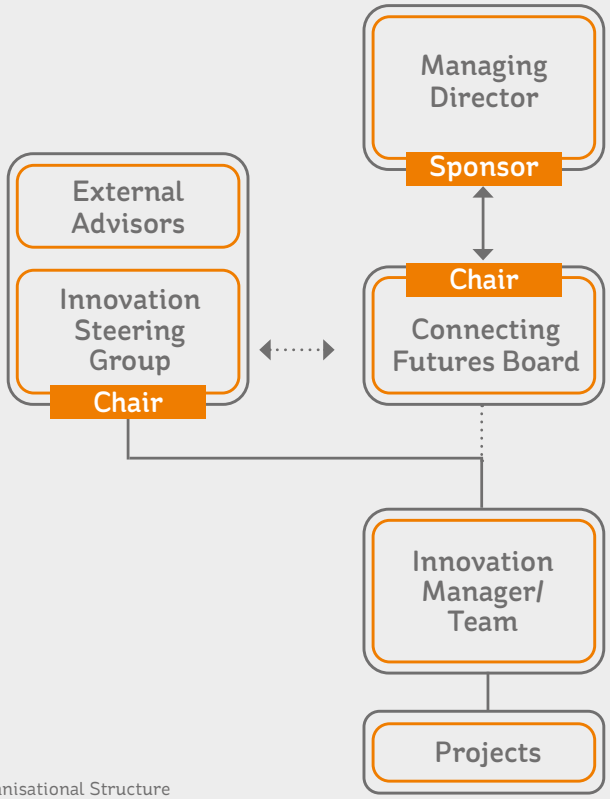


Figure 1.7: Innovation Governance Organisational Structure

1.5 STRENGTHENING INNOVATION CULTURE, EXPERTISE AND CAPACITY BUILDING

ESB Networks has 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. Innovation is not just about the big innovation ideas, it's across a spectrum that also considers the everyday improvements that we can make to challenge the way we do things and deliver everyday innovation together.

ESB Networks Internal Innovation Community

ESB Networks internal innovation community is made up of ESB Networks staff members involved in innovation across the business and encourages all staff members to engage and learn about the innovation initiatives in ESB Networks and across industry and academia. Throughout 2021 in addition to our stakeholder spring and autumn innovation webinars we continued our internal innovation community webinar series. These webinars are used to keep staff informed of ongoing innovation activities and to encourage open discussion and feedback on our current innovation projects and potential innovation opportunities arising in different areas in ESB Networks. In 2021, we held 10 internal webinars; examples of some of the topics hosted were the Lean Connections programme, CIGRE Ireland - Active Distribution System and Distribution Energy Resources, EU Horizon Programme and Emerging Technologies to Address Climate Change. Research institutes and industry such as MaREI and IBM also delivered webinars to our staff on topics such as technology adoption to diffusion of sustainability and creating new flexibility markets and systems.

ESB Networks Innovation Ideas Hub and Yammer

In 2021 we developed a new internal Innovation Ideas Hub through the Wazoku platform to share, inform and update ESB Networks staff on our Innovation Project Portfolio and activities. The interactive platform and hub enabled our innovation community to grow, engage and to provide feedback across our innovation portfolio of projects and pipeline.

The Innovation Ideas Hub is updated regularly as projects progress from pipeline, through delivery and transition into the business.

Through our "Innovation in ESB Networks" Office 365 SharePoint hub site and Yammer channel we connect and engage with colleagues across a range of social and professional groups. We post the latest updates on our Innovation projects and activities and share project reports, recordings of our internal and external webinars as well as wider industry events.

Training and Development Programmes

ESB Networks has 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 titled Innovation, Design Thinking, The Smart Grid, Renewable Technologies and Emerging Technologies. Dogpatch Labs is a start-up hub, located in Dublin's Digital Docklands, which in 2021 was chosen by the Government to run the national accelerator programme, and which offers platforms for entrepreneurs to solve problems and mentors for early-stage businesses. Graduates take part in design thinking modules in Dogpatch Labs as part of the programme to develop an innovative mindset. A large portfolio of technical courses is available online and at our Networks Training Centre (NTC) 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 working with the NTC in developing proposals where ESB Networks can leverage existing partnerships to provide relevant training. ESB Networks also promotes ongoing professional development through membership and support of professional institutions such as Engineers Ireland, the Irish Management Institute and CIGRE. An online portal has been developed to support staff to plan and gain their chartership through Engineers Ireland. 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.

The Innovation Academy

In 2021, ESB Networks sponsored and mentored one of the 5 project teams and encouraged applications from staff to participate in the UCD-led Innovation Academy training programme, with this collaboration continuing in 2022. It is delivered via a highly experiential and practical, action-based learning process built around the four pillars of creativity, collaboration, curiosity and communication. The programme is designed to build competency in customer centric innovation. It 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, following the 2020 innovation academy project on "SigFox Internet of Things (IoT) monitoring devices", ESB Networks initiated the project "Using Sigfox Current & Temperature Sensors to Assess Substation Loading". This project was completed and transitioned into BAU in 2021, see Section 4.4.12 and 5.2 for details.

X_Potential - Promoting Innovation from Within

X_Potential is a structured innovation programme, run over a thirteen-week period, supported by the innovation start-up hub, Dogpatch Labs and external innovation mentors, with visible senior management sponsorship. The training programme is designed to enable the X_Potential teams to explore innovative ideas, with the support and assistance of external mentors assigned by Dogpatch Labs, to help create new potential business solutions. Some of the projects are progressed into further development through similar programmes such as the 2020 project looking at using deep learning technologies to automate the review and assessment of vast volumes of data, triggering information-base action. A key benefit of the programme is embedding an innovation culture in ESB Networks with staff supported and encouraged to challenge the way we've done things and approach problems with an innovative mindset to deliver business solutions.

Figure 1.8: X_Potential Incubator Programme

Free Electrons Programme furthers our Innovation Strategy

Free Electrons is the global energy start-up accelerator programme that connects the world's most innovative start-ups with leading global utility companies to co-create the future of energy. Through the Free Electrons Programme, ESB Networks continues to investigate new technologies and conduct pilot projects to build strong relationships with start-ups and other utilities, which will allow us to identify new opportunities to improve performance and reduce costs. The utility partners in Free Electrons are leaders in the clean energy transition, covering more than 40 countries and with access to over 80 million end customers worldwide.

Now in its sixth year, Free Electrons is known as the world's most innovative programme for promising energy start-ups. The other Free Electrons partner members are American Electric Power (USA), AusNet Services (Australia), CLP (Hong Kong), DEWA (Dubai), EDP (Portugal), Eon (Germany), Origin Energy (Australia) and SP Group (Singapore). Further initiatives that are in place in ESB Networks to strengthen innovation expertise and capacity building are detailed under Collaboration, Engagement and Dissemination in Section 2 of this report.

1.6 PERFORMANCE IMPROVEMENT

ESB Networks is committed to assessing and implementing performance improvement programmes to ensure we continue to build on best practice.

1.6.1 Innovation Audit Implementation

In 2020 ESB Networks commissioned an independent audit of our innovation framework by Dr Frank Devitt, Associate Professor of Design Innovation at Maynooth University. The audit highlighted areas of improvement and ESB Networks established four Working Groups (WG) to develop an action plan and deliver on an overall performance improvement programme which has been embedded throughout 2021. For example, in line with recommendations from the audit report we have now expanded the definition of innovation to include new ideas with significant impact to processes, systems or materials.

Improvements across our governance and 3rd party collaboration led to the establishment of the Innovation Stakeholder Panel and 2021 saw the benefits from the engagement and feedback with the panel members as outlined in Section 2.2.

1.6.2 EFQM Innovation Assessment

In 2021 ESB Networks moved from the Innovation Management Framework (IMF) Assessment model to the European Foundation for Quality Management (EFQM) as an internationally recognised and certified model of excellence. Founded in 1989, EFQM is an innovative, not-for profit, international organisation that supports leaders as they manage cultural change and transformation to deliver performance improvements and benefits for their key stakeholders. The EFQM Model is a tried and tested world class framework for helping organisations improve their performance. ESB Networks is the first Distribution System Operator (DSO) to be assessed under the new EFQM Innovation Lens.

ESB Networks was assessed under the EFQM Innovation Lens focusing on the activities, processes and culture in ESB Networks. The Innovation lens allows an organisation to assess its level of innovation maturity against a comprehensive suite of indicators and uses a weighted scoring mechanism across 7 areas under the frameworks of Direction, Execution and Results as per Figure 1.9. ESB Networks is recognised as a 5-star organisation, out of a maximum of 7 stars, under the EFQM innovation lens. This achievement from our first assessment representing "Growth in Innovation" demonstrates how we are integrating our innovation culture, processes, and procedures throughout the business. Under this internationally recognised excellence model framework, we received positive feedback across vision and leadership, strategy and innovation culture, stakeholder engagement, creating sustainable value, knowledge management, people engagement and culture, processes and resources, business, market and stakeholder impact. This was the first time ESB Networks used this model of assessment and is establishing a strong baseline which will look at trends for future assessments and improvements.

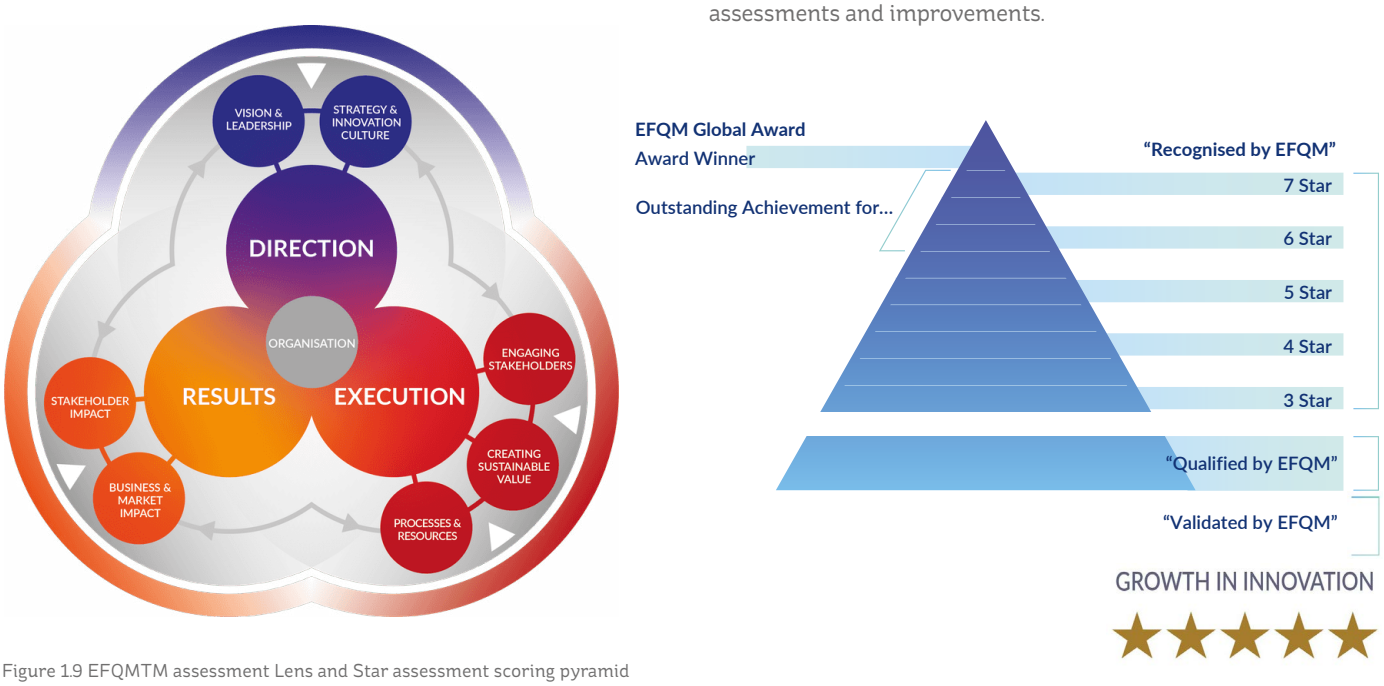


Figure 1.9 EFQMTM assessment Lens and Star assessment scoring pyramid

2 COLLABORATION, ENGAGEMENT AND DISSEMINATION

2.1 COLLABORATION AND ENGAGEMENT

Stakeholder collaboration and engagement are essential parts of our Innovation Strategy and take place at each step of our innovation process. 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 Units (DSUs) and battery storage providers. We acknowledge that the challenges posed by the transition to a low-carbon economy are substantial, and a collaborative approach to addressing these challenges is essential. We understand we have a role to work together with our external partners' research and innovation activities that are aligned with our innovation pillars and our CAP targets for the network. Furthermore, to achieve our 2030 CAP targets we acknowledge that enabling the connection of greater levels of renewables, electrification of heat and transport and active energy citizens can only be achieved by collaborating and engaging with our external partners, stakeholders and customers.

Engagement in innovation is guided by ESB Networks Strategic Stakeholder Engagement Framework, which sets out our enduring engagement strategy to enable an open and ongoing dialogue with all our stakeholders. It provides opportunities for our stakeholders to contribute to projects and programmes, have their issues heard and inform the decision-making process. It gives our stakeholders a better understanding of our priorities, increased ownership of outcomes and greater capacity to engage in how energy will be used in the future. We value the feedback we receive and this document offers examples of how we have acted on it. For example, Section 3.4.1 details the improvements we have made to our innovation assessment and approval processes through stakeholder feedback and Section 3.9 details how the feedback and engagement from our stakeholders on our Medium Voltage (MV) Standard Modular EGIP substation has supported and informed the development and final design.

2.2 INNOVATION STAKEHOLDER PANEL

In 2020 we established our Innovation Stakeholder Panel following stakeholder feedback and a call for expressions of interest. The panel provides a platform to enable open discussion and feedback with stakeholders from across industry sectors on our Innovation strategy, projects and activities. The panel is represented by 19 members across 10 stakeholder sectors. Members were selected based on a number of criteria including diversity of sector and experience. The panel convened its biannual meetings in Q1 and Q2 of 2021 in which the panel members presented and discussed areas of focus for their sector, were updated on ESB Networks Innovation projects and activities as well as the NNLC Programme and ESB Networks Electrification Strategy. ESB Networks would like to thank all the panel members for their ongoing support, feedback and input into our innovation strategy and activities. As per the Terms of Reference (TOR) the current panel members 18-month representation is coming to an end and we will be selecting the new panel in Q1 2022 through an expression of interest call. We welcome applications from new and current members who wish to re-apply.

2.3 COLLABORATION AND ENGAGEMENT WITH ACADEMIA AND RESEARCH ORGANISATIONS

ESB Networks continues to have deep engagement with academia across all areas of energy innovation that are aligned with our Innovation Pillars. In order to better understand the choices our customers are making and the choices they would like to see us make, we have been working with UCD (ESIPP) and MaREI at University College Cork (UCC) on, for example, the Dingle Project, to better understand what techniques are most effective in diffusing active energy citizen behaviours across society. ESB Networks works off the definition that an energy citizen is someone who understands their behaviour has consequences for the electricity system, whereas an active energy citizen is someone who alters their behaviour to create an impact on the electricity network. The benefits and learnings from this are already being seen through our ambassador's engagement across the Dingle community and beyond (see Section 2.4)

To understand the digital services and platforms of the future energy system and how they can support customer interaction, we have been working with Technological University (TU) Dublin, National University of Ireland Galway (NUIG) and Waterford Institute of Technology (WIT). To understand the future tools and services that we could use to enhance reliability on our networks, we are engaged with University Limerick (UL) on Autonomous Drone Technologies. To understand the capabilities, services and roles of customer-sited Distributed Energy Resources (DERs), we are working with UCD's Energy Institute in their Integrated Energy Laboratory. We also are collaborating on a number of research areas on community energy and island resilience in Limerick city and the Aran Islands through our EU Horizon 2020 partners in +CityxChange and React projects respectively. Other academic and research institutions that ESB Networks collaborates with include:

- UCD, WIT Telecommunications Software and Systems Group (TSSG), Limerick Institute of Technology (LIT), UL, UCC MaREI and National Microelectronics Applications Centre, NUIG
- International Energy Research Centre (IERC), Ireland
- EA Technology, UK
- Tipperary Energy Agency (TEA), Ireland
- Norges Teknisk-Naturvitenskapelige Universitet (NTNU), Norway

- Novogrid, Ireland
- Polito - Politecnico di Torino - Polytechnic University of Turin, Italy
- Teeside University, UK
- University of the Aegean, Greece
- Tekniker, Spain
- Fraunhofer Institute, Germany
- Uppsala University, Sweden
- Austrian Institute of Technology
- Institut Mihajlo Pupin, Serbia
- Université de la Réunion, Réunion, French Overseas Department
- Sustainable Energy Authority Ireland (SEAI)
- Lancaster University

2.4 COLLABORATION & ENGAGEMENT WITH IRISH AND INTERNATIONAL ORGANISATIONS

ESB Networks also undertakes significant collaboration with Irish electricity suppliers, generators and other international parties/companies to support their research and development.

It can be said that, as standard, the majority of our projects feature an element of industry involvement and various levels of collaboration.

2.4.1 Active Collaboration and Engagement

During 2021, we collaborated and engaged with the following international organisations:

- Utilities: UK Power Networks, Western Power Distribution, Northern Ireland Electricity, Scottish and Southern Energy Networks, Electricity Northwest, AusNet and Edison Electric.
- ENA (Energy Networks Association) – workshops and conferences across a range of working groups which ESB Networks staff are represented by.
- Eurelectric: Representing EU Distribution Network Operators (DNO's) where ESB Networks are represented on the relevant committees including Technology and Markets.
- Dedicated intra-utility Memorandum of Understanding (MoUs) on innovation with:
  - NIE Networks
  - New York Power Authority and EirGrid with EPRI acting as secretariat.

- Eurelectric: Representing EU Distribution Network Operators (DNO's) where ESB Networks are represented on the relevant committees including Technology and Markets.
- Dedicated intra-utility Memorandum of Understanding (MoUs) on innovation with:
  - NIE Networks
  - New York Power Authority and EirGrid with EPRI acting as secretariat.

ESB Networks also actively engaged and collaborated with these Irish organisations in 2021:

- Industry representative bodies – quarterly and bi-lateral meetings with Demand Response Aggregators of Ireland (DRAI) and Wind Energy Ireland, (WEI), Irish Solar Energy association (ISEA), Micro Energy Generation Association (MEGA) and Micro Renewable Energy Federation (MREF) as well as presenting and participating at industry conferences
- CRU – in relation to various innovation activities, PR5 and project-specific areas
- National Standards Authority of Ireland (NSAI) Wiring Regulations Committees on Solar PV (NSAI/TC 31/SC 07 Solar Panels) and EV Charging Points (NSAI/ETC/TC 02/WG 03 - EV Charging points)
- During 2021, we issued letters of support for research proposals, issued for various grant funding applications (the award of which is as yet unknown):
  - UL/NUIG – "Ever Green Joule Counts' Project
  - International Environmental Solutions – Dr Rebucan project
  - UCD/Community Power/Clean Renewable Energy Ltd/ Ampere for their 'Community Virtual Power Plants (VPPs)' Project
  - IERC – Investigation of Autonomous Adaptive Control for Distributed Energy Resources (InCODER)' Project.
- ESB Networks is a member of the NSAI's Technical Committee on Smart Grids, Renewables, EVs, Energy Efficiency and Energy Storage.
- ESB Networks engaged with and presented to a number of government departments, working groups, government bodies and Local Authorities on a number of topics such as the electrification of heat and transport.

Through 2021, in parallel to several other joint working groups and initiatives, ESB Networks, in our role as Transmission Asset Owner (TAO), worked collaboratively with the TSO to review new technologies for use in their Technology Toolbox for future transmission network planning and development. A programme for each asset category of Overhead Lines, Underground Cables and Stations is currently under development to outline the steps required to transition these technologies to BAU. This Technology Toolbox will facilitate the increase in renewable connections, hand in hand with the transition to a low-carbon energy system. ESB Networks will continue working with the TSO on collaborative innovative solutions to support delivery of the CAP target of up to 80% renewable energy by 2030.

2.4.2 Presentations, Conferences and Workshops

ESB Networks personnel attended and presented at meetings, conferences and workshops during the year with a view to sharing innovation project learnings and strategy:

Organisation(s)	Type	Topic
Government Departments, Industry Lobby Groups, Suppliers, Generator Owners and Academics	Webinars	Series of innovation topics & Dingle Webinars – see Section 2.4 & 2.6 below
	Meetings	Direct Bi-Lateral Meetings and presentations to working groups
	Showcase events	Dingle ambassador visits
Industry Lobby Groups, Suppliers, Generator Owners and Academics	Showcase Demonstration	Modular MV Embedded Generation Interface Protection (EGIP) Substation demonstration at ESB Networks NTC Portlaoise
World Economic Forum (WEC) – Humanising Energy Transition	Conference	Dingle Project -Discussion Panel
Safe Electric and Engineers Ireland	Briefing	Electrification of heat and transport, microgeneration, community energy & standards
Renewable Power Generation Conference	Presentation – Panel	Dingle Electrification Project
NASI	Presentation	Dingle Electrification Project update
IERC Conference	Presentation – Panel	Innovation in the Electricity Network enabling Decarbonising Heat and Transport through Electrification
ISGAN 6 Transmission and Distribution	Online Meetings	Renewable generation on systems
UCC – MaREI – Credence Showcase Event	Conference	Showcase Video & Speaker

Table 2.1: Presentations, Conferences and Workshops

Organisation(s)	Type	Topic
UCC MaREI – Shaping the Future of Marine & Maritime Communities	Workshop	Presentation on Community Engagement – Dingle Project.
World Energy Council	Conference	Dingle Community Engagement presentation – World Energy Organisation – "Humanising the Energy Citizen"
EUSEW 2021 Conference	Conference	Discussions of Platforms for Community & Customer Integration - Dingle
2021 International Power Summit	Conference	Presentation on Electrification and Innovation Initiatives
EPRI	Workshops	Attendance at the European Workshop Week
450 MHz Alliance, EU Joint Research Council, EUTC and Tech UK	Meetings/Conference	Shared learnings from 'National Radio Access Network' Project and 400MHz smart grid delivery
2021 Irish Solar Energy Association	Conference	Presentation on ESB Networks Innovation activities to support increased penetration of renewables
Smart Dublin	Workshop	Knowledge sharing event - Innovation Strategy and Process
Engineers Ireland Lecture Series & National Recovery Event	Lecture Series	Dingle Project Lecture
	Conference	Disseminate and share learnings with stakeholders on Electrification and Network Developments in ESB Networks
ABB	Presentation/Panel	Energy Storage for Network Resilience, Novel Fault Isolation, EVs and the Grid
Eurelectric	Workshop	DSO development
CIGRE Sessions	Workshops / Seminars	Presentations and participation in a range of working groups and panel discussions.
UCD ESSIP	Workshops	Energy Systems Integration
Distribution Code Review Panel (DCRP)	Presentations	Regular presentations on innovation projects at the quarterly DCRP meetings
ENA – ENIC	Conference	Attendance at the ENA's Energy Networks Innovation Conference (ENIC)
ENA	Workshop	Engagement and input into cross purpose working groups with UK DSO/DNO peers - Review Policy, Standards practices across a range of working groups including Low Carbon Technology Overhead Lines, Cables and Earthing
United Nations (UN)	Review	Total Cost of Ownership (TCO) Tool for Procurement of Energy-Efficient Distribution Transformers
	Showcase	Sustainable Development and the Dingle Peninsula
ENLIT Africa	Webinar	Panel discussion on innovation to support increased electrification
E.DSO Stakeholder and Innovation Council	Webinar	Discussion on energy transition
IEI	Webinar on Network Reinforcement for Electrification	The Sustainability Grand Tour: Sustainable Living - Engineers Ireland

Table 2.1: Presentations, Conferences and Workshops

2.4.3 Publications

In 2020, ESB Networks personnel authored or co-authored a number of peer-reviewed, published papers and articles. These are listed below with ESB Networks personnel in **bold**:

1. Carroll Paula (UCD), **Lyons Pádraig**, Chesser Mike (UCD); Air Source Heat Pumps Field Studies: A Systemic Literature Review; Elsevier – Renewable and Sustainable Energy Reviews.
2. Carroll Paula (UCD), Chesser Mike (UCD), **Lyons Pádraig**, O'Reilly Padraic (LIT); Probability Density Distributions for Household Air Source Heat Pump Electricity Demand; 10th International Conference on Sustainable Energy Information Technology (SEIT), Leuven, Belgium; Vol.175, 2020:468-475.
3. Cigre C2.40 working group - **Tony Hearne** (co-author); "TSO-DSO Co-Operation Control Centre Tools Requirements". Cigre publications.
4. **Anthony Walsh, Clem Power**; Development of Retrofit MV/LV Transformer Designs to accommodate increased Electrification (Electric Vehicles / Heat Pumps); Cired Porto Workshop 2022 (submission).
5. **Anthony Walsh**; Doubling the ADMD in Housing Schemes to cater for future EV loads; Cired Porto Workshop 2022 (submission).
6. Zarko Janis, **Anthony Walsh**, Adesh Singh, Yorda Botec; Power Transformer Efficiency–Survey Results and Assessment of Efficiency Implementation; 5th International Colloqium on Transformer Research and Asset Management.
7. **Ken Atkinson**, Robert Southey, Measuring the Resistivity of Crushed Rock in Existing HV Stations; CEATI 2021 Grounding & Lightning and Stations Conference.
8. Jack Herring; **John Fitzgerald, Dan Catanase, Emma Silke**, Francois Pienaar, **Clem Power**, Hugh Cunningham; Online Monitoring and Data Analytics Enabling LV Network Investment Optimisation for a Low Carbon Future in Ireland, Cigre Session 2022 (submission).

2.4.4 Publications & Public Consultations

ESB Networks is committed to consulting publicly about its innovation activities annually. We are also committed to informing our stakeholders on their feedback through response papers and strategy documents which are published on our website publications Last year we published the following public consultations and documents:

1. Electrification of Heat and Transport Strategy – January 2021
2. Innovating to Transform the Electricity Network – February 2021
3. Response Paper to Innovating to Transform the Electricity Network – March 2021
4. Innovation Project Portfolio KPI – **Quarterly Update**
5. ESB Networks 18 Month Innovation Programme – **Bi-annual update** – Q1 2021 & Q2 2021
6. Response Paper to stakeholder Feedback Received from MV Customer connection standard Module EV Charging Hubs in Urban Environment – March 2021
7. Response to Stakeholder Feedback received from MV EGIP Standard Module Substation Public consultation – May 2021

2.5 COLLABORATION & ENGAGEMENT: Dingle Electrification Project

Since its launch in 2018 the Dingle Electrification Project has seen the deployment and implementation of a range of low carbon technologies within a local community setting to help us explore the impact of low carbon technologies on the electricity distribution network. It also gives us a better understand how energy consumer behaviours and their day-to-day interactions with these types of technologies impact the local network. Additionally, the project has been engaging with citizens and groups across the community to identify barriers to and enablers of low carbon transformation at an individual citizen level. See Section 4.4.2 for details on the project and technologies deployed.

Collaboration: The Dingle Electrification Project is founded upon collaboration. At community level, ESB Networks is working with the 5 Dingle Project Ambassadors, 10 electric vehicle ambassadors and 20 Solar PV trial participants to understand how their interactions with and use of low carbon and clean energy enabling technologies deployed at their homes and businesses impact the local electricity network. In addition, collaboration with the social research team at MaREI is helping ESB Networks understand the effectiveness of its programme initiatives - the Ambassador Programme and the EV Trial – in diffusing active energy citizenship and low carbon technology adoption across the peninsula.

Further collaboration with other members of the Corca Dhuibhne 2030 Group (Dingle Innovation & Creativity Hub, MAREI and North East West Kerry Development) has contributed to the establishment of other low carbon energy initiatives across the wider transport and agriculture sectors on the peninsula and the wider diffusion of sustainability behaviours. ESB Networks partnered with the Dingle Innovation & Creativity Hub to deliver the Dingle Adapts Energy podcast series, broadcast on multiple social media channels, to provide a platform for the ESB Networks Dingle Project's Ambassadors to share their experiences on low carbon energy living and the role that the clean energy enabling technologies provided by ESB Networks were playing in their lives.

Each of the five ambassadors, together with the ten electric vehicle ambassadors have been engaging with members of the wider community to share their experiences on the retrofit of their properties, the benefits of solar PV and batteries, the comfort and hot water available through the air source heat pump and the electric vehicle driving and charging experience. Diffusion of learning and shared experiences is a key aspect of the technology trials.

Working with Radio Kerry, the local radio station on the peninsula, the project team, in collaboration with external experts, Project Ambassadors and EV Ambassadors, delivered 4 podcasts on topics ranging from Solar PV and electric vehicles, to the work being carried out to deliver a more

resilient electricity network. With listenership of over 29,000, the broadcast of these podcasts provided an opportunity to reach citizens across the wider community who were not actively participating in any of the project's trials.

Collaboration with and across all 8 technology providers (see Section 4.4.2) has been core to the implementation of the integrated test bed infrastructure which is underpinning many of the Project's flexibility trials. The provider of the digital platform which optimises and controls the operation of clean energy enabling technologies in the home has worked closely with the providers of the electric vehicle chargers, air-source heat pumps and the residential battery systems to enable the integrated operation of all this technology.

Engagement with trial participants, in the early months of 2021, was conducted primarily through on-line platforms due to Government restrictions on travel to minimise spread of COVID, rather than at physical face-to-face events. These engagements covered the sharing of plans for the installation of remaining technologies at their homes and businesses with any questions and concerns addressed.

To encourage engagement across and between trial participants, the project team established an online messaging group for all 15 participants on the electric vehicle trial, to enable them to share their experiences of EV charging, whether at home or through using the public charging network. Dingle Project team members also joined this group to understand and address any challenges emerging early in this trial. The community-wide discussion and elements of social gamification evidenced on this platform has demonstrated the interest that all EV trial participants have in leveraging their electric vehicle to its full potential so as to displace a petrol or diesel vehicle on the peninsula and in supporting others in this aim also. Through this online platform, ESB Networks has gained further insights into the "lived experience" of these active energy citizens.

As the final pieces of the technology test bed were installed and commissioned – residential batteries, vehicle-to-grid chargers, gateway devices, enhanced Wi-Fi communications – the Project Team engaged both through webinar sessions in advance and then directly on-site with each of the trial participants to ensure they had a good understanding as to how these technologies would operate. Feedback was provided by the trial participants as they began to use these devices and, in some instances, modifications were made (e.g. implementation of the EV boost technology to override optimisation schedule) to the technologies deployed, providing a further level of validation across the technology suite.

The wider local community on the peninsula was also kept up to date on the progress of the Dingle Project through engagement with the local press and local radio stations. In addition, through our position on the Corca Dhuibhne 2030 steering committee, the activities and progress of the project were regularly shared with other partners on that initiative. Furthermore, by participating in actions led by Corca Dhuibhne 2030, for example the Energy Clinic initiative, engagement with other citizens across the peninsula, who were not participants on the ESB Networks-led project trials, was possible. Corca Dhuibhne 2030 is a multi partner initiative based on the Dingle Peninsula. It involves the Dingle Creativity and Innovation Hub, North East West Kerry Development (NEWKD), MaREI and ESB Networks. This steering committee allowed access to a wide variety of networks across a broad range of sectors and enabled The Dingle project to not only to get to the heart of the local community and county, but also nationally and internationally. MaREI collaborates with 36 countries across industry, academia and government and promotes the research that is underway on the peninsula regularly.

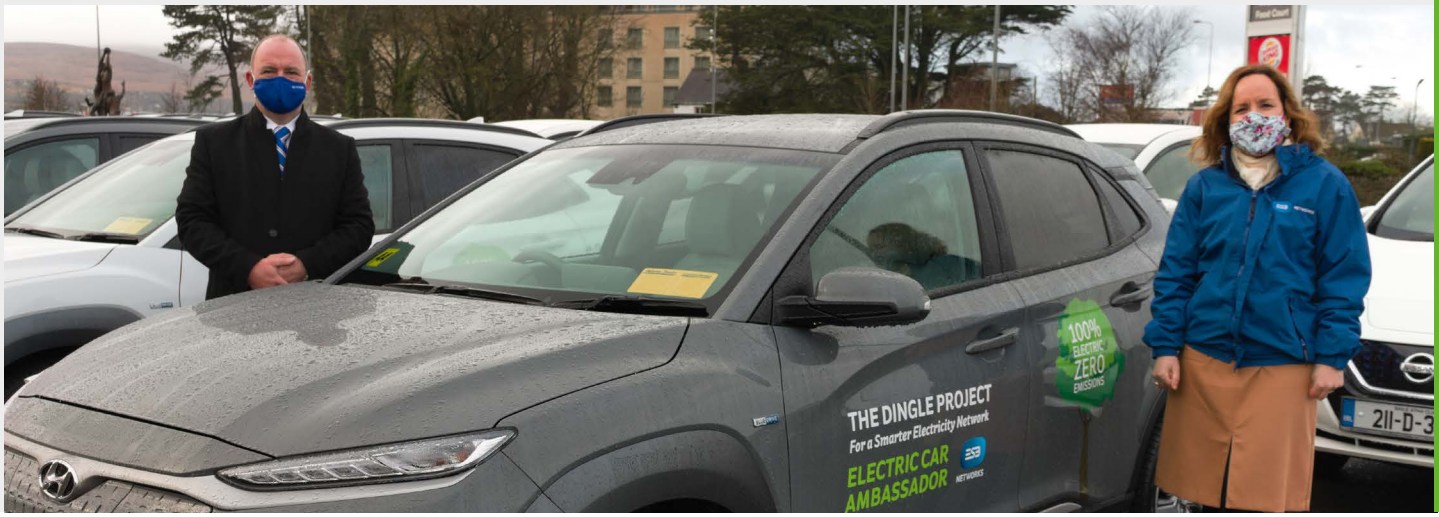
Dissemination is happening at multiple levels within the project. At one level the 5 Dingle ambassadors, 10 EV ambassadors and 20 Solar Photovoltaic (PV) champions have been sharing their experience at a local level and in some instances have participated in dissemination events with a wider audience. The Dingle Project Team has also led a number of successful dissemination initiatives throughout 2021. The team has delivered 20 webinars on the Dingle Project and the emerging learnings as they arose. The audience of over 800 for these webinars has included a mix of ESB Networks and external stakeholders. The Dingle Project has also participated in webinars and discussions at international conferences including (World Energy Week, European Union Sustainable Energy Week) and National events (SEAI's Transport Energy Research Conference and Engineers Ireland).

In October 2021, the work of the Dingle Project was highlighted on the evening news bulletin of Ireland's national TV station RTÉ, with a supporting article posted on its website. This communication brought the work of the Dingle Project to a national audience and significantly increased interest across other media groups and stakeholders. The Dingle Project web page views increased by 76% and the average time per page increased by 75% in 2021.

In addition, an extensive outreach programme was designed and delivered over the months of October and November where 12 external and internal stakeholder groups were invited to Dingle, to learn more about the project, meet some of the ambassadors so as to hear their lived experience and to see a demonstration of some of the innovative technologies deployed. The feedback from these visits was overwhelmingly positive. Government recommendations on restrictions to social contacts in mid-November to combat the spread of COVID infections at that time, necessitated the deferral until early 2022 of 8 additional visits that were planned for the period up to end of 2021.

ESB Networks also held the Dingle Project Webinar Series in December 2021, sharing observations, learnings and insights emerging from the project. The 4-day lunch time series was structured around a different theme for each day; Policy, Technical Trials, Active Energy Citizen and Network Resilience. It was well received across a national and international audience.

Over the course of 6 hours across the four days, 280 attendees heard ESB Networks' speakers share learnings from the Dingle Electrification Project and insights into how citizens and communities may participate in the future energy system. External speakers from Accenture, SEAI, MaREI and Dingle Innovation & Creativity Hub shared their thoughts on the evolution of consumer values in relation to low carbon technologies, state supports available to citizens, businesses



and communities to support adoption of low carbon measures, learnings from engaged research across participants on the ambassador and electric vehicle trial, and other plans for low-carbon transformation across the Dingle peninsula. The webinar series also provided an opportunity for two of the Dingle Project Ambassadors and one of the EV Ambassadors to share their experiences throughout the trial. Videos of each of the webinars are accessible on the ESB Networks website.

Feedback from attendees at the October / November site visits to the Dingle Project has been very positive in relation to the technical trials and the citizen and community engagement activities. Third party social media posts referring to the work of the Dingle Project have also been very positive. There has been an observed increase in the confidence level of the project ambassadors over the period since the remaining elements of the test bed infrastructure have been implemented.

Analysis of electric vehicle journey data has shown a growing confidence in the range of the vehicles and the performance of home charging, with total distances travelled per week increasing consistently over the duration of the trial. The provision of the mobile app providing next to real-time information on the energy footprint of the home and the operation of each of the low carbon technologies, has provided the appropriate level of information to equip the ambassadors to speak with a greater degree of authority on the interaction of those technologies with their day-to-day lives. This confidence was very evident during stakeholder visits to the project during October and November. The learnings and outputs from the project will be published and the anonymised data will be made available to stakeholders in 2022.

2.6 DISSEMINATION OF KNOWLEDGE AND LEARNINGS

The distribution system is evolving to support Ireland's transition to a low-carbon economy. Throughout this transition, ESB Networks will ensure that customers and stakeholders remain at the centre of our business. Listening to and engaging with customers is key to understanding their needs and preferences as to how we develop the network and deliver services.

In response to stakeholder feedback to our 2021 consultation for increased visibility of the innovation programme portfolio we published our 18 Month Innovation programme on our website. This was published biannually in 2021 and we will continue to update and publish this report biannually in 2022.

At a range of industry events throughout 2021 and through a variety of channels, ESB Networks focused on engaging with our stakeholders who were either impacted by our innovation activities, or who may have had an influence on them. The purpose was varied, ranging from seeking feedback to informing terms of references and project approaches, to sharing updates on project progress and plans, to disseminating knowledge and learnings from projects to the wider industry. These channels of engagement included bilateral meetings, our revamped website, public consultations, Innovation Stakeholder Panel and our Innovation Webinars.

2.6.1 Bilateral Meetings with Stakeholders

As part of our ongoing engagement with stakeholders throughout 2021, we held various bilateral meetings and workshops with the renewable electricity sector, energy flexibility and storage bodies, academia/research, e-heat, e-transport, professional institutions, energy agencies/ authorities, equipment/systems manufacturers, utility/TSO, industry & large energy users, electricity suppliers, industry consultants and international organisations as outlined in Section 2.4. We received 15 responses to our Innovation Consultation, Innovating to Transform the Electricity Network which had been published in February 2021. As part of our response to this feedback, we offered bilateral meetings to each of the respondents and extended the offer to additional interested stakeholders. As a result of this, we held several interactive sessions with stakeholders including, MaREI, Electricity Association of Ireland (EAI), and UCD Energy Institute.

In addition to the dingle stakeholder visits in October and November the Modular MV EGIP substation project team held a series of showcase events at the NTC in Portlaoise where a demonstration unit was installed for stakeholders to visit and ask questions on the module. These events gave stakeholders the opportunity to see and ask questions on the module to assess its suitability as an option vs the traditional brick-built substation for their connection applications, in particular for Independent Power Producer (IPP) renewable wind and solar generation connections. (see Section 3.9)

2.6.2 ESB Networks' Website

During 2021, the innovation section of ESB Networks' website was revamped and updated with an improved user-friendly interface and increase transparency of our innovation activities. The section on ESB Networks' innovation projects was updated with five additional close-out reports. Project reports will continue to be published under the relevant innovation pillars as they become available. A new 'Innovation Stakeholder' section is under development for the website to disseminate and share the recordings of our innovation webinars and details from our Innovation Stakeholder Panel meetings. In response to stakeholder feedback to our last innovation consultation, in 2021 we have published an 18-month programme plan which is updated biannually to share our high-level programme plan on our innovation projects and pipeline with stakeholders. As part of our stakeholder survey the website has continued to be ranked highly as one of the preferred channels for dissemination, after webinars and bilateral meetings. For more information on our innovation projects and activities please visit Innovation in ESB Networks.

2.7 ENGAGEMENT & DISSEMINATION OF LEARNINGS: Spring and Autumn Innovation Webinar Series 2021.

Our Spring and Autumn Innovation Webinar Series continued to be a central dissemination channel for our innovation projects and activities in 2021. Over the last two years the webinar series, established in response to COVID restrictions, have proved to be a welcome addition to our engagement channels and enabled a more agile approach to stakeholder engagement, the sharing of information on our innovation activities and the dissemination of project learnings and outcomes.

The webinar topics for the 2021 Spring and Autumn webinars are listed in table 2.2. To best serve our stakeholders and to ensure we were hosting webinar topics that were of interest to them we issued a survey providing 14 topics options across our three innovation pillars and innovation in ESB Networks activities. This allowed stakeholders to vote on their preferences. The Spring and Autumn Series reflected the top topics chosen by our stakeholders and feedback through the survey. We also asked our stakeholders whether they wanted these webinars delivered all in one session or through one webinar per week. 83% selected one per week, and as a result, the series was scheduled and delivered this way.

Our Spring and Autumn Innovation webinar series covered a range of topics across our Innovation projects such as supporting the connection of renewable generation, electrification of heat and transport, community engagement, network resilience and the transition of flexibility projects and trials into our newly launched NNLC Programme.

#	**Spring Innovation Webinar Series**
1	Compact Standard Modules for Electric Vehicle Charging, Embedded Generation Interface Protection (EGIP) & HV Connections
2	Electrification '25 – EV Ready
3	Delivering a Network for the Future - Active System Management (NNLC Programme)
#	**Autumn Innovation Webinar Series**
1	ESB Networks Innovation Project Portfolio & Pipeline
2	Dingle Project
3	National Network, Location Connections (NNLC) Programme

Table 3.1: Initial Assessment Criteria

Our innovation webinars continue to encourage interaction through open discussions via an online platform and were attended by a diverse group of stakeholders across government, industry, academia and representative associations. We had strong engagement with our stakeholders with an average attendance of 90 stakeholders for each webinar with some exceeding 110. All our webinar recordings have been made available to our stakeholders for reference and

can be viewed by selecting the links above for each webinar. This has been welcomed by our stakeholders with over 270 views of our webinar recordings to date.

Throughout and at each stage of the webinar series, we sought feedback and engagement using an interactive presentation tool which has informed our innovation projects and activities. The feedback showed that webinars are the preferred choice of communication channel for dissemination, and the innovation webinar series successfully increased stakeholders' awareness and understanding. A stakeholder survey carried out as part of our webinar series showed that 94% of respondents believed their understanding of ESB Networks' innovation projects and activities had increased over the previous 12 months.

We look forward to continuing the Spring and Autumn Innovation Webinar series in 2022, to share our innovation progress, discuss feedback we have received, and collaboratively consider how we tackle the transition to the network of the future.

3 PROJECT IDENTIFICATION EVALUATION AND APPROVAL

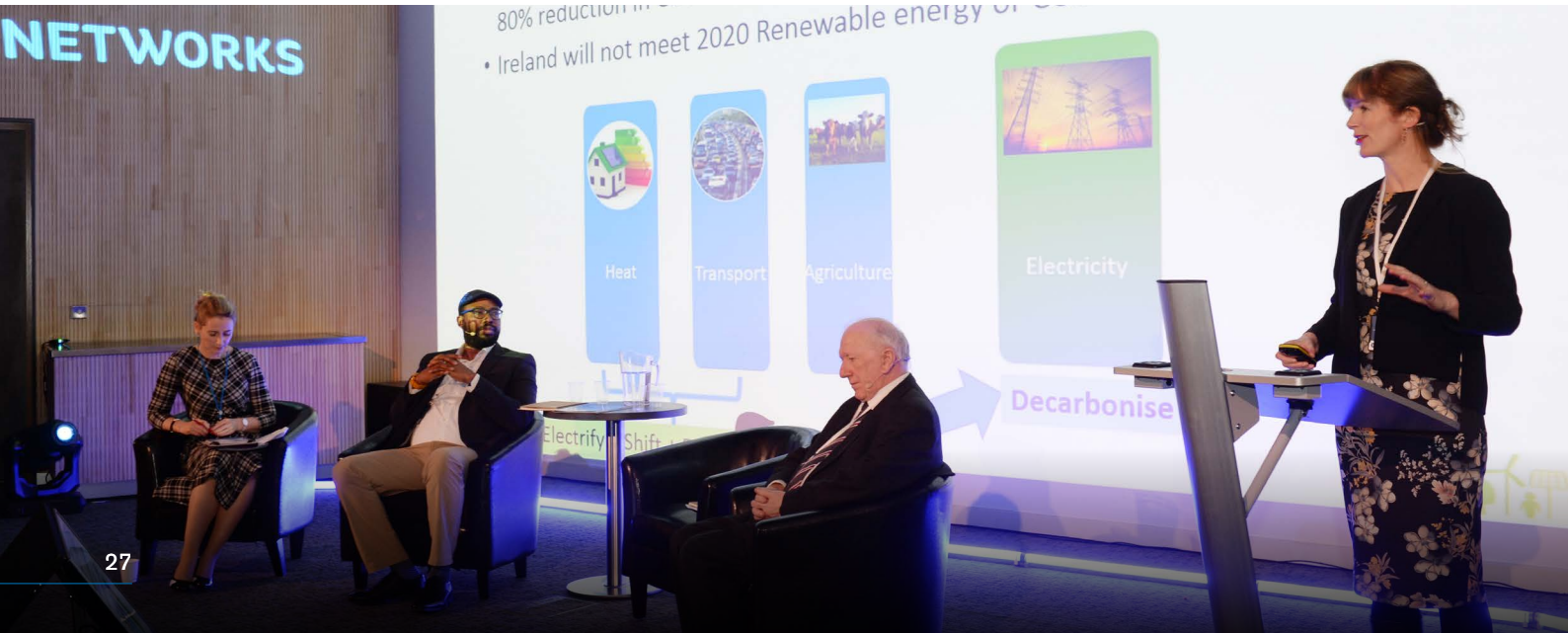
3.1 OVERVIEW OF PROJECT IDENTIFICATION AND EVALUATION

The process from idea identification to project delivery includes project identification, evaluation, scoping and approval stages:

Figure 3.1: Project Identification and Evaluation

1. **Identifying Project Ideas Beyond Business-As-Usual**
   - Innovation ideas are initially reviewed to ensure that the scope of the idea proposed is to trial a technology or concept that is beyond BAU.
2. **Project Prioritisation and Initial Assessment**
   - Innovation ideas then go through an initial assessment and prioritisation 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.
3. **Impact Assessment Framework**
   - 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;
     - Social and Sector Learning.
4. **Detailed Project Evaluation and Benefit Assessment**
   - Once the ideas have passed these early reviews and assessments, they are scoped out and an investment appraisal is developed for each project. The investment appraisal includes a detailed benefit analysis; this is a qualitative and a quantitative analysis where possible. If the investment appraisal deems the project viable (which may be conditional on a successful pilot project), then a project proposal is developed with clear project objectives for recommendation to the ISG for transition to project delivery stage.
5. **Strategic Validation Through Collaboration with Stakeholders and Third Parties**
   - Innovation ideas and projects are validated throughout the project lifecycle through collaboration with stakeholders and third parties.

Last year's annual innovation consultation resulted in significant interest in our innovation assessment processes, so we offered as part of our 2021 Autumn Innovation Webinar series to present, details of our innovation assessment processes and stages to inform our stakeholders and garner their feedback. We presented current examples of projects at each stage of the Identification, Assessment, Delivery and Transition into BAU process highlighting improvements we have implemented following feedback and engagement with our stakeholders to our assessment process. The innovation webinar is available to view here and Section 3.4.2 provides further details on improvements.



3.2 IDENTIFYING PROJECT IDEAS BEYOND BUSINESS-AS-USUAL

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.

This report deals with innovation as defined in the Oslo Manual[2] (2018, published by the OECD and Eurostat) as a technological innovation, a business process innovation or a combination of a business process and technological change. Innovation is not considered to be a minor change or routine improvement in BAU. However, major changes in existing BAU processes or alterations which produce significant benefits are considered innovation, as to produce such large changes innovation is deemed to have been required. However minor changes in BAU, which may be quite worthwhile and deliver significant economic benefit, are not covered in this report.

The project proposers/sponsors assess their innovation idea using standard 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, be considered from a whole system perspective.
2. What options or alternatives exist, and what risks are associated?
3. Is there an optimal way of scheduling the project such that the timing and level of investment is optimised in relation to future options which may develop
4. What are others in industry doing about the same issue?
5. What are the risks associated with not pursuing it?

The assessment process and appraisal of the innovation idea, including reflecting on these five 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.

It should be noted that later in the evaluation and approval process, project proposals may be rejected by the ISG as they may be deemed insufficiently innovative. In these cases, they can continue to be executed as BAU projects.

3.3 INNOVATION PIPELINE IDEAS

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

Innovation pipeline ideas are project ideas that have been deemed to be beyond BAU and thus to be innovative. These ideas have not gone through the Project Prioritisation and Initial Assessment process stage but are under consideration by ESB Networks. Our current project ideas are listed below with their assigned ESB Networks Project Reference Numbers:

Future Customer

- Assess Performance of Existing Commercial Battery Installation in regard to Facilitating Increased DER (ref: 165)
- Trial Future Grid Approach to Transformer Load Monitoring Using Smart Meters (ref: 166)
- Investigate Feasibility of Three-Phase Connections for Upgrades to Domestic Premises with High Loads (ref: 175)

Climate Action

- Modification of MV Voltage Drop Calculations by New Load Models Validated by Trial Data (ref: 110)
- Investigating the Impact on Rapid EV Charge Points on Power Quality of the Distribution System (ref: 167)
- Optimal Voltage Management Across Voltage Levels MV to LV Distribution Networks (ref: 212)

Network Resilience

- Develop Dynamic Line Ratings (DLR) for HV using Westnetz approach (ref: 190)
- Trial of Fused Minipillar (to ensure correct protection on long, heavily loaded LV Cables using graded sub-fusing on the network) (ref: 198)
- Investigate Scope Available for Use of Single-Phase MV/LV Transformers with Voltages in Excess of 244V (ref: 201)
- Investigate use of MV bundled Conductor for new routes (ref: 222)
- Investigate use of MV overhead lines on existing infrastructure in urban areas for new transformer technology installations. (ref: 223)

[2] The 'Oslo Manual, 2018' is available for download from Eurostat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3.4 PROJECT PRIORITISATION AND INITIAL ASSESSMENT

3.4.1 Overview of Project Prioritisation and Initial Assessment

In order to carry out an initial assessment and preliminary ranking of project ideas, prior to more detailed consideration, a simple set of criteria outlined below is used to score the projects.

Lifecycle Savings Potential	The potential for a project to generate savings within five years. In general, the savings are to ESB Networks on the basis that ESB Networks represents customers' 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 (not explicitly called out in strategy).
Risk	What is the expected level of risk of the project in relation to the likelihood of project completion and the delivery of expected benefits in relation to costs?
Customer Need and Demand	How relevant is the product/service potentially and is there known demand within five years?

Table 3.1: Initial Assessment Criteria

A screening matrix (See Table 3.2 below) for shortlisting project ideas is used. The process is intended to provide clarity to the assessors and allow a common evaluation method for projects across all innovation pillars 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 scoring for each section has an appropriate weighting, as show in table 3.2, to give a total score up to a maximum of 105 points.

Weighting	Score	1	2	3	4	5
4	Lifecycle Savings Potential	Under €200k	€200 - €500k	€500 - €750k	€750-€1,000k	Over €1,000k
1	Time Frame/ Complexity	Over 5 years	4 to 5 Years	3 - 4 Years	2 - 3 Years	Under 2 Years
3	Core Competencies	100% External	75% External	50% External	25% External	0% External
4	Strategic Fit and Innovation Type	Unaligned		Adjacent		Core
4	Risk	High		Medium		Low
5	Customer Need and Demand	Under 10%	10 - 25%	25 - 50%	51 - 75%	Over 75%

Table 3.2: Screening Matrix for Initial Assessment of Project Ideas and the Mandatory Requirements Assessment

Mandatory Requirements		Description	1000
Score of 1000 points for each mandatory requirement. Overall Total then gives the inherent benefits of the project as the numbers after the thousand's separator, with the requirement to do the project by the thousands score.	Legal Requirement		
	Environmental Requirement		
	Regulatory Requirement		
	Enabler of Essential Project		
	Project: Stakeholder Commitment		
	Other		
	Mandatory Total		
		Overall Total	
		Date of Assessment	

Table 3.2: Screening Matrix for Initial Assessment of Project Ideas and the Mandatory Requirements Assessment

The projects which emerge from this initial screening process are then subjected to a detailed project Evaluation and Benefit Assessment in the next stage (Section 3.7) to confirm that they will provide long-term value to our customers and/or our other stakeholders.

However, projects may not simply be selected because of the benefits they provide, but also for other potentially mandatory reasons which require the project to be undertaken directly. This area is covered by scoring the project on the basis of the commercial benefits expected which gives an overall score in three figures, and then adding in a score of 1000 if any of the mandatory requirements associated arise. Having a very high score prioritises the project, but the underlying benefit is still seen in the last three digits from the standard initial assessment criteria.

Justification for Mandatory require would include the following:

- Legal/Regulatory/Environmental: There is an obligation on ESB Networks to achieve a certain result and the project is justified on this basis
- Enabler: The project may be required in order to let a more important project proceed
- Project/Stakeholder: Project is critical to a stakeholder

Similar issues may also arise in relation to Radical/ Breakthrough projects. Following feedback from stakeholders we have created a new assessment criterion for breakthrough and radical projects above.

3.4.2 Process Improvements for 2021

Breakthrough and Radical Projects

During 2020, we received feedback via webinars, bilateral meetings and consultations in relation to the appropriate split between Incremental, Breakthrough and Radical innovation projects and the TRL levels ESB Networks should prioritise.

Feedback from our 2020 external audit highlighted that our initial assessment process favoured lower risk incremental projects and potentially biased against radical and breakthrough projects. In recognition of this and feedback from our stakeholders, in 2021 we developed separate assessment criteria for Breakthrough and Radical Projects shown in table 3.

For the new assessment criteria for breakthrough and radical projects a similar weighted scoring system to that in Table 3.2 is used with a more granular list of criteria detailed in table 3.3 below.

Criteria	Description
Idea/Project Sponsor	In Breakthrough/Radical projects, there is relatively little prior knowledge. Therefore, the reputation, track record and knowledge of the ideas sponsor is a critical part of the innovation idea/project assessment.
Feasibility / Realisability	Is the idea understandable and intuitively understandable as a good idea? Are the technical and economic assumptions underpinning the idea or project correct? Will it lead to other opportunities? Will it develop core competencies? Does it require competencies outside ESB Networks and are appropriate partners available to provide those competencies?
Meets Customer Needs	Does the idea meet a customer need or requirement? Ideas/concepts/technologies are more likely to be successful if they meet existing or future customer needs.
Scalability	Can the idea be scaled? The value of the idea is greatly increased if it can scale in volume and scope.
Degree of Fit to ESB Networks' Strategy	ESB Networks' strategy is designed to meet national requirements within areas of ESB Networks' responsibility – if not aligned with ESB Networks' Strategy, then it is possibly a project for another entity to carry out.
Costs / Benefits and Resource Availability	Costs and benefits should be proportional to the risk involved and should be within the budgets and resources available to ESB Networks.

Table 3.3: Proposed Initial Assessment Criteria for Breakthrough and Radical Project Ideas

While ESB Networks continues to favour projects with a TRL7 and above, following feedback from stakeholders in 2022 we set a new innovation type split that's appropriate for an organisation of our size and resources. That target is 70% incremental, 25% breakthrough and 5% Radical. In 2021, our average innovation split was 74% incremental and 26% breakthrough.

In order for these targets to be met and maintained, we will look for opportunities for collaboration on more Breakthrough and Radical Projects with third party organisations. These opportunities will be sought through, bi-lateral meetings, webinars, our Innovation Stakeholder Panel and public calls for partners which we hope to issue a call in Q2 of 2022.

An interesting aspect of this review was that, in assessing the benefits of 'Incremental' projects, they tend to lie primarily within ESB Networks, whereas for 'Breakthrough' projects, they are probably shared between other stakeholders and ESB Networks, e.g. 'Flexibility' might benefit ESB Networks from investment deferral but also benefit customers selling flexibility services (See Figure 3.2 below). Accordingly, it was decided that the value expected would be more heavily weighted towards the societal value rather than the value to ESB Networks.

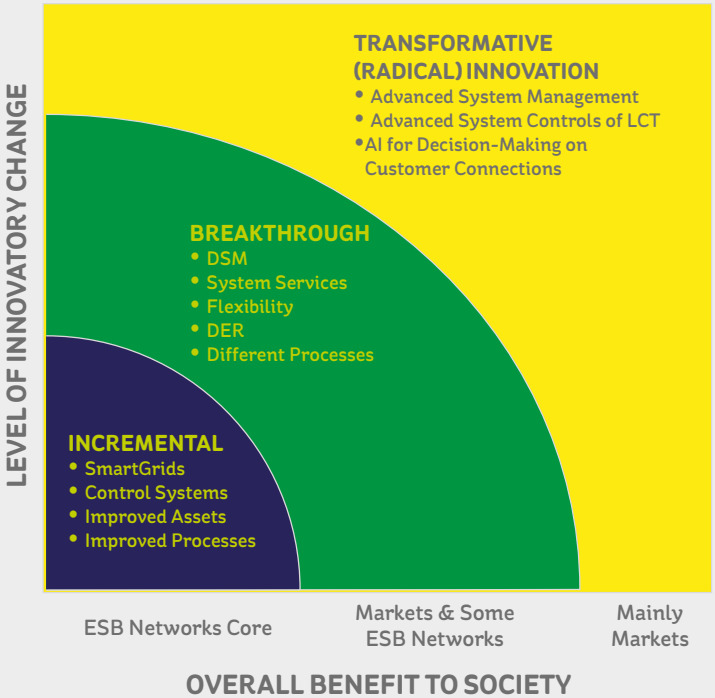


Figure 3.2: Impacts of Incremental, Breakthrough and Radical Projects

3.5 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 pipeline projects have been proposed as they address the challenges identified by our Innovation Strategy and provide benefits to customers. However, they are in the pipeline and have not been formally evaluated and approved as innovation projects. It's important to note that pipeline and approved pipeline projects may be replaced or superseded by alternative projects reflecting the dynamic nature of innovation. A list of the projects which were in the pipeline in 2021 are listed below:

Pipeline project	Project description
Climate Change Adaptation Approaches (Flooding) (ref: 71)	The impact of climate change on weather and thus on ESB Networks infrastructure is uncertain however it is expected that extreme weather events will become more common. The project aims to make use of new digital data such as Office of Public Works (OPW) flood plan models to forecast the impact of extreme weather events on distribution network infrastructure. This will develop strategies that cost effectively deals with the risk associated with these events in a holistic manner and the future effects of climate change on our current assets and planning our future assets linked to flooding and other climate risks.
How to use Data Analytics for Efficient Operation of Distribution Networks (ref: 213)	The project aims to build on learnings from previous projects to assess efficient use of data analytic skills to operate, monitor, analyse, automate and optimise the power distribution network in relation to the impact of climate driven renewable generation such as solar and wind. The project learnings will feed into standards for planning and operation of the network to support the increasing renewable generation required to meet our climate action targets.
Optimal Heat Pump Scheduling to Improve Hosting Capacity of Distribution Networks for DER's (ref: 214)	The project aims to investigate and identify the capabilities of air source heat pumps for the purpose of optimal scheduling to improve the hosting capacity of distribution networks for DERs and the potential for services that they can offer for demand side management to the DSO under different environmental conditions.
LoSplitz – Maximising LV Routes (ref: 222)	Increasing electrification in rural areas may result in voltage drop issues on the network at LV which would require network reinforcement. The aim of this project is to investigate and trial a different approach to standard LV network reinforcement on overhead lines where we currently split the LV group and install a new transformer. The project will investigate a new approach testing new larger LV conductor types, than our current maximum of 2x95Al, and upgrade to a new innovative 33kVA low impedance transformer solution (see ref: 172) to reduce voltage drop. This will defer the more expensive investment and speed up the reinforcement required.
Electrification Uptake Data Analytics Forecasting (ref: 160)	The distribution network has considerable capacity to accommodate electrified heat and transport; however, there will be areas of the network which are already heavily loaded or where clusters of EVs or heat pumps emerge that will require smart solutions or reinforcement. This project will focus on developing and refining additional sophisticated forecasting tools to predict where the network may need support. There are several datasets that could feed into this forecasting tool and thus we are looking to collaborate with external stakeholders to support this development. The projects objectives are being assessed and may be integrated for efficiency reasons with another project with similar objectives supporting electrification.
Provision of Optimised Design for 38kV Arc Suppression Coil (ASC) (ref: 164)	This project aims to investigate different modifications to the design of the ASCs and the changeover switch for HV substations to improve maintenance accessibility and installation. The project proposal supports improvements in safety for staff access to ASC and will improve the maintenance processes and procedures for future installations.

Pipeline project	Project description
Single Phase Recloser - Networks Automation and Control (ref: 218)	Advances in single phase reclosing technology and functionality supports the continuity and reliability of supply and network resilience by limiting momentary reclosing interruptions to the customers on long circuits (60 to 200 customers typically). This gives our customers better reliability and service. The project's aim is to build on the learnings from a pilot trial in Dingle by deploying the technology in multiple trial locations on our network. By adopting a fast follower approach the project will trial different scenarios and locations and use the broader learnings to determine best practice use cases of these devices and develop a wider deployment strategy for our network and the integration of the technology into our Network Management System.
Modelling Future Impact and Facilitation of Microgeneration in Various Scenarios (ref: 202)	Generation connected at LV results in voltage rise and in an increase in harmonics on the LV system, so that at higher penetration levels, power quality standards may be breached. Understanding when and where microgeneration will occur will be key to the development of a strategy to cost-effectively enable these connections without power quality problems. The key output of this project is to assess the broader impacts of large quantities of micro or mini generation and finalise a strategy to innovatively enable and manage their connection up to 2030 and beyond in line with new Micro Generation policy.
Assessment of LV Rural Overhead Infrastructure for Upgrade to 1,000V (ref: 42)	In Finland and parts of Norway, where domestic electrical load is very high and fed on an overhead LV network, it has been found to be economical to convert areas of LV to operate close to 1,000V. This gives a very large increase in power due to the squaring effect of the voltage and improves the strength of the network in relation to power quality equipment. In turn, it does not tend to produce issues such as high harmonic voltages or large voltage dips. The project proposes to assess the economic and technical feasibility of this approach on our LV overhead network vs alternative approaches.

Table 3.4: Pipeline Projects

With the establishment of the NNLC Programme in 2021 the following pipeline projects, which were included in previous innovation reports, have been transitioned over to it as the projects scope and objectives are being achieved under the NNLC Programme.

- Identification of Network Configurations for Active Network Management (ANM) (ref: 151)
- Development of Robust Low Voltage (LV) Models for the Future Network Planning and Operations Required to Facilitate Active Energy Citizens (ref: 152)
- Developing and Trialling Novel Approaches to Manage LV Flexibility (ref: 154)
- Framework for the Optimal Coordination of Network Management Systems (NMS) and Distributed Energy Resources (DER) (ref: 205)
- Congestion Management and Capacity Allocation using Operational Management System (OMS) (ref: 156)
- Development of Optimised LV Design Framework to Enable a Unified Mobile Support Application (ref: 157)
- Real Options for Pricing of Flexibility (ref: 104)
- Smart Meter Customer Referencing (ref: 223)

3.6 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. Each innovation opportunity is assessed against the six strategic areas as either Significant, Moderate, Minor or Non-Applicable.

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

Table 3.5: Impact Assessment Framework – Six Strategic Areas

3.7 DETAILED PROJECT EVALUATION AND BENEFIT ASSESSMENT

Innovative technologies or concepts which have the potential to support a lower-carbon energy system, reduce costs for customers, and improve system reliability are sought by the Future Networks Development team. Our Innovation Strategy Framework and innovation process acknowledges that the cost of our innovation projects which investigate these ideas is supported by our customers. Therefore, robust governance and risk management is in place to ensure projects run efficiently and effectively and deliver value for money.

Our thorough approach to screening has been outlined in earlier sections. All projects need to successfully go through the project pipeline selection process and a standard investment appraisal before any technologies or concepts are trialled. This approach limits the risk of conducting trials which may not provide benefits or savings.

At this stage in the process, the project scope and investment appraisal are developed. In order to assess project benefits and establish clearly defined measures of success at the outset, qualitative and, where possible, quantitative analysis of the costs and benefits of all innovation projects are carried out. These are captured in the investment appraisals and / or dedicated CBAs. The assessment and tracking of benefits continue throughout each stage of the project lifecycle.

We undertake CBAs in a consistent and transparent manner based on discounted cashflows. Our CBAs demonstrate a positive cost benefit when the resulting Cost Benefit Ratio (CBR) is greater than one. In situations where ESB Networks considers qualitative assessments only, success is measured by clearly defined project objectives, outputs and benefits recorded at investment appraisal stage. These defined outputs and benefits are then used as the baseline metric to measure success throughout the project lifecycle.

3.8 STRATEGIC VALIDATION THROUGH COLLABORATION WITH STAKEHOLDERS AND THIRD PARTIES

As detailed in Section 2, our customers and key partners including the CRU, national and EU government departments, local communities, the TSO, academia and industry are key stakeholders throughout the identification, delivery and transition to BAU of a project. As part of project evaluation, where appropriate we engage with key external stakeholders to ensure alignment with their needs and requirements to enable the transition to a low-carbon economy. This can take the form of engaging with projects initiated externally, e.g. +CityxChange or the Wind Farm Reactive Power Optimisation Trial, or it might take the form of bilateral meetings, webinars and consultation events which took place, for example, as part of the MV Standard Embedded Generation Interface Protection (EGIP) Modular Substation project.

3.9 VALIDATION: MV STANDARD EGIP MODULAR SUBSTATION (REF: 81)

The MV Standard EGIP (Embedded Generation Interface Protection) Modular Substation project supports the connection of further renewable generation to the network by facilitating a faster connection of embedded generation, including solar, to the distribution system. This can be achieved by developing an MV Standard EGIP Module solution that will allow for generation connections of between 1 and 20 MVA (subject to local system capacity) to ESB Networks' MV System. At the core of the proposal is the development of a standardised prefabricated substation module that can be deployed readymade to site, allowing for faster renewable connections to the system.

Introducing an alternative connection option for MV customers requires significant stakeholder engagement and consultation. The project published its MV EGIP Standard Module Connection public consultation in December 2020 with feedback closing date of January 11th 2021 and a public webinar was held to explain our proposal and encourage feedback. In March 2021 we published a response paper to stakeholder feedback. To further facilitate stakeholders' views on the proposed solution we arranged a showcase of the standard module build at ESB Networks National Training Centre in Portlaoise with weekly stakeholder visits across October and November. The numbers per visit were limited for compliance with COVID restrictions. In advance of this showcase a public webinar (view recording) was held in April 2021 to detail the specifications and requirements to our stakeholders with 78 stakeholders attending.

The aim of both stages highlighted the benefits of the proposed standard module and to ensure that our final enduring modular solution will cater to customers and in particular the majority of Independent Power Provider MV customers. The key benefits of our proposed solution are:

- Reduced MV Substation construction time on site
- Reduced requirement for commissioning work on-site, thereby removing conflict with civil works stage of project that can regularly occur
- Reduced Footprint of MV Substation
- Standardised Modular design providing the industry with certainty on design and build requirements for MV EGIP connections

There were 14 showcase events in Q4 2021 with 56 stakeholders attending. It was well received by our stakeholders and following our extensive engagement with stakeholders the MV Standard EGIP Modular substation is now progressing to a BAU solution as an option for customers with 4 modules under construction in preparation for new IPP connection offers with planning permission for use of the MV Standard EGIP Module.

3.10 FAST FOLLOWER APPROACH

ESB Networks' 'Fast Follower' approach reviews new solutions/ technologies that have been trialled by other utilities and which may be feasibly transferred for use by ESB Networks in Ireland.

This approach seeks to leverage research and innovation that has already been implemented by other comparator utilities. It offers opportunities to adopt and/or adapt such solutions for Irish circumstances, cognisant of the fact that the Irish electricity network has characteristics that are not necessarily replicated elsewhere. These somewhat unique characteristics include the challenges associated with having almost six times as much overhead line rural network per capita as most other European countries, combined with having large amounts of non-synchronous generation on an islanded system with substantially less interconnection than the vast majority of comparable 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 context of global innovation efforts, ESB Networks believes it worthwhile to leverage successful innovation outcomes from others wherever possible, and that this approach should offer value for money for our customers. This has been echoed in previous stakeholder feedback.

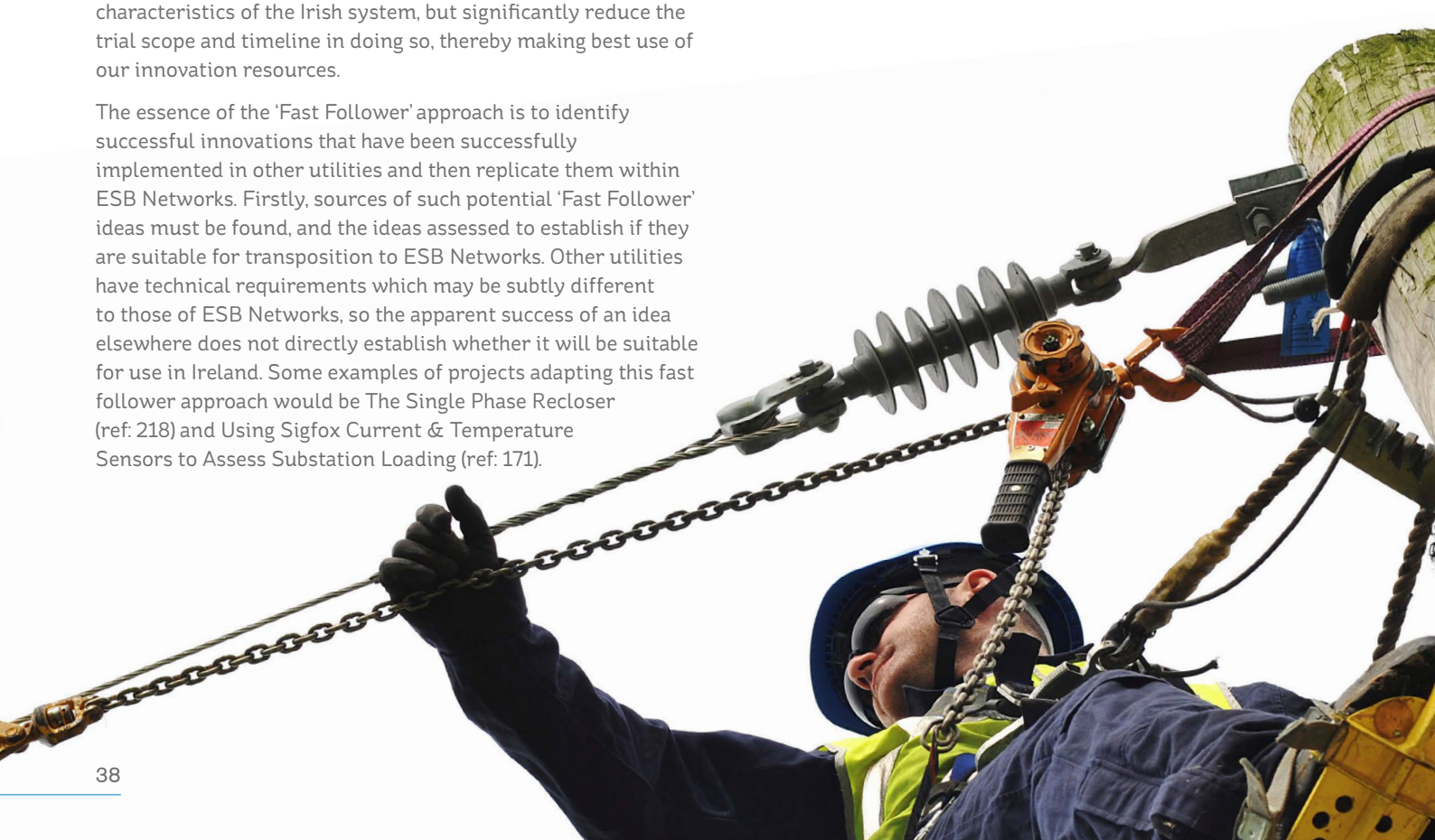
In some situations, ESB Networks may not be in a position to directly implement suitably identified 'Fast Follower' projects. It may still be required to trial the solution due to particular characteristics of the Irish system, but significantly reduce the trial scope and timeline in doing so, thereby making best use of our innovation resources.

The essence of the 'Fast Follower' approach is to identify successful innovations that have been successfully implemented in other utilities and then replicate them within ESB Networks. Firstly, sources of such potential 'Fast Follower' ideas must be found, and the ideas assessed to establish if they are suitable for transposition to ESB Networks. Other utilities have technical requirements which may be subtly different to those of ESB Networks, so the apparent success of an idea elsewhere does not directly establish whether it will be suitable for use in Ireland. Some examples of projects adapting this fast follower approach would be The Single Phase Recloser (ref: 218) and Using Sigfox Current & Temperature Sensors to Assess Substation Loading (ref: 171).

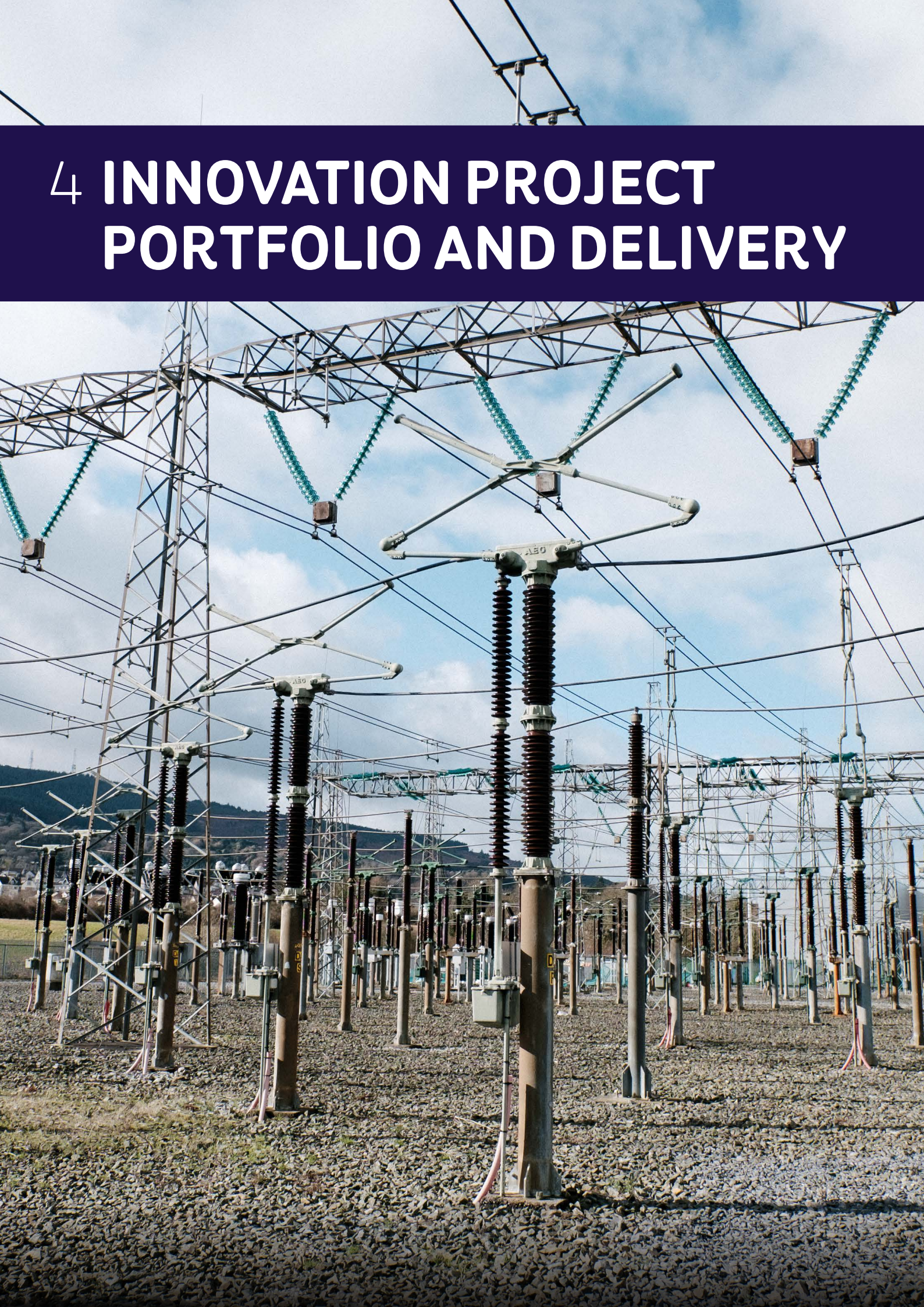
3.11 PROJECT PROPOSAL TO TRIAL / PILOT

Following successful completion of the assessments outlined in the earlier sections, an innovation pipeline idea can make the transition to an innovation trial or pilot project with an approved scope and clear measurable deliverables. In some cases, an innovation trial or pilot project may not be required and the 'Fast Follower' trial approach may be used.

Our robust approach to project identification and evaluation enables us to deliver the optimum mix of projects that have CBRs (Cost Benefit Ratios) greater than one, provide maximum impact and deliver long-term benefits to the operation of a low-carbon electricity system powering the decarbonisation of domestic heat and transport.



4 INNOVATION PROJECT PORTFOLIO AND DELIVERY



4.1 DELIVERY OF INNOVATION PROJECTS

The Innovation Strategy Framework that is in place since 2018 guides ESB Networks innovation activities, providing an appropriate level of process, governance and accountability across the entire innovation lifecycle, from the setting of vision through to the transition to BAU. It includes our Innovation Strategy Cycle and our Innovation Governance Framework. It recognises the particular risks and uncertainties inherent in investing in innovation projects that trial or pilot new technologies or concepts for the distribution system. The strategy seeks to quickly establish the viability of new technologies or concepts, in order to minimise unnecessary costs, by using a robust selection and evaluation process that deselects innovation projects that evaluate technologies or concepts that are unlikely to deliver enduring value to our customers and prioritises those that are more likely to deliver benefits in the short to medium-term when transitioned to BAU.

Having received appropriate assessment and scrutiny by the Future Networks Manager and the ISG, projects are prioritised according to our governance framework outlined in Section 1.3. Following this defined process and rigour, innovation projects are then passed to the innovation team as and when they are approved by the ISG. Section 1.3 details our innovation process. Where resources and time allow, those projects with the highest priority are attended to first.

In general, projects approved for delivery are then assigned to a Project Manager in one of two ways. Firstly, a Project Manager who becomes free after completing a previous project may be tasked to lead a new project for delivery. The project managers available to the Innovation Manager are experienced Project Managers who have completed several innovation projects. They also have a breadth of experience that includes other engineering and energy infrastructure projects. They are specialists in their fields, familiar with best-practice Project Management methodologies and are well placed to adopt the most suitable methodology and approach to deliver the designated project. Alternatively, a project may be assigned to a specific business unit for execution and delivery. In this case, the project is not delivered by the innovation team as it is deemed that the business unit is the most suitable and best-placed vehicle to do so. In this case, the Innovation Secretariat functions as the interface with the business, whereby project tracking, reporting and dissemination are all managed, with the detail of the innovation activities captured, recorded and relayed accordingly.

Project risks are usually identified and called out in the investment appraisal stage, and these are reviewed by the Project Manager at delivery stage kick-off. As projects progress, those risks are monitored, mitigated and reported. Where additional risks emerge or are identified by the Project Manager in the project delivery stage depending on the scale and scope of the project these are added to the risk log and where these are significant, the ISG is notified. This approach ensures appropriate risk management principles are applied throughout.

4.2 ASSESSMENT OF BENEFITS AGAINST COST

Projects that are approved by the ISG will have had an investment appraisal completed for them, and the benefits anticipated at completion will be identified. Project Managers report on these as the project proceeds and note their achievement, or otherwise, in regular periodic project reports.

Savings from innovations trialled and piloted in our innovation projects are tracked, and a rolling overall figure is compiled. We have estimated that the lifetime savings that could accrue from our current portfolio of projects underway is €60 million. This figure includes:

- Projects that afford one-off savings to ESB Networks
- Projects that deliver an ongoing multi-year saving to ESB Networks
- Projects where the savings are proportional to the actual uptake of the product. On a conservative basis, low uptake assumptions have been made to determine the savings for these projects
- Projects that provide a saving to the customer (without any saving for the company)

Some projects make only a small or no financial contribution to overall monetary savings; however, they make significant contributions to society, knowledge accumulation and learnings.

4.3 INNOVATION PROJECT PORTFOLIO OVERVIEW

The ISG receives a report on a quarterly basis that outlines the status of each innovation project. The report contains some graphs samples below which allow board members to quickly see project statuses and understand how the innovation programme is progressing. Following feedback from our stakeholders our 18 month Innovation Programme is published on our website bi-annually which gives a high level status overview of our innovation projects to our stakeholders. Due to the nature of innovation ESB Networks take an agile approach to its project portfolio and pipeline assessing the project status and relevance. Projects may be cancelled, subsumed or put on hold pending further investigation to their benefits in order to maximise use of resources.

Of the 180 innovation ideas assessed across various sources in 2021 our innovation project porfolio has 29 projects in active delivery, including 5 new Innovation projects, and 13 projects at pipline stage of which 4 are approved pipeline and are detailed in Section 3 and 4. There were 6 projects succesfully completed, 3 projects on hold and 1 project, Netflex, was cancelled as its scope and learning objectives were subsumed into the NNLC Programme objectives.There were also 8 projects at pipeline stage, detailed in section 3, whose goals and objectives have been subsumed into the NNLC programme.

The following sections detail each of our projects in active delivery and approved pipeline projects across each of our 3 Innovation pillars: Future Customer, Climate Action and Network Resilience.

4.4 FUTURE CUSTOMER PILLAR

Empowering and Supporting Customers and the Economy: This innovation pillar consists of projects that focus on enabling customers to transition from a passive customer to an active energy citizen. Key activities will be enabling energy communities, facilitating the connection of microgeneration and energy storage, and investigating how we can enable customers to actively participate in the energy market and provide energy system services. The following outlines the portfolio of projects either undertaken or underway by ESB Networks and which are attributable to the Future Customer Pillar.

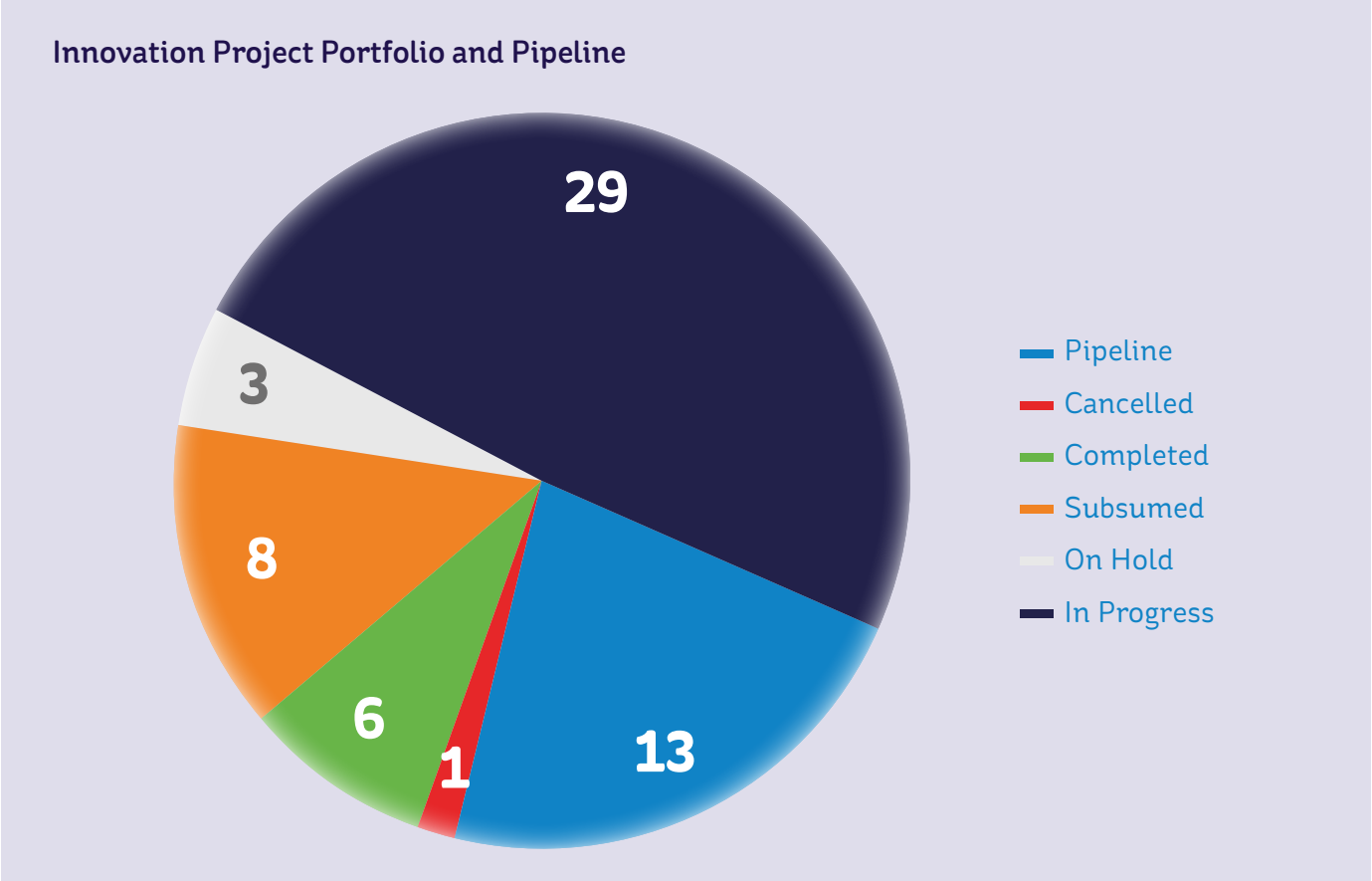


Figure 4.1: Q4, 2021 - Breakdown of Project Status

4.4.1 Artificial Intelligence (AI) in Smart Metering Applications (ref: 211)

Status: In Progress **Project Timeline: Q1 '21 – Q4 '24**

The Smart Metering program is replacing every electricity meter in Ireland, to assist the country to manage its energy usage more efficiently. Smart meter auditing is carried out to ensure quality and standards are maintained and improves safety. The auditing process is resource intensive.

ESB Networks requires 5 images to be taken of every smart meter exchange at installation. These images are used to check and audit that the installation is compliant with our installation and safety procedures. The volume and speed of installations means that there is a large volume of images to audit and the task is repetitive and manually intensive. As part of the auditing process, we have developed and are using innovative AI technology to assist with the checking and auditing of images.

There were nearly 600,000 smart meter installations completed by the end of 2021 and there will be 2.4 million-meter replacements by end of 2024. There will be 10 million images to check and audit and the AI enables ESB Networks to do this as part of our audit process of the smart meter program.

The AI development had 2 phases. Phase 1 focused on improving the image and data quality being received from installers through four checks; duplicate photos, meter type match, legible serial number and "Reads the Meter". This initial quality phase of the project is crucial for ensuring quality of data and driving the operators to improve how they record the photographic information.

AI Phase 2 focused on (i) providing ESB Networks with a national database of cut-out fuses, and (ii) performing 5 key audit checks on every smart meter installation. The national database is crucial to ensure upgrades are made to customers with older cut outs. This will inform work programs on upgrades required and generates a dataset of cut-out fuses for the country for continued use into the future. These 5 key audit checks help us identify any issues with the installation and rectify them directly. This maintains our high-quality standards with our contractor staff.

Benefits/Deliverables: The use of AI has brought significant benefits to the Quality Assurance Audit function of the smart meter programme.

- Saves cost in terms of time auditing reducing the audit time by up to 10%
- Improves ESB Networks asset infrastructure database.
- Is a key safety and quality anchor on the project by alerting us to 40% of quality assurance issues
- Ensures quality standards are kept high with staff and contractors maintain a >99% pass rate
- Provides security through automation and reduces costs without which the audit budget would need increasing 400%.

The AI technology allows us to check and validate all images, and highlights images that may need to be manually checked. The AI and its use cases is being continuously developed and improved for use in the smart meter programme and learnings from the project are feeding into other potential areas for application in the business.

4.4.2 Dingle Electrification Project (ref: 59)

Status: In Progress **Project Timeline: Q1 '18 – Q3 '22**

Key partners / stakeholders: MaREI, Molteic (Dingle Creativity and Innovation Hub), Tipperary Energy Agency, Greencom Networks, Wallbox, Sonnen, Mitsubishi Electric, Europcar, Hyundai, MAC, Salis, KN Circet, Solar Beo

The Dingle Electrification Project involved the deployment and implementation of a range of low carbon / clean energy enabling technologies at customers' homes and small businesses so as to evaluate their impact on the network and their capability to support the development of a smart, resilient, low-carbon electricity system. An important element of this project was the opportunity it allowed ESB Networks to collaborate with local communities, as we explored both the impact and capabilities of new, low-carbon technologies and how customers and communities interacted with these new energy systems.

Throughout 2020 and early 2021, significant progress was made in preparation for the flexibility trials which commenced later in 2021:

- Smart EV charge-points were procured and installed at the premises of the five Dingle Ambassadors and ten more EV trial participants were selected after a call for expressions of interest.
- Clear learning objectives from the Flexibility Trials were defined.
- The Digital Platform, used to optimise and control the range of distributed energy resources (DER) participating in the trial, was procured and configured to support these trials.

Significant progress was made on the installation and commissioning of technologies on the LV and MV networks to support the network reliability objective of the project:

- LV monitoring devices installed at key transformer locations.
- Smart Fault Passage Indicator (FPIs) installed on the network, and the extent to which they help to reduce outage durations, will continue to be assessed.
- Recloser upgrades and SCADA integration – reduce network switching time and outage durations.

The effectiveness of these technologies in improving customer confidence in the reliability of the network continued to be assessed. There were also several activities progressed to help understand the effectiveness of behaviours and the mechanisms required to transition individuals and communities to active energy citizens, see Section 2.5 for details. ESB Networks has been keen to support the identification of those techniques and activities that are most successful in diffusing active energy citizen behaviours across society, through the various trials and activities being undertaken by the Dingle Electrification Project.

2021 saw the remaining elements of the test-bed infrastructure to support the Flexibility Trials implemented. At the ambassador properties, residential scale batteries were installed and integrated with the solar PV systems.

The 12-months long electric vehicle trial commenced in February 2021, with 15 electric vehicles distributed to the 5 Dingle Ambassadors and 10 additional citizens across the peninsula. Electric vehicle chargers (smart chargers) had been installed at each participants property prior to the distribution of the EVs. An additional 2 electric vehicles were also made available to members of the wider community, on a managed basis, so that additional people could experience electric motoring.

As part of the infrastructure roll-out to support the flexibility trial, a gateway controller was installed in each of the 35 properties participating on the trial. Home monitoring devices were also installed so as to provide next to real-time information on key electrical loads at each property. In some instances, upgrades to the Wi-Fi networks at trial participants properties were required to enable the gateway devices communicate with each technology in the property.

Flexibility trials commenced when the digital platform was fully configured. The platform was initially configured to optimise the operation of the clean energy enabling technologies at each individual site, in the best economic interests of the trial participant. Over time the range of flexibility tests commenced, to demonstrate that key electrical loads, for example EV charging and hot water heating by the air source heat pump, could be moved away from peak periods in the day. Other tests demonstrated that the technology in the home could be controlled to operate in line with time of use tariffs, with key electrical loads switching on at off peak or cheapest tariff times and switching off at higher price periods. In addition, a number of tests were performed to demonstrate that should a significant event happen on the power system, the technologies in the home could be controlled to provide maximum flexibility to the network, i.e. all discretionary electrical load (EV charging and hot water heating) switched off and power injected via the property onto the network from all batteries. These tests will continue until end January 2022.

A significant achievement of the project in 2021 was the installation of the first residential-scale vehicle to grid / bi-directional EV chargers in Ireland. 5 of these V2G units were installed for selected EV trial participants. Demonstration of these devices showed that power could be fed from the electric vehicle battery, into the home, with any residual power fed onto the local network. Further testing of the V2G technologies as part of the wider suite of flexibility tests will occur until end of January 2022.

On the electricity network, analysis of data returned by smart FPIs continued. The relatively small number of faults on the associated circuits during 2021 may require continued analysis of this data beyond the end of the Dingle Project. In addition, the two single-phase recloser units installed on the peninsula, transitioned into full fusesaver mode of operation during late 2021. Should transient faults occur downstream of these devices, the operation of this technology can be fully assessed.

As highlighted in Section 2.4 above, significant engagement and dissemination activities progressed throughout 2021, to share the observations, insights and learnings from the project, with interested stakeholders, as they emerged.

For more information on the Dingle Electrification Project, please visit our website link: ESB Networks' Dingle Project

4.4.3 SERVO (Modeller, Live and Flex) (ref: 23)

Status: Completed **Project Timeline: Q4 '17 – Q2 '21**

Key partners / stakeholders: Telecommunications Software and Systems Group, WIT

Overview: The SERVO project was split into SERVO Modeller and SERVO Live & Flex. SERVO Modeller is an IT-based project, the aim of which is two-fold. Firstly, it is to develop a sandbox data lake to allow research projects that generate data access to a single location for data storage in a uniform and structured way. This then enables dashboards and reporting on the data for trial evaluation. Secondly, it is to act as a testbed software platform to deliver use cases on ESB Networks' data and evaluate the DSO requirements for interconnected data sources into the future. In June 2020 the Servo Modeler and planner module of the project was completed and transitioned into BAU (see Section 5.2) and a project report published on our website, SERVO Modeller Innovation Progress Report.

The Servo Live and Flex project modules of the project were completed in June 2021 and a project close out report published on our website; Servo Live & Flex Close out Report. Servo Live & Flex were developed to support the Dingle Electrification Project, with two objectives in mind: to develop the technical infrastructure to enable secure collection, storage and reporting of data collected from IoT devices deployed on the electricity network and to develop a secure application programme interface (API) to securely enable access to this IoT data set held within the Microsoft Azure Cloud database. SERVO Live is supporting the flexibility trials within the Dingle Project. Data from low voltage monitoring units (IoT devices) at ground mounted substations and pole mounted transformers are fed in real-time into SERVO Live. Dashboards within SERVO Live present the data in usable format such that the impact of different modes of operation of low carbon technologies on the peninsula can be observed and analysed.

4.4.4 StoreNet – Customer Side Energy Storage (ref: 45)

Status: Completed **Project Timeline: Q2 '16 – Q1 '21**

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

Overview: Led by IERC, the StoreNet project comprises a consortium of partners which includes ESB Networks, SMS Plc. (previously Solo Energy) and Electric Ireland. The project aims to validate the performance of twenty 10kWh 4kW Battery Energy Management Systems (BEMS) on the distribution network. The batteries are installed in residential premises in the townland of Ballyferriter, west of Dingle town, Co. Kerry.

A trial programme evaluating the performance of the BEMS was carried out in 2020. The trials investigated the capability of the BEMS to provide peak shaving and reactive power management. Further trials, including a 'Full Battery Discharge Test', took place in December 2020 and may help to understand how the BEMS can support local grid voltage. The project completed in Q1 2021 and the StoreNet Innovation Project close out report for this project was published on ESB Networks website in June 2021 and the learnings from the project have been transitioned into the business. Our partners will be publishing their reports separately including journal and conference papers by the IERC.

4.4.5 Exploration of ASHP for Ireland's Residential Heating needs (ref. 74)

Status: In Progress **Project Timeline: Q1 '19 – Q2 '22**

Key partners / stakeholders: UCD/Limerick institute of Technology (LIT)

Overview: Air Source Heat Pumps (ASHP) 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.

This project is leveraging data from the Superhomes Project and Limerick Institute of Technology is now a partner on the project (Superhomes Innovation Close-Out Report). Two journal papers and a conference paper documenting the findings of the project have been published (see Section 2.4.3). Furthermore, an opportunity to extend this project, with our partners UCD and LIT, has been undertaken with follow-on research investigating the power quality impacts of heat pumps on distribution networks underway at three trial locations into 2022.

4.4.6 +CityxChange (Positive City Exchange) (ref: 75)

Status: In Progress **Project Timeline: Q4 '18 – Q4 '23**

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

Overview: Through active citizen engagement, the +CityxChange (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. +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), Pisek (Czech Republic), Sestao (Spain), Smolyan (Bulgaria) and Voru (Estonia). This is the first such award to an Irish city.

In Limerick, a community energy concept proposed to trial 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 (DPEB) and District. ESB Networks' proposed focus is to support the integration of the DPEB into the distribution network and provide technical advice and support on concepts such as peer-to-peer energy trading and the Energy Community Utility (ECU) to be trialled. COVID has had a significant impact on the progress of the project during 2020 and 2021. A project-wide change request has been submitted to the European project office requesting that elements of scope associated with energy trading and flexibility at a community level, transition from physical trials to computerised simulations due to the challenges associated with recruiting prosumers and the installation of renewable generation within the footprint of the project.

4.4.7 DEVELOPMENT OF MODULARISED METERING AND CONTROL FOR RES CONNECTIONS (ref: 81)

Status: In Progress **Project Timeline: Q1 '19 – Q4 '22**

Key partners / stakeholders: Cental, Independent Power Providers, Maxol, Ecars, Circle K

Overview: There are two parts to the project which support the connection of renewable generation and EV chargers.

Project 1: The development of the MV EGIP Standard Modular Substation project supports the connection of further renewable generation to the network by facilitating a faster connection of embedded generation, including solar, to the distribution system. The solution will allow for generation connections of between 1 and 20 MVA (subject to local system capacity) to ESB Networks' MV System. At the core of the proposal is the development of a standardised prefabricated substation module that can be deployed readymade to site, allowing for faster renewable connections to the system.

Introducing an alternative connection option for MV customers requires significant stakeholder consultation. The project published its MV EGIP Standard Module Connection public consultation in December and held a public webinar to garner feedback from stakeholders. A copy of the consultation document is available from ESB Networks' website (MV Customer Connection – MV EGIP Standard Module Substation). In 2021 a showcase unit was installed in ESB Networks National Training Centre, Portlaoise in 2021, see Section 3.9 for further details. There are 4 units planned to be constructed to hold in stock to enable improved connection time for IPP's who choose this option for their connection agreement.

Project 2: The Compact Standard Modules for Electric Vehicle Charging Infrastructure Connections projects aims to evaluate new and innovative approaches to MV substation design where large EV chargers are expected to connect. The project aims to explore the use of modular solutions to increase the efficiency and speed of (large) EV charger connections to the MV. This approach will reduce the overall footprint of the substation and reduce construction effort when compared to a conventional MV block-built substation building.

The project has engaged with customers to identify challenges and to propose solutions. Following the consultation in 2020 entitled "MV Customer Connection Standard Module – Electric Vehicle Charging Hubs in Urban Environment" the response paper was published in March 2021. A webinar was held as part of the spring innovation webinar series to update on the proposed designs and trial site partners. As a result of these engagements, we have selected proposed trials with partners who expressed their interest as part of our consultation and engagements, with the trials expected to be developed in 2022 pending approvals. The project timelines have been extended to facilitate the trials in 2022.

4.4.8 REACT Project - Horizon 2020 (ref: 210)

Status: In Progress **Project Timeline: Q1 '19 – Q2 '23**

Key partners / stakeholders: Údarás Na Gaeltachta, NUIG, SEAI, Veolia, Mitsubishi Electric

Overview: The REACT project aims to assess the self-sustainability of island communities that adopt renewable energy technologies. REACT consists of a consortium of 24 partners from 11 countries with island community representatives, regional authorities, DSO/ESCO, technology providers, academia and Research and Technology Organisations (RTO's). The project is aiming to develop a technical and business model to demonstrate that the large scale deployment of renewable energy sources and storage assets coupled with and ICT platform to enable an integrated and digitalised smart grid can bring economic and environmental benefits to their local energy communities.

As part of the project, PV, heat pumps and batteries are being installed on the three European islands of La Graciosa (Canary Islands), San Peitro (Sardinia) and Inis Mor (Arann Islands). Several premises on Inis Mor have agreed to join the project with five community buildings to receive Low Carbon Technologies (LCT's) such as solar panels and some installation receiving heat pumps. To assess the possibility of the island becoming energy self-sustaining, the island's network is being modelled with a view to understanding how a more widespread adoption of micro-generation would impact energy consumption, network services provision and network stability. ESB Networks has installed LV monitoring equipment on the network to capture data and support the modelling analysis as part of the project. The project has expanded to include a number of homes installed with the REACT interactive monitoring equipment and connecting to the REACT cloud system. The project has been significantly impacted by COVID delaying the installation of equipment across the islands and has been granted an EU extension to Q2 2023. However, significant progress has been made throughout 2021 in installing all the REACT systems in Inis Mor and the partner island with the system trials commencing in 2022.

4.4.9 300 kVA Pole Mounted Transformer (ref: 170)

Status: In Progress **Project Timeline: Q1 '19 – Q2 '22**

Key partners / stakeholders: Kyte Powertech

Overview: Currently the maximum size of Pole Mounted Transformer available is a 200kVA unit. When such units are at or are approaching full capacity, the only options available to us to upgrade this type of transformer are either, splitting the group by installing another transformer, or installing a ground mounted unit substation. Both options are expensive and take time to implement. 200kVA pole-mounted transformers are in widespread use in ESB Networks. When they are approaching their limit of capacity to feed the electrical load, they tend to remain in service longer than other sizes of transformer, as conventional upgrade alternatives are challenging to implement due to the limited availability of sites, their expense and the length of time needed to install. With the electrification of heat and transport, these substations may become overloaded, potentially resulting in expensive and delayed reinforcement.

This project aim is to develop a larger capacity, 300kVA, pole mount transformer to replace our 200kVA pole mounted unit. There are limits however, to the maximum size and weight of transformer that can be pole mounted. These limits are the physical mechanical limitations of the strength of the pole itself. When we propose to increase the size and weight of a transformer, we must ensure that the physical loading limits on the pole and equipment dimensions are not exceeded.

Our innovation partner Kyte Powertech worked to produce a suitable transformer unit during 2020. The target was to have a 300kVA Pole Mounted transformer, however, despite careful design of the transformer, when initial design testing of the first prototype unit was carried out, the transformer failed the Temperature Rise test. The maximum rating for the transformer only achieved a rating of 270kVA which was below the anticipated 300kVA rating. For the prototype unit developed in 2021, the manufacturer replaced the mineral oil, with an Ester oil. This change was subsequently, retested and the transformer passed all type tests and the transformer achieved the required 300kVA rating. Future 300kVA Pole Mounted transformers can revert to using Mineral Oil but will be designed using higher temperature insulation, thus achieving the required 300kVA rating. There has been interest from other DNO's in this project who we continue to share learnings.

Benefits/Deliverables: The latest prototype unit is ready for installation and trial on the network in Q1 2022. The specification, policy and procedures for installation and use on the network for the trial have been completed. It is anticipated that in early 2022 following a successful field trial of the unit that this project will transition into BAU. The benefits of this project are significant in supporting the electrification of heat and transport. There are currently about 3,000 x 200kVA transformers installed and about 800 of these feed sufficient domestic customers that large increases in load caused by electrification could require their uprating. Such uprating's could be very disruptive and expensive, taking a long time to design and install if only traditional options were available. Using the novel 300kVA unit which has 50% extra capacity and can be installed in situ within 1-2 days at significant less cost and disruption will be of significant benefit to our customers.

4.4.10 Improved Average Demand Estimates for Domestic Customer (ref: 169)

Status: In Progress **Project Timeline: Q1 '19 – Q2 '22**

Key partners / stakeholders: ESB Networks, VT IoT

Pending the availability of smart meter data, the only way of estimating load on a MV/LV transformer supplying a housing scheme is by multiplying the number of customers by a standard average demand to form a load estimate. The transformer headroom then available for EVs and heat pumps is the difference between the estimated load and the transformer rating. Therefore, if the average demand varies, so can the estimated headroom.

This project will deploy monitoring on representative housing schemes to assess the possibility of deriving an average demand for different house types and socio-economic areas. This would enable us to identify with more certainty those substations most likely to require uprating. Temperature and current monitoring equipment has been installed to provide the data that will support the average demand assessments. These have been integrated into an IoT platform to capture and analyse the data and the results of which will be published in 2022.

4.4.11 Novel LV Investment Analysis Tools (ref: 170)

Status: In Progress **Project Timeline: Q1 '19 – Q2 '22**

Key partners / stakeholders: ESB Networks / UCD

Rationalising increases in the average customer's power requirements for use in distribution network planning can be done relatively simply using tried and trusted conventional investment evaluation techniques.

However, sensitivity analysis can be considerably more complicated, depending on the variation allowed in the input factors. This project considered whether real options analysis can be used in an understandable and useful way to assess the low voltage network investment options associated with catering for increased average customer growth and thus give an insight into the use of real options for more complex analysis. An initial draft report has been completed with UCD and has illustrated the potential complexity in the use of real options in this area with potentially limited advantage over current approaches. This is currently being reviewed and in 2022 we will publish our findings together with a view on whether further work in this area is of benefit.

4.4.12 Using Sigfox Current & Temperature Sensors to Assess Substation Loading

(ref: 171)

Status: Completed **Project Timeline: Q3 '20 – Q4 '21**

Key partners / stakeholders: ESB Networks, VT IoT

ESB Networks MV/LV substation transformers are not equipped with load monitors. With the proposed electrification of heat and transport, loading levels on existing substations will increase rapidly and many of these which are already estimated to be at 80% or above, they may become overloaded within the timeframe of PR5.

The project notes that the use of traditional voltage and current monitoring equipment presents a costly option – as part of a mass rollout program. Therefore, the use of inexpensive current and temperature monitoring devices, coupled with Sigfox IoT communications capabilities is proposed. These current and temperature sensors can also be installed much more quickly and in a simpler fashion, requiring no physical electrical power connections as they are battery powered. Current and temperature devices record the current on each phase and temperature of the transformer every minute. The maximum and the median readings over each hour, are transmitted back to a digital platform. It is noted that the temperature monitors provide readings that are effectively ambient temperature during low-load operations.

A platform has been used to capture and stage the collected data, from where it is transferred to an ESB Networks platform via an API (an Application Programming Interface - a software intermediary that allows two programmes to talk to each other), where the data can be processed and analysed. The project is being delivered as part of the LV System Development Allowance. The project has targeted transformers in MV/LV substations which are statistically in 'EV friendly' locations and in locations where loadings are already estimated to be high. It is anticipated that the current and temperature sensors will provide an early warning of loading levels, allowing a pre-emptive uprating of substation capacity over the next 2-3 years. The project has been successfully transitioned to BAU, under the LV System Development Allowance with up to 1000 devices installed on the network in 2021. A project close out report will be published in Q1 2022.

4.4.13 Estimation of Allowable Loading on 15/33kVA Single Phase Transformers Based on Annual kWh Throughput

(ref: 172)

Status: In Progress **Project Timeline: Q1 '19 – Q2 '22**

Key partners / stakeholders: ESB Networks

Overview: Without dedicated monitoring devices or aggregated smart meter data, it is not possible to directly measure the loading on existing 15 and 33kVA transformers. This has not been a problem in the past as load growth patterns were relatively static. However, with increased electrification of heat and transport with heat pumps and EVs, there is likely to be a significant increase in load on existing single phase transformers. The capability of the transformer to deal with such new loads needs to be assessed so that action can be taken to ensure our customers' service levels are not negatively impacted by increased electrification.

The aggregation of smart meter interval data, once available later in PR5, will enable peak loadings on existing transformers to be accurately established. The approach proposed for the interim is to establish what levels of kWh throughput have been tolerated by large cohorts of transformers, as this establishes a relationship between loads which have been used for many years without damage to the transformer. This would infer that the higher values of these kWh loadings would align with transformer rating, so that addition of an EV or heat pump would then add a predictable amount to the peak and be acceptable pending the introduction of smart meters and access to data. A selection of 15kVA and 33kVA transformers have been included in the set of 100 transformers selected to have Sigfox temperature monitors installed, see Project ref: 171. Temperature and current monitoring equipment is currently being installed on these transformers to measure the kWh on each cohort of substations that will estimate the upper levels of power throughput commonly experienced on these subs. This will then give an estimate of the upper power limits that these transformers can accommodate. This relates to actual peak loading assessments.

APPROVED PIPELINE PROJECTS

4.4.14 Investigation of Three-Winding Transformers (ref: 106)

This project aims to assess the scope for the use of Three-Winding Transformers on ESB Networks. Transformers with 110kV, 38kV and MV windings could be used to replace existing 110/38kV transformers and so provide two 20MVA stations in city centre sites without the need to buy new sites/buildings. These transformer types have been introduced in Christchurch in New Zealand and Belfast.

Anticipated benefits include:

- Avoid expensive site acquisitions while making a speedier upgrade
- The new transformers can be equipped with tap changers, most likely on the 38kV side
- The approach has the potential to provide additional capacity in spatially challenged locations such as city centres

4.5 CLIMATE ACTION PILLAR

Decarbonising Electricity, Heat and Transport: This innovation pillar 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 Pillar.

4.5.1 Smarter HV and MV Customer Connections (ref: 51)

Status: Complete **Project Timeline: Q1 '17 – Q2 '21**

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

Overview: This project involves ESB Networks proposing fundamental changes to how it connects new customers to the distribution network and reinforces the network whilst maintaining security of supply. It was clear that innovative approaches were needed if ESB Networks is to enable increased penetration of renewable energy, increased flexibility (demand side and energy storage) and satisfy future customer requirements. The key innovations introduced by this project include the concepts of Non-Firm Access to transformer capacity which represents a meaningful change from the "connect and forget" approach within conventional planning standards, and Non-Wires Alternatives to network reinforcement, in the use of demand reduction and flexibility services to manage peak loadings as an alternative to conventional reinforcement. The aim was to ensure that Ireland's energy policy objectives can continue to be met economically and sustainably whilst maintaining or enhancing security-of-supply.

This project step-changed how ESB Networks engaged with stakeholders on our innovation projects. From the initial drafting of the terms of reference through to public consultations, conferences, workshops and bilateral sessions, the project team engaged comprehensively with stakeholders to understand their needs, listen to perspectives, inform our approaches, and influence the final deliverables so that we could develop new methodologies on how to connect customers and reinforce the network that balanced the needs of our customers and enable the delivery of the Climate Action Plan targets.

Following comprehensive stakeholder engagement, consultation research, analysis and modelling, ESB Networks developed recommendations to fundamentally revise the Distribution System Security and Planning Standards and developed two new associated guides which were approved by CRU on 23rd September 2020 and published on the ESB Networks website. The three documents approved and published were:

- Distribution System Security and Planning Standards
- Non-Wires Alternatives to Network Development Guide
- Non-Firm Access Connections for Distribution Connected Distributed Generators Guide

Key changes and improvement to the Standards which were transitioned into BAU (see Section 5.2) are:

- A more transparent approach with the inclusion of more detailed distribution network planning criteria and information, such as security of supply standards, asset loading levels, voltage regulation standards and network development policies which is published on our website to provide customers with a greater understanding of the planning process and rules used in the assessment of customer applications and network development.
- Up to 80% of generators connecting to the distribution system will have the option of Non-Firm Access allowing more economical and faster connection methods from ECP-2.1 onwards.
- The introduction of Non-Wires Alternatives or 'flexibility solutions', as an alternative to delay or defer conventional network reinforcements in up to 25% of situations (% based on limited research and information from other jurisdictions to date).
- Inclusion of a 30% capacity provision of HV and MV transformer capacity for expected future growth in microgeneration connections, to be applied for ECP-2.1, in situations where a non-firm distributed generation connection is under consideration at a HV Station. This interim measure supports the growth of microgeneration which is strongly supported in the Climate Action Plan and was recommended to and approved by the CRU. Following a separate public consultation by ESB Networks in 2020 on the capacity provision for ECP-2.2 onwards, along with further stakeholder engagement in 2021, this capacity provision was approved by CRU for ECP-2.2 onwards.
- Technical criteria applied to the assessment of Energy Storage facilities which will enable the connection of this new type of customer which will provide important system services to cater for the change in landscape in the electricity industry.
- Future consideration of a statistically appropriate contribution from DER to available network capacity to account for the increased connection of DER on our network. This has led to a follow-on Innovation Project, see Section 4.5.4 for further details.

Other deliverables from this project were:

- The development of a 'Load Indices Approach' for use by ESB Networks which provides a loading level profile for HV Stations allowing ESB Networks to use this as an indicator for identifying and prioritising work. This has transitioned to BAU with first use in preparation and submission of PR5 plans. This is another tool that allows ESB Networks' to deliver on our PR5 Commitments efficiently and effectively.
- The incorporation of Demand Connection Code requirements (Commission Regulation (EU) 2016/1388) into the Irish Distribution Code and internal network planning processes, along with the development of the Non-Wires Alternatives Guide and the launch of 'Flexibility Services' trials as part of our "National Network, Local Connection Programme" will enable our customers to actively participate in providing Demand Response Service to ESB Networks.

During Q4 of 2020 and into 2021, the project transitioned and embedded the new standards and related processes into BAU along with further follow-on work (e.g. F-factor Innovation Project, Section 4.5.4), stakeholder engagement and consultation (e.g. Public Consultation on the "Provision in HV and MV Capacity for Expected Future Growth in Microgeneration Connections") taking place throughout 2021.

The Smarter HV and MV Customer Connections Innovation Project Close out Report was published on ESB Networks Website in Q2 2021.

4.5.2 Introduction of Sidewalk Transformer (ref: 41)

Status: In Progress **Project Timeline: Q3 '17 – Q2 '22**

Key partners / stakeholders: Kyte Power Tech (Previously CG Power Systems Ireland Ltd)

Overview: The electrification of heat and transport will lead to increased demand loads and potential congestion on LV networks with the proliferation of LCT.

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

Miniature secondary substations, known as sidewalk transformers, are a potential solution to such spatial restrictions, allowing transformers to be located 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 increase capacity for our residential customers in situations where the use of LCT is anticipated. The project aims to benefit customers by providing a solution to the anticipated increase in loads from EV's and HP's, particularly in urban settings where space is limited, by providing a viable option with an acceptable MVA rating, as cost effectively as possible.

A 10kV 200kVA prototype sidewalk transformer has been designed, type tested, and installed in ESB Networks Training Centre in Portlaoise. The prototype has been designed to meet ESB Networks requirements to be suitable for installation and operation on our Network. The project aims to test and assess the prototype with expert stakeholders and build a "version 2" unit to be energised on the electrical network in early 2022. The live trial will enable the standards, processes and procedures to be developed to bring this solution towards a BAU implementation. The use of the sidewalk transformer will form part of a suite of options available to network planning engineers.

4.5.3 630+ kVA FR3 Natural Ester Transformer (ref: 62)

Status: Complete **Project timeline: Q2 '18 – Q4 '21**

Key partners / stakeholders: Kyte Power Tech

Overview: This project supports the delivery of one of ESB Networks' core objectives, which is to provide necessary infrastructure to support the transition to a clean electric future. As customers transition to the electrification of heat and transport this will result in increased loads on our LV network. Upgrading an existing transformer to a larger size model to accommodate increased loads can be challenging. In situations where the space is not available, except at significant cost, and/or in compact urban areas, innovative approaches that leverage new and improved technologies and materials may be needed. Electrification of heat and transport may result in the largest currently available MV/LV transformer (630kVA capacity) becoming inadequate for both existing and proposed installations.

The proposed solution is to develop a 630+kVA transformer, using FR3 Natural Ester oil and thermally upgraded paper insulation, so that the transformer which can be temporarily loaded safely to circa 1MVA at peak times. This transformer is designed to be retrofitted into the available footprint of a modern walk-in type of Unit Substation, and whose heat output can be adequately ventilated by the Unit Substation Housing, thus allowing existing Unit Substations to be uprated to 630+kVA.

During 2021 the project successfully developed, tested, installed, and commissioned into operation a prototype transformer. All type testing, certification and trials have been successful completed with a 630kVA+ transformer prototype in full operation on the Network. The project is now completed, and a transition plan is being implemented to move the project into BAU (see Section 5.3). The Innovation project close out report has been published on ESB Networks website.

4.5.4 Investigate Statistical Contributions from Distribution Generation - F-Factor (ref: 216)

Status: In Progress **Project Timeline: Q4 21 – Q1 24**

Overview: Traditionally, distribution network security has relied on conventional network assets such as transformers and circuits to supply energy to consumers from the upstream grid. In recent years, there has been an increasing interest in utilising non-network assets to improve cost efficiency and increase security of supply.

The existing ESB Networks' security of supply standard is a deterministic standard that focuses on ensuring that sufficient network redundancy is available to secure demand during peak demand conditions and that loss of supply is recovered within defined timeframes.

As part of the technical consultancy support for the ESB Networks Innovation Project "Smarter HV and MV Customer Connections Project" ESB Networks sought specialist advisory support from EA Technology to review ESB Networks Planning and Security of Supply Standards. One of the recommendations made by EA Technology was for ESB Networks to "*consider the adoption of F-factors in the security standard to take account of the contributions of embedded generation to security*".

F-factors are a statistical means to account for the contribution of embedded generation to security and have been utilised in the UK for a number of years. F-factors are used in planning studies to propose a basis for setting assumed generation output in order to show a reduced requirement for network assets to meet demand but are applied differently depending on whether a generator is not in control of its fuel source (intermittent generation) or whether a generator can control its fuel source (non-intermittent). This project adopts a Fast Follower approach to consider methodologies in other jurisdictions and how ESB Networks' security of supply standard might be enhanced to include the security contribution from embedded generation connected to the network.

Work is underway to scope a public consultation in Q1, 2022 that will seek views on the contribution of embedded generation to distribution system security and the methodology in calculating an appropriate level of contribution.

Benefit: The contribution of embedded generation to distribution security of supply should be accounted for statistically in the development of medium and long-term network development plans and in Load Indices calculations. This project will determine an appropriate contribution of embedded generation to be considered when determining distribution system security. As the levels of embedded generation increase on the distribution network the F-factor approach has the potential to enhance decision making around the optimum network investments which would provide better value for money for customers and help facilitate the Climate Action Plan objectives.

4.5.5 Big Data Analytics for Wind Farm Connections (ref: 82)

Status: In Progress **Project Timeline: Q4 '18 – Q4 '22**

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 project was on hold for a period of time over 2020 and 2021. In 2021 the project was assigned a new project manager who is investigating collaboration with an academic partner.

4.5.6 Introduction of MV/LV Tap Changing Transformers (ref: 22)

Status: In Progress **Project Timeline: Q3 '17 – Q3 '22**

Overview: The LV network is designed so that voltage drop of no more than 5% of nominal voltage (230V) occurs. However, the increased loading on the system, due to the electrification of heat and transport, challenges our design assumptions and this increased loading could result in some LV networks exceeding this 5% limit. There is in addition to voltage drop, the added complexity of voltage rise during the daytime where large amounts of Solar PV is installed.

With a tap changing transformer, the voltage level can be monitored by a relay, which can control an On Load Tap Changer (OLTC). Thus, the LV voltage level can be maintained across a wide range of loading conditions. The transformer has been designed to have 10 raise taps and 7 lower taps and the allocation of upstream voltage drop for 38kV and MV infrastructure can effectively be reallocated downstream to the LV network by using a tap changer to regulate the voltage at the LV busbar to 244V. This means that a larger voltage drop can then be used in the design of the LV network.

A prototype transformer was produced in Q2, 2020 and type testing was arranged with a specialist transformer testing facility in Hungary. The transformer was dismantled after these tests and it was observed that the windings had moved beyond permitted tolerances. In 2021 the transformer was redesigned with additional core and winding clamping. The transformer will be resubmitted for full type testing in Q4 2021 and if successful will be installed under trial in 2022.

4.5.7 Climate-Adapted Alternatives to Creosote Wood Poles (ref: 24)

Status: In Progress **Project Timeline: Q3 '16 – Q1 '25**

Overview: This materials science innovation project requires that improved, if not new, products are needed to replace wood poles currently in use under Irish climatic conditions and to substitute the hazardous components of the chemicals currently in use. The recommended solutions must be adaptable to and reliable in the Irish climate cognisant of the forecasted impacts of future climate change. Not only are non-hazardous products needed but replacement processes must also be introduced to install, maintain, operate as well as to un-install the products.

The sale of creosote has been banned to the general public and although business users are entitled to continue to use it under certain conditions, the Irish Government has indicated its intent to phase out its use in all situations. There are over 2.2 million creosote-treated wooden poles installed countrywide on the LV, MV and HV networks. The Irish climate challenges and impacts the decay of wooden poles. Untreated wooden poles decay at an increased rate, with consequential risks to safety, continuity and reliability. Therefore, alternatives to the creosote treated pole need to be trialled and evaluated.

Substitute pole preservatives have been trialled as an alternative to creosote however they have not satisfied the performance requirements to date. The reduction in the usage of chemicals, such as creosote, is perceived positively by the customer. Any substitute for the existing stock of wooden poles must be robust and reliable or risk inconvenience for the customer and reputational damage to ESB Networks. The project has been researching and trialling alternative materials and has installed 160 composite poles on three overhead line sites. These are being monitored for signs of wear, degradation and weather effects. The timelines of this innovation project have been extended to reflect the need to monitor the trial poles for a more appropriate time (up to 10 years) to better reflect their long-term performance in the Irish context. No adverse effects are reported on the trial pole sets to date and final performance comparison stress tests will be required at the end of the trial.

4.5.8 Wildlife OHL Contact Prevention (ref: 77)

Status: In Progress **Project Timeline: Q1 '19 – Q1 '22**

Overview: The project aims to identify and trial novel measures to prevent wildlife from coming into contact with live conductors and overhead line (OHL) network equipment in general. It is intended to use technology to allow technicians to report bird strikes and other issues caused by wildlife, and the use of mobile device technology can allow workable solutions to be shared. The benefit to the customer will be an improved service (reduced Customer Minutes Lost) through a reduction in wildlife-caused interruptions to supply, while the primary benefit will be to wildlife, who will be deterred from harming themselves. 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.

The project reports positive results from a particular design of 'diverter' which has been trialled in ESB Networks' Northern Region to deter contact between birds and overhead lines. Collaboration with Lancaster University has yielded a better understanding of how birds visually detect obstacles and which colours and shapes work best to highlight them. The ESB Networks' aerial warning devices specification has now been updated to include a variety of solutions intended to reduce wildlife interaction with overhead network, these devices include anti-perching devices, bushing guards, larger spiral diverters and dynamic bird flight diverters.

4.5.9 Wind Farm Reactive Power Optimisation (ref: 83)

Status: Complete **Project Timeline: Q1 '18 – Q4 '21**

Key partners / stakeholders: UCD, Enterprise Ireland

Overview: ESB Networks has collaborated with UCD and Enterprise Ireland to trial 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 a designated circuit further upstream.

The trial of the device demonstrated that the use of the system could bring potential benefits to the operation of the distribution system, however changes would be required to standards. The changes may also have operational ramifications which would need to be taken into consideration in conjunction with operational requirements for our network. The project trials have been completed and the learnings of the project transitioned into the business with a project close out report to be published in 2022.

4.5.10 Developing 400MHz Spectrum Use for Smart Grid Applications (ref: 158)

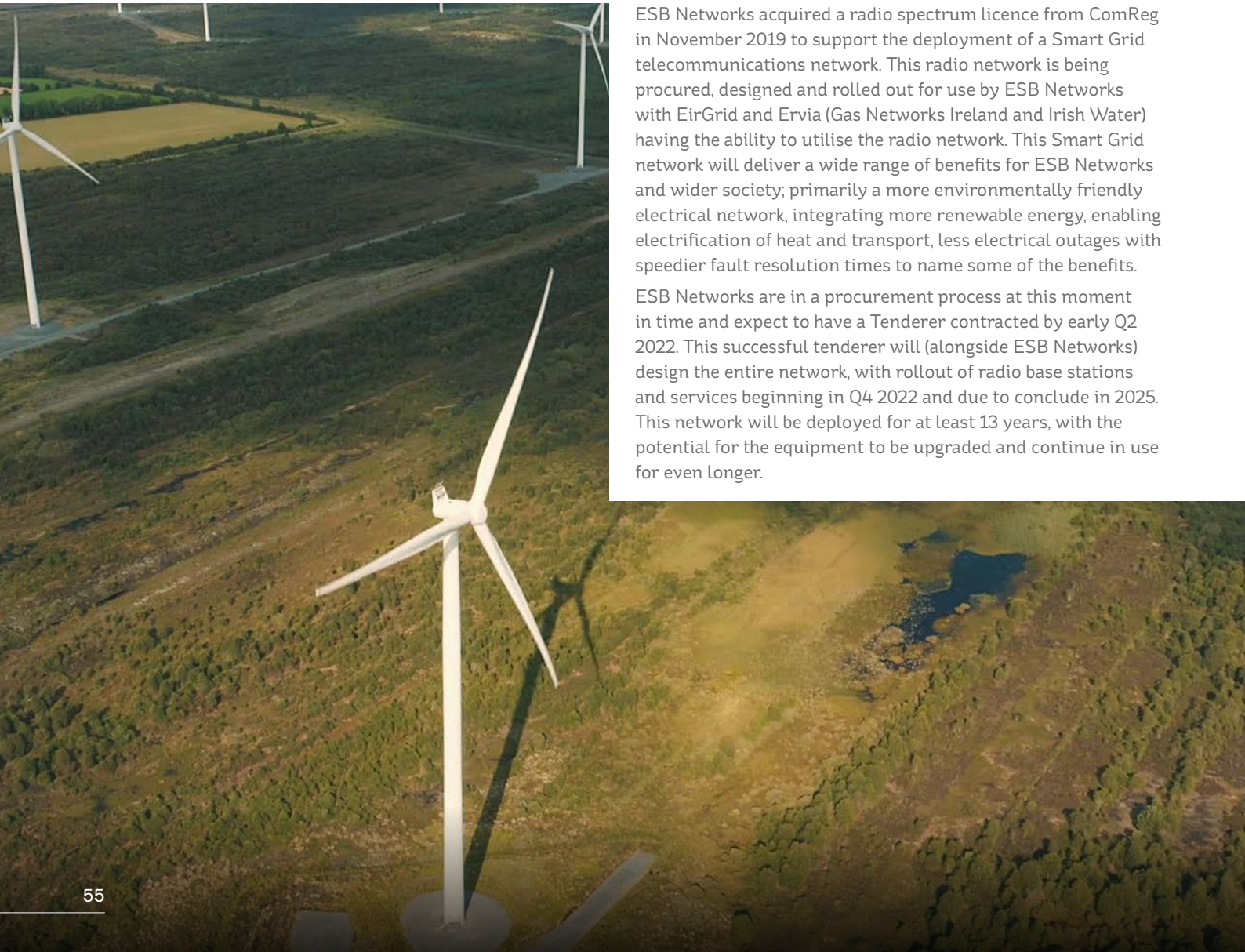
Status: In Progress **Project Timeline: Q1 '21 to Q4, 2025**

Overview: The electricity industry is undergoing unprecedented change, and the methods by which electricity is produced and consumed are fundamentally altering. Secure telecommunications are fundamental to this change and to the safe and efficient operation of the electrical grid.

ESB Networks' existing telecoms infrastructure is fully managed and maintained by ESB Networks Telecoms. ESB Networks Telecoms supports connectivity to primary substations down to 38kV substations. Connectivity beyond the 38kV substation is currently supported by a third-party mobile network. Third party networks are not suitable to meet predicted growth in sensors and line equipment on MV feeders and substations primarily due to coverage, availability, and insufficient power backup. Cyber security weaknesses are also a key limiting factor of third-party solutions. Existing private telecoms solutions deployed by Networks Telecoms are not viable on a large-scale basis.

ESB Networks acquired a radio spectrum licence from ComReg in November 2019 to support the deployment of a Smart Grid telecommunications network. This radio network is being procured, designed and rolled out for use by ESB Networks with EirGrid and Ervia (Gas Networks Ireland and Irish Water) having the ability to utilise the radio network. This Smart Grid network will deliver a wide range of benefits for ESB Networks and wider society; primarily a more environmentally friendly electrical network, integrating more renewable energy, enabling electrification of heat and transport, less electrical outages with speedier fault resolution times to name some of the benefits.

ESB Networks are in a procurement process at this moment in time and expect to have a Tenderer contracted by early Q2 2022. This successful tenderer will (alongside ESB Networks) design the entire network, with rollout of radio base stations and services beginning in Q4 2022 and due to conclude in 2025. This network will be deployed for at least 13 years, with the potential for the equipment to be upgraded and continue in use for even longer.



4.5.11 AI Vegetation Survey System (Tesselo) (ref: 133)

Status: In Progress **Project Timeline: Q4 '20 TO Q2, 2022**

Key partners / stakeholders: Tesselo

Overview: ESB Networks plan to use LiDAR to assess the clearance distance available between trees and overhead lines as part of our vegetation management programme. An approach has been developed by a Portuguese start-up company called Tesselo, which uses satellite imagery in conjunction with LiDAR data to produce additional information on vegetation growth to help inform vegetation management decisions. Tesselo's innovative technology and systems, which use AI technology and satellite imagery, were brought to the attention of ESB Networks as part of the 2020 Free Electrons programme in which ESB Networks sources innovation through start-up companies (see Section 1.5).

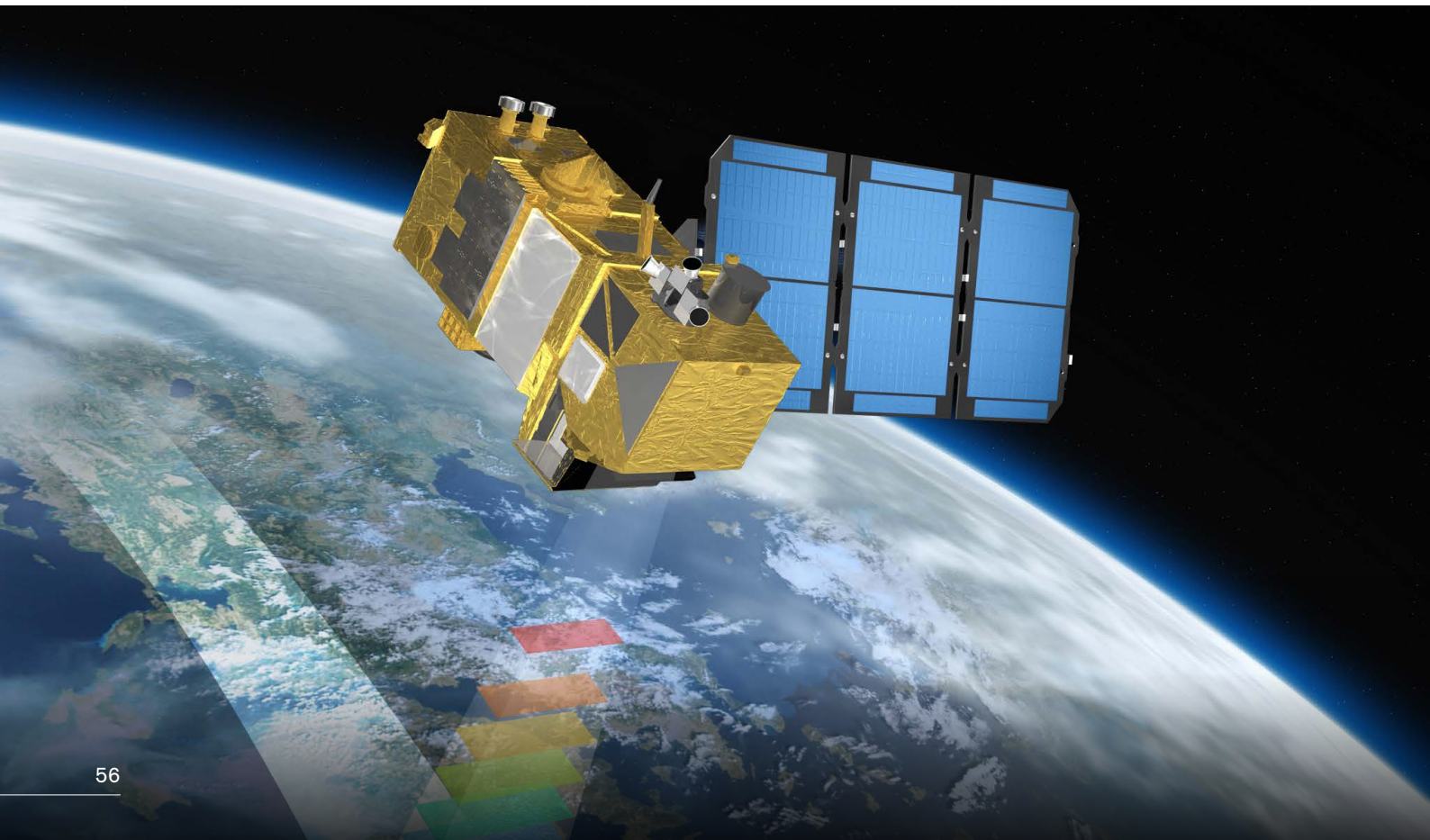
Over 2021, a proof of concept trial for vegetation management assessment was undertaken on a sample of the overhead transmission line network in conjunction Tesselo as part of the Free Electrons programme. Following a review of the data and results submitted during Q2/Q3 2021, the project identified further work required for validation of the Tesselo model using LiDAR contractor-identified vegetation risk sites. This was completed in Q4 2021 with the final steps associated with the original scope of the trial being closed out. A final assessment of the data and overall results from the trial is expected to be completed in 2022.

Approved Pipeline Projects

4.5.12 Novel Low Impedance 33kVA Transformer (ref: 215)

This involves the development of a new low impedance 33kVA transformer which will have a higher short-circuit level and lower regulation than the existing 33kVA transformer on our network. The advantage of this approach is that it will have less voltage drop and be and be able to accept more LCT's connected to the network.

Benefit: If successful in its development and trial the benefit of using this new type of transformer will form a new suite of tools and technology to support the reinforcement of our network in a more efficient and cost-effective way than traditional methods.



Approved Pipeline Projects

4.5.13 Transformer Loss Load Factor Calculation (ref: 107)

As part of the 'Data Analytics to Temperature Correct Loads' project, it was observed that data had been collected which would allow the calculation of Loss Load Factors (LLFs) for transformers. The LLF is defined as average power losses over a period of time to the losses at the time of peak demand, and gives an indication of the energy lost in transformer operation.

This project was formed to provide a visualisation of a sample set of the data to include:

- total power loss per transformer for the selected period;
- average load factor (LFav) / average Loss Load Factor (LLFav) / Transformer Utilisation Factor (TUF) / TLLF; and
- coefficients for converting average LFs to LLFs.

Once trialled, the resultant dashboard/calculations can then be scaled up to include all transformers in the country that are instrumented.

Benefit: It will then be possible to form a picture of each transformer type's LLF according to their rating and voltage levels and to then identify whether different load mixtures had significantly different loading patterns. 38kV/MV transformers may have high LFs, high TUFs and hence high Transformer LLFs. 110kV/MV transformers will have low TUFs as they are less loaded etc. Transformers can then be categorised to aid specification of Loss Capitalisation rates at tender stage.

4.5.14 LV Voltage Regulator – TRON (Temporary Response to OH rural Network Voltage support) (ref: 215)

The aim of this project is to trial the use of LV voltage regulators on our network as a rapid temporary response to voltage issues which may arise on our LV overhead rural network due to the electrification of heat and transport. There have been increased development and usage of LV voltage regulators in recent years to support voltage issues on the network. Due to the asset life of these devices the project will test and trial their installation and operation as a rapid, temporary response to voltage support while traditional network reinforcement can be planned and implemented. If the trials are successful, this would become part of a suit of agile solutions for network reinforcement to support the electrification of heat and transport.

4.6 NETWORK RESILIENCE PILLAR

Efficient, Secure, Reliable Electricity: This innovation pillar focuses on the evaluation of innovations to provide an efficient, resilient and reliable future network that can support a low-carbon future. The following outlines the portfolio of projects undertaken by ESB Networks under the Network Resilience Pillar.

4.6.1 Inspection of Overhead Lines Using Drones and Image Processing Analytics (ref: 19)

Status: In Progress **Project Timeline: Q3 '16 – Q2 '22**

Key partners / stakeholders: TSO

Overview: Currently, line inspections on ESB Networks' overhead transmission lines are carried out manually. To carry out these inspections, the HV lines need to be switched out before inspectors are deployed to carry out visual inspections on all structures and equipment associated with the HV line by climbing its structures. Information on the condition of the HV line is then manually transcribed onto line assessment sheets which are then compiled into an overall report. Disadvantages associated with this approach include: limited range of ability to undertake inspections due to outages; dependence on accessible locations on the structures; data collected can vary in quality and subject to error.

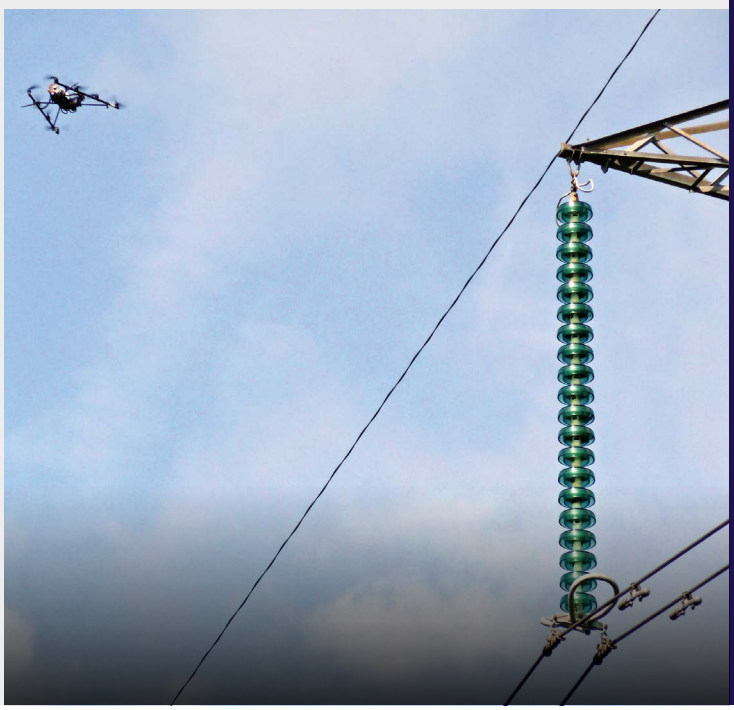
By using new drone and AI systems, this project aims to evaluate a solution as an innovative alternative to the traditional line inspection. This has the potential to reduce time and resources spent on overhead line inspections, improve safety, reduce or eliminate the need for outages and optimise the use of materials and resources. A specification is being developed to procure and engage a specialist service provider to inspect transmission lines using drones. The drone provider will collect visual and location data through visual inspection of structures, insulators, hardware and conductor. The AI service provider will assess the data through automation, at a basic level to produce an automated report detailing the necessary requirements for line refurbishment with a priced options for more advanced capabilities such as automated maintenance order generation in SAP.

The use of AI/machine learning to routinely screen collected inspection images for anomalies, could also allow human experts to focus on high-value-adding analysis of identified anomalies, such anomalies may include installation/design anomalies. AI can aid in building of network models that can be used for asset health assessment, asset recording, maintenance planning and future analysis. Customers, and particularly large customers, are eager that outages for any reason are minimised. The technology trialled in this innovation project supports that ambition by potentially reducing scheduled outages and providing a reliable means to identify asset faults before they result in unscheduled outages.

The COVID pandemic has had a significant impact on the project however it was possible to complete a tender for the procurement of airborne LIDAR services as part of the projects assessment of drone carried LIDAR equipment. Additionally, a procedure for the visual inspection of overhead lines using drones has been drafted.

Benefits/Deliverables: The key objective of the project and trials will be to:

- Demonstrate a saving over the current average line patrol.
- Evaluate the risks associated with the interaction of drones and network components such as insulators and to establish clearance distances and no-fly zones, if necessary, around live and/or delicate equipment.
- Certain inspections would no longer need lines to be switched out, thus improving system security and customer continuity. Additionally, physical line maintenance can be scheduled for regular maintenance outages when works identified by data analyses/AI software can also be conducted. In the event the project proves successful, significant saving (millions €'s) may be realised over a number of years from avoided market adjustments and customer inconvenience that result from scheduled line outages.
- The potential to reduce exposure of personnel to working-at-height hazard is also of significant benefit.



4.6.2 Development of High Voltage Stations Health Index (ref: 69)

Status: In Progress **Project Timeline: Q1 '18 – Q2 '22**

Overview: The project aims to enhance the knowledge of our network assets through near-to-real-time status information and by enabling field technicians to report and carry out maintenance activities using new software applications developed for smart mobile devices. This will allow for an up-to-date status of network assets to be supplied to asset owners, planners, operators and others; arming them with information to make better decisions about more timely maintenance and an understanding of operational limitations. This, in turn, supports the connection of increasing DER on our network.

This project has developed the first phase of a functioning Health Index for all HV substations and their components. The project will involve reviewing current end-to-end maintenance activities and mapping current business processes to develop new systems that allow the capture and updating of network assets information. The project aims to produce a specification document for tender enquiry purposes relating to the procurement of systems and support services. A plan is currently being developed to widen the application of this project to other asset categories.

The HV substations Health Index project has been trialling the use of new apps developed for smart mobile devices that allow the accurate and up-to-date asset health information to be recorded and stored.

During delivery, the project identified that an Asset Health Index methodology was in use in other DSOs and DNOs called 'Common Network Asset Indices Methodology' (CNAIM). By performing due diligence in line with a Fast Follower approach, it was felt that the asset health matrix could be introduced into BAU and this was brought about by transitioning the asset health indices analytics software platform into the business.

4.6.3 Nodal Controller for Reactive Power (ref: 3)

Status: In Progress **Project Timeline: Q1 '16 – Q3 '22**

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, allowing as much reactive power support as possible to be delivered to the TSO-DSO interface, respecting voltage and thermal capabilities of the distribution network. 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, on Topology 2 wind farms. The project team suggests that this solution should be considered for other wind farm types. During 2020 the controller and communications equipment were installed and tested with the control algorithm developed and deployed for test. Installation checks were complete, and the equipment was powered up and tested on the cluster. Testing of the controller was completed and some adjustments were made to the algorithm as a result.

A three-month trial of the controller in full operation began in Q4, 2020. During this trial, some issues occurred at participating windfarms causing suspension of the trial. The cause of these were investigated however the investigation was hampered due to COVID. In July 2021, a risk assessment was concluded, which included further mitigation mechanisms to the controller algorithm and monitoring equipment that facilitated resumption of the trial in August 2021. Upon resumption, further issues with the controller came to light, requiring a second suspension of the trial. A deep dive investigation has identified two issues, one of which is linked to the root cause of the trial suspension. Discussions are ongoing on how best to address these issues. The trial to date has enabled us to highlight issues and develop solutions which is the nature of innovation. The aim is to resume the trials once the issues are addressed.

4.6.4 Leveraging Fibre Infrastructure for Smart Networks Management (ref: 9)

Status: On Hold **Project Timeline: Q1 '16 – Q4 '22**

Key partners / stakeholders: SIRO

Overview: SIRO, a joint venture between Vodafone and ESB, has initiated a program to deploy fibre to the building (FTTB) services to over 300 urban locations in Ireland. The rollout of this service involves the deployment of fibre-optic cables which pass close to primary and secondary substations. ESB Networks has reserved a single-fibre pair on all SIRO cabling for operational use. The fibre runs alongside existing ESB Networks cable ducts and channels. The objective of this project is to identify the best method of installing the additional, usually short lengths of ducting to attain a viable fibre route between SIRO Point of Isolation (POI) and primary/secondary substations.

ESB Networks intended delivering communication services over operational fibre to provide a backup for data communications and to potentially offer control of secondary substations. While the plan was to trial different types of use cases over different technologies, developments in the 'New Core and Aggregation IP Network' innovation project in conjunction with the smart grid 400MHZ spectrum project, have progressed with backup communications being facilitated over existing wired and wireless networks. Consequently, the project scope and objectives is to be reviewed against the long-term strategy and overall communications infrastructure plan in Q1, 2022.

4.6.5 Data Analytics to Temperature Correct Loads (ref: 38)

Status: In Progress **Project Timeline: Q1 '17 – Q2 '22**

Key partners / stakeholders: Met Éireann

Overview: This project uses data analytics 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 can be created using SCADA load data and Met Éireann temperature data. Load, temperature and weather conditions for each MV circuit can be used to set appropriate temperature correction factors. This will result in a baseline temperature corresponding to realistic worst-case conditions, allowing all loads to be 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.

The timeline for this project has been impacted due to COVID and availability of data analytics resources. In late 2021, a new project manager was assigned and an agreed workplan has been developed with the data analytics team to deliver the project by Q2, 2022.

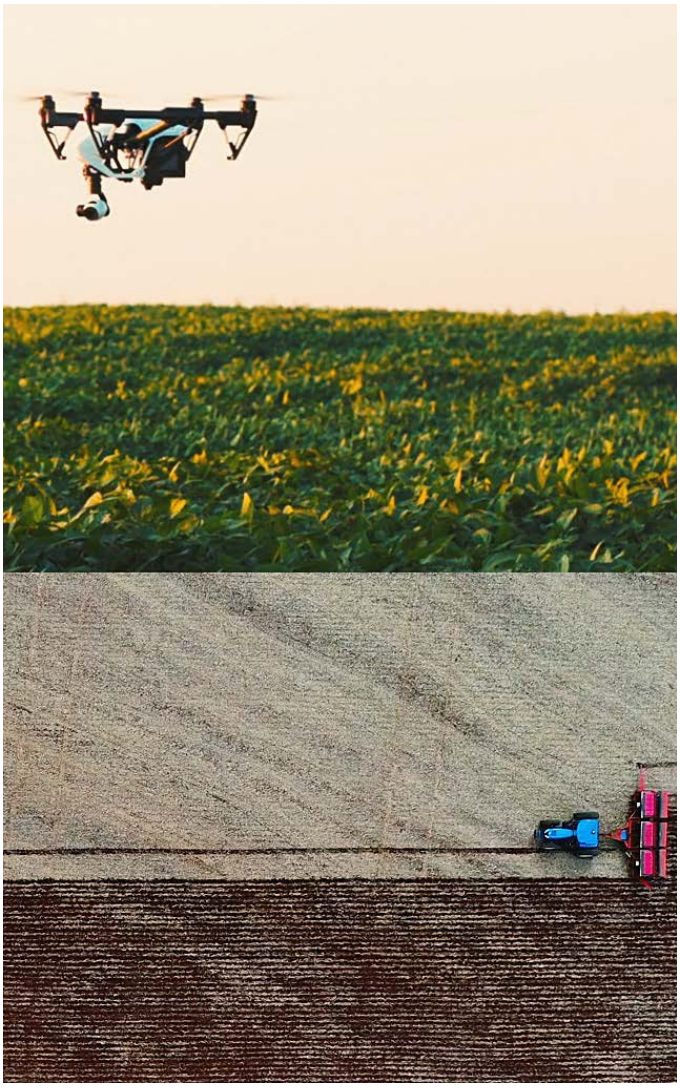
4.6.6 Novel use of Drone Technology and AI for Fault Location and Line Patrolling (ref: 150)

Status: In Progress **Project Timeline: Q1 '21 – Q1 '23**

Overview: ESB Networks have 150,000km of overhead distribution lines on our network. To manage and maintain the network we carry out preventative maintenance such our vegetation management programme and line patrols where NT's walk the route to identify potential faults or issues on the distribution network through often challenging rural and forest terrain. With the advances in drone technology an informal trial of a drone in Dublin South has demonstrated the successful use of 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.

The aim of this project is to investigate the use of drone patrols by our staff where drones will be flown Beyond Visual Line of Sight (BVLOS) and AI will be used to assess the data captured to optimise the patrolling process. ESB Networks was granted authorisation to operate at an Extended Visual Line of Site (EVLOS) licence from the Irish Aviation Authority to trial and operate the drones and are targeting BVLOS certification using our own Light UAS operator certification in 2022. The project has successfully used Drones for line patrol, audit vegetation management and assess vegetation encroachment on our overhead lines. The drones have proven to reduce patrol times by 80% with one drone able to assess as much as 60km of lines in 1 day. The drones can also patrol inaccessible lines due to flooding or inaccessible ground. The project plans to further develop the use of drones and image capture capabilities to audit and assess our network under several use cases.

The benefits from the use of drone patrols will support an improvement in continuity by introducing new ways of identifying faults and network concerns. Using the technology nationally will allow us to capture a large amount of network image data to help our teams identify faults and issues quickly. The use of AI can further enhance the use of this data across a range of use cases from vegetation management audits to line patrols following storms or issues relating to intermittent faults on our network. Using drones for network assessment and fault hunting will support reduced outage times and unplanned outages while improving continuity and network resilience for our customers. This project moved from project pipeline to in progress in 2021.



4.6.7 Storm Resilience for Overhead Networks (ref: 39)

Status: On Hold **Project Timeline: Q4 '17 – Q2 '22**

Key Partners/stakeholders: EPRI

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 in storm conditions. This project will trial several 'hardening' initiatives on an overhead MV line. The project scope involved the destructive testing on an overhead line, the establishment of a larger than standard vegetation exclusion zone on a three-phase backbone line and trialling of smart reinforcement techniques for vulnerable areas of the network.

Testing was carried out at EPRI's facility in New York in the autumn of 2019. Some significant learnings began to emerge about failure mechanisms from tree strikes. Test results led to a focus on the strength and failure mechanism of cross-arms and the consequential damage they inflicted on conductors during failures. It was felt that using fibreglass composite material in the construction of cross-arms could relieve some of the damage. Furthermore, the failure mode analysis seemed to suggest that new methods of stringing conductors need to be carefully considered if lines are to be designed in such a way as to protect the pole from damage. Further testing for this project is on hold due the impacts of COVID and the travel restrictions to the test site in the USA and this mean that the original project completion date of Q1, 2021 was missed. An assessment will be conducted in Q1, 2022 as to how or if this project is to be progressed should COVID continue to cause travel restrictions.

4.6.8 Smart Network - New Core and Aggregation IP Network (ref: 49)

Status: In Progress **Project Timeline: Q3 '16 – Q1 '22**

Overview: The ESB Networks' telecommunications network consists of multiple hardware platforms using a number of manufacturers and is the main means of providing communications and control connectivity for system critical services on the electricity network. To accommodate the introduction of a smart grid equipped with smart devices, the range of critical and non-critical services that will require connectivity on the electricity 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. While project activities have been affected by COVID restrictions, live services for the TSO have been migrated to the new network, with disturbance recorder data initially being made available from a small number of pilot locations. Significant progress has been made on the implementation of 24 aggregations sites developed in 2020 expanding to 78 aggregations sites across the 10 nodes in 2021 and 108 in 2022. The project timelines were extended due to the impact of COVID and the expanded role out of aggregation sites.

4.6.9 Weather Forecasting and Network Damage Prediction (ref: 54)

Status: In Progress **Project Timeline: Q4 '17 – Q4 '22**

Key partners / stakeholders: DTN

Overview: ESB Networks often receives positive feedback from customers in relation to storms and storm damage repair. Nevertheless, customers expect best efforts to manage the impact of an increasing number and severity of storms. Forecasting damage and required response through storm damage prediction is a new and innovative way of meeting expectations. It will also contribute to ESB Networks ability to reinstate safe conditions in the system following storms. This project looks to introduce a system incorporating:

- 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 – on a 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-related network outage events and local continuity data in conjunction with the look ahead forecast.
- The system will be used alongside existing operational technologies to forecast damage and outage numbers to relevant stakeholders and feed into the ESB Networks' response to major weather events.

Phase 1 of this project developed a customised multi day weather forecast service. Weather forecast is broken down into geographical areas corresponding to ESB Networks customer delivery regional boundaries. Specific weather metrics with colour coded thresholds (wind, lightning, rain, snow and frost/ice) are included in the tool information which is sent as an information pack daily via email to specific ESB Networks. This supplements existing Met Éireann weather forecast service to ESB Networks which includes general national forecast and weather warnings. The forecast tool enables network operations and regional management to have a clear view of the upcoming weather patterns to guide decisions on required readiness and response. Over the last two years this has been used successfully and proven to be of great benefit. It has been successfully transitioned and embedded into BAU. It often provides the earliest indication to trigger the consideration of a requirement for additional resources.

Phase 2 of the project was to develop a proof of concept network damage/fault forecasting prediction service. Our project partner developed a model by combining ESB Networks historical network fault data and historical weather events. The prototype tool provided a multi-network fault prediction as part a first-cut model using localised forecasts and asset damage data to predict vulnerable parts of the network during weather events. The trial period of November 2020 to April 2021 had limited data available from real-life events to cross check daily predictions as there were no major weather events during the period. Further analysis is being proposed and development of the prediction tool which will be reviewed in 2022.

4.6.10 Voltage Allocation Between MV and LV (ref: 102)

Status: In Progress **Project Timeline: Q2 '20 – Q3 '22**

Key partners / stakeholders: UCD

Overview: Network reinforcement is required when the voltage drops below standard, with the level of voltage drop being proportional to the load. This means that adding additional load such as EVs and Heat Pumps will cause greater voltage drop and hence drive a need for more reinforcement. However, an alternative approach to reinforcement on the LV system would be, instead, to improve voltage regulation on the MV system which could be more cost-effective. This project looks at the possibilities of using MV voltage regulators to more tightly manage MV voltage excursions and hence allow greater increased LV voltage regulation, with less need for reinforcement. A detailed report on the feasibility of using MV Boosters in multiple configurations (Single Phase, Single Phase in Open Delta and Three Phase configurations was completed by the UCD team and reviewed by ESBN. These results were encouraging and it was decided to progress to the next phase of the project where in a proposed trial in 2022, direct measurements on the network will be used to confirm the results predicted in the analysis. This will involve the addition of voltage and current sensors to the network as well as an additional MV Booster.

4.6.11 Development of Dynamic Line Ratings (ref: 56)

Status: In Progress **Project Timeline: Q1 '17 – Q4 '22**

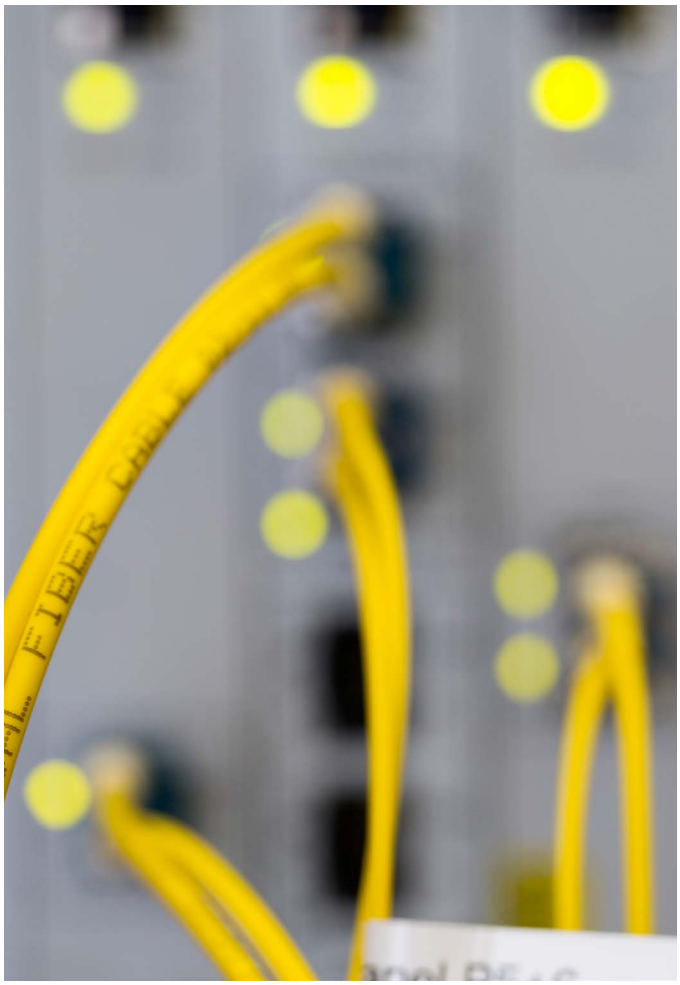
Key partners / stakeholders: Eirgrid (TSO)

Overview: Currently conductors on the overhead distribution and transmission network are assigned static seasonal based ratings. The daily capacity on the network is determined by the conductor size deployed on the circuit and the current season, i.e. Autumn, Winter, Summer. The use of blanket seasonal temperatures (i.e. summer 24°C) for determining the ratings is thought to be very conservative as daily temperatures rarely meet these in summer, however in winter, due to climate change there is an elevated risk that daily temperatures can on rare occasions exceed the winter ratings.

This project represents a fundamental shift in the way the capacity available on the circuits with this new technology is deployed on is determined. Factors such as meteorological parameters (ambient temperature, wind-speed, wind direction) and the current state of the conductor on the circuit (ground clearance, sag, conductor temperature) will determine the allowable capacity on the circuit on an hourly/forecast day ahead basis. As the current seasonal capacity ratings of circuits are considered very conservative, it is expected that the circuits the technology is deployed on will realise an increase in capacity. However, this new technology also comes with the additional control that in the rare event a circuit is exceeding the allowable maximum conductor temperatures (due to high ambient temperatures and low wind speeds), it will be possible to reduce the capacity of the infrastructure to ensure optimum life of the conductors. In certain cases it is expected that this technology will provide:

- An alternative solution to uprating some circuits where it is expected that the increase in capacity is only required during high wind conditions (i.e. wind farms).
- Operational resource improvements.
- Avoided outages – any consequential inconvenience or costs are avoided by not requiring a line outage to increase its capacity.

As of Q4 2021, both the EirGrid functional specification and the ESB specifications for dynamic line ratings are now completed and approved. The tender documentation has been issued to ESB Networks' procurement who will shortly issue a tender to the open market for up to four projects over a period of three years. Tender submissions received will be evaluated in mid-January and February 2022 with the first project to be completed in Q3 2022. The projects timeline has extended in line with the first project completion and reporting timelines.



4.6.12 Real Time State Estimation on Irish Distribution Network (ref: 211)

Status: In Progress **Project Timeline: Q2 '20 – Q2 '22**

Key partners / stakeholders: NovoGrid, SEAI

Overview: Real time visibility of electrical distribution networks will be a key challenge for DSOs in the coming years. Increasingly active distribution networks are now a hosting infrastructure for renewable generation and demand side aggregators. This, when accompanied by new dynamic pricing regimes, poses challenges to many of the assumptions which have driven network planning and operation. The challenge of network visibility is fundamentally about having a real-time, live picture of network states of sufficient granularity such that control actions can be taken. This requires minimising errors in measurements, time stamps and any required communications.

A real-time picture of network status is essential to the secure integration of renewable distributed resources and demand flexibility. This project entails research and innovation activity targeted at the development of a software platform to provide a real-time view of network status for network operators. It represents a collaboration with ESB Networks (as DSO) who together with NovoGrid will undertake a pilot of the software platform of the system to be developed in this project. This pilot aims to provide a necessary and valuable validation of the platform as well as aiming to enable demonstration of the benefits of such systems to network operators as they develop low carbon energy networks. Network modelling and validation of data and model is ongoing for this project. Access has been provided to a network model for use on this project. Additional 3 months of data has been provided from over 100 MV/LV sub monitors, installed under another innovation project, for use in validating the state estimator.

4.6.13 Leveraging Enhanced LV Monitoring to Optimise Targeted Network Reinforcement (refs: 153,160, 171, 174)

Status: In Progress **Project Timeline: Q3 '20 – Q1 '22**

Key partners / stakeholders: Eirgrid (TSO)

Overview: ESB Networks must ensure LV network readiness for increased uptake of low-carbon technology to support decarbonisation and enhance customer continuity. Smart solutions to provide additional capability to the distribution network must be considered as options, as well as conventional reinforcement to provide this capability.

Based on forecasts of areas of the LV network that may require additional capability, the project will focus on the targeted deployment of enhanced monitoring equipment on MV/LV substations. This will validate forecasts and ensure that additional capability is added to the distribution system in a cost-effective and timely manner. Average demands of customers on substations in different socio-economic areas is being used to provide more accurate forecasts of MV/LV substation load taking into account the propensity of customers to buy EVs and heat pumps.

The project developed a network forecasting tool which integrated data sources such as socio-economic data from the Central Statistics Office (CSO) with our own network data. This was used to determine the targeted installations of our LV monitoring equipment on highly loaded substations, or EV friendly locations, where increases in load due to electrification is likely in the near term, as per project ref 171. The project overview was presented to stakeholders as part of the 2021 spring innovation webinar series, Electrification '25 – EV Ready.

5 TRANSITION TO BUSINESS: PROJECTS AND LEARNINGS

5.

ESB Networks' innovation projects deliver quantifiable benefits by successfully embedding the new knowledge, processes, solutions and technologies into our BAU practices to improve the ways in which we work and serve our customers. ESB Networks continues to reap the benefits of projects that have previously closed, as they are embedded in the organisation.

5.1 TRANSITION TO BAU

A culture of innovation is fostered across every level of ESB Networks' business. We have clear innovation objectives and a centralised innovation function that identifies and trials innovation projects before transitioning to BAU. A dedicated Innovation Portfolio and Transition manager continues to focus on improving the transition process and enhance how we disseminate learnings.

The ISG, established in 2019, has enhanced our governance and Innovation Strategy Framework. The internal and external ISG members bring a wide range of experience, expertise and knowledge to the decision-making process. This ensures that the most appropriate innovation projects which also give the greatest benefits to our customers will make their way through the innovation process and transition into the business.
We have found that one of the keys to a successful transition to BAU is to engage the business owner early and ensure engagement and buy-in throughout the project lifecycle.

The Innovation Portfolio and Transition Team use a systematic methodology and implementation process (see Figure 5.1 below) to ensure that a consistent approach to project transition and dissemination is maintained.

Figure 5.1: Transition Methodology and Implementation Process

Once an innovation project is complete and approved by the Innovation Steering Group for transition to the business, the project delivery team compiles a handover document for the business owner. Projects at this point may reveal further innovation opportunities which, once passed the appropriate approvals, may be then followed through within the scope of an existing project or as a new project.

A workshop with the delivery team and Innovation Portfolio and Transition Team is held where a draft implementation plan is developed using a standard checklist (See Table 5.1) as a guide. Subsequent workshops are then held with the Innovation Delivery Team, the Business Owner and the Innovation Portfolio and Transition Team to finalise the implementation plan and allocate roles, responsibilities and timelines to actions.

Checklist Items	Checklist Sub-Items
Scope of Transition	• Scope/Objectives/Measure of Success
Ownership and Stakeholders	• Business/Solution Owner • Business/Solution User • Key Stakeholders
BAU CBA/Benefit Assessment	• Cost Benefit Analysis for BAU • Benefit Assessment for BAU
Business/Systems Transition	• IT Systems • Policies/Standards/Legal Docs • Processes
Resource Transition	• Training • Internal Dissemination
Asset Transition/Procurement	• Tender Requirement: - Specification - Evaluation
External Dissemination	Publications (Consultations/Papers/Reports), Webinars, Workshops, Presentations, Videos , Bilateral Meetings with Stakeholders etc.

Table 5.1: Transition to BAU Checklist

Once the implementation plan has been delivered and the innovation project has been embedded into the business, the outputs and benefits are monitored and tracked by the business owner. This enables ESB Networks to demonstrate true integration of the innovation projects' outputs to BAU and the realisation of the expected benefits.

A dissemination plan is developed for all projects, whether they transition to BAU or not, and whether the trials or research outcomes/findings were successful or not. The purpose of the dissemination plan is to ensure all learnings from our innovation activities are disseminated internally in ESB Networks and externally to the wider industry. The detail of these dissemination activities is covered in Section 2.6 above.

The innovation team continue to engage with other organisations and jurisdictions to investigate best practice and potential improvements for transitioning innovation project portfolio outcomes to BAU. This has enabled shared learnings in relation to the innovation process, governance, project reporting, transitioning projects to BAU, assessing benefits, measuring success and the dissemination of learnings.

5.2 PROJECT LEARNINGS, BENEFITS AND TRANSITION TO BAU

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

In 2021, our engagements were varied and ranged from soliciting feedback and suggestions, to sharing updates on project progress and disseminating project learnings via a range of online industry events, ESB Networks' website, webinars and engaging with research groups in Ireland and abroad. As outlined in Section 2, 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.

Another key priority is to realise the benefits of innovation to our customers by disseminating and transitioning successful projects into BAU. A number of projects that delivered benefits and learnings in 2021 and which are transitioning into BAU are summarised in the following table.

Innovation Projects	Benefits and Learnings	Dissemination and Transition to BAU
Innovation Pillar: **Future Customer** StoreNet Project (ref: 45) Close out report	The purpose of the project was to develop and deploy an intelligent Virtual Power Plant (VPP) consisting of distributed energy storage (batteries) installed at residential settings on the distribution network with the intention of maximising learnings on the potential benefits from the energy storage system. There were learnings around the ability to somewhat reduce the peak demand in the area; measurement of total harmonic distortion and the use of the LV Vision measurement devices, as well as the diffusion of active energy citizen behaviours such as purchasing of Solar PV and battery systems. The learnings have been shared with the NNLC Programme as it looks to engage with customers on the development of a flexibility market.	Project partners publicised the project and its learnings online and the project was also mentioned in the World Energy Council's "Five Steps to Energy Storage" publication. The project was nominated for an SEAI Sustainability Award in 2020. The project partners held a number workshops in Q4 2020 and Q1 2021 to share learnings and outputs from the projects. ESB Networks StoreNet Innovation Project close out report was published on ESB Networks website in June 2021 and the learnings from the project have been transitioned into the business. Our academic research partner will be publishing their reports separately including a number of journal and conference papers.
Innovation Pillar: **Future Customer** Servo (ref: 23) Servo Modeller Close Out Report	**The SERVO Modeller** Innovation Project looked to centralise disparate data sources within ESB Networks to drive digital solutions via cloud technology for process improvement. The project developed and implemented a central repository for all Network Asset data and related time series data for data management and reporting. This will enable other use cases such as special load readings and innovation projects for data analytics. The time series data visualisation web application use case is now being used as a BAU application by over 150 ESB Networks staff across; Networks Planning, HV Operations, System Performance and Planner Group Supervisors to visualise historic SCADA and Large Customer Meter data. The ability to use the web application to visualise historic load data from SCADA and Large Customer QH metering avoids the necessity to download this data from propriety systems and avoids the creation of multiple spreadsheets and unwieldy manual manipulation of data.	Project reports on Servo Modeller and Servo Live & Flex have been published on ESB Networks' website. Workshops, training and internal webinars have disseminated the project learnings and uses to the business. The project was awarded the EPRI Interoperability Leadership award in 2019. SERVO Modeller module has been successfully set up in ESB Networks' MS Azure Cloud infrastructure, thus enabling use cases for the centralised data to be rolled out to the business. Servo planner application, a web-based interface has transitioned into BAU. It is a web-based interface to the Supervisory Control and Data Acquisition (SCADA) and large customer metering that Network Planners use to assess network loading for studies relating to new connections. Other use cases for this centralised data being developed are; Load Indices Report, SLR Report, Capacity Heat Map Website & Data Warehouse for Networks Planning. The planning Datawarehouse will automate these manual processes using Servo data.
Innovation Pillar: **Future Customer** Servo Live & Flex Close Out Report	**Servo Live & Flex** supports the assessment of the impact of low carbon technologies such as Solar PV and Heat Pumps on the low voltage electricity network as part of the Dingle Project flexibility trial use cases. The Servo Live & Flex project developed the technical infrastructure to enable secure collection, storage and reporting (in ESB Network's Microsoft Azure Cloud Environment) of data collected from IoT devices deployed on the electricity network; It has also developed a secure application programme interface (API) to securely enable access to this IoT data set held within the MS Azure Cloud database.	**Servo Live & Flex** provided technical learnings, relating to time series database deployment in the Microsoft Cloud environment which has been shared across the relevant ICT teams across the business. The technical architecture designed for the Dingle Project has been recommended by ESB Networks' IT team as appropriate to support other IoT data collection and storage projects for ESB Networks. Specific Microsoft Azure functions can be developed to recognise payload data from other devices deployed on the network. Initial learnings from the data captured and visualised using the Servo Live & Flex platform in the Dingle Flexibility trials have been shared through the Dingle series webinars and further learnings will be shared in 2022. Learnings from the project in terms of data architecture, communication requirements and technical specifications for low voltage monitoring devices have been shared with the NNLC Programme.

Innovation Projects	Benefits and Learnings	Dissemination and Transition to BAU
Innovation Pillar: **Future Customer** Dingle Electrification Project (59) -LV Mapping -EV Trials -Flexibility trials -Diffusion of learnings -Network Resilience Dingle Electrification Project Website	The Dingle Project is enabling insights and learnings on the adoption of Low Carbon Technologies and how they are used by its ambassadors and trial participants. The project has explored what mechanisms might contribute to a greater take-up of these technologies across communities and what is needed to activate the energy citizen. LV Mapping - this has provided an accurate representation of the entire LV Network on the Dingle peninsula and recording of each LV asset in ESB Networks' databases. The experience and learnings has fed into the LV visibility and mapping programme being developed under PR5 EV Trials - feedback provided by the trial participants led to some changes (e.g. implementation of the EV boost technology to override optimisation schedule) to the technologies deployed; further learnings around profile/smart meter information and impact Flexibility - learnings around battery management; potential for peak energy reduction; home energy management Network Resilience - increased remote control and automation of the MV system including faster response times; lessons around software applications and modelling. This is feeding into the development approaches to improve reliability and continuity in PR5. See Section 2.5 for further details.	The new processes, systems and tools used to undertake the LV mapping across the Dingle peninsula have been disseminated and transitioned into the business under the NNLC Programme In addition to local press and radio, benefits and learnings across all aspects of the Dingle project have been discussed as part of 5 sessions of the Dingle Adapts Energy series in June, and 4 webinars in December of 2021. Updates from the project have been tracked and hosted by ESB Networks, the Dingle Hub, and MAREI, and the project was highlighted as a case study by the United Nations Regional Information Centre for Western Europe (UNRIC) as an example of sustainable development (www.unric.org). The Dingle Project has also participated in webinars and discussions at international conferences including (World Energy Week, European Union Sustainable Energy Week) and National events (SEAI's Transport Energy Research Conference and Engineers Ireland). At the end of 2021, key stakeholders and organisations were invited to Dingle to see the project installations and discuss the outcomes first-hand with the participants and project team. Further project learnings, insights and outcomes will be disseminated through various channels throughout 2022 with the anonymised data being made available to stakeholders for analysis and research. See Section 2.5 for further details.
Innovation Pillar: **Future Customer** Using SigFox Temperature Sensors to Assess Substation Loading (ref 171)	The project supports the electrification of heat and transport by providing data and insights through monitoring the load on targeted MV/LV transformers in statically EV friendly locations and highly loaded in locations. The project has provided visibility and insights of the LV network of to enable targeted pre-emptive uprating of substation capacity in the next 2-3 years to support Ireland's increased electrification.	A platform has been used to capture and stage the collected data, from where it is transferred to an ESB Networks platform via an API, where the data can be processed and analysed. The installation and operation of the LV monitors has successfully transitioned into the business with standard operating procedures, training module, guides and videos developed as part of the project. The projects has successfully transitioned into Business as Usual, under the LV System Development Allowance, with approximately 1000 devices installed on the network.
Innovation Pillar: **Climate Action** 630+kVA FR3 Ester Transformer (ref 62)	The project supports the electrification of heat and transport by providing an innovative and proactive reinforcement solution to LV networks where an MV/LV transformer will become overloaded due to increasing loads from electrification. It allows increased capacity to be provided within the same footprint of a the standard 400kVA and 630kVA transformers. This is particularly advantageous in compact urban environments where real estate may be difficult to acquire and/or be expensive.	The 630+kVA transformer team has successfully transitioned the project to the business asset owner and the project is being Transitioned into BAU. Further information of the transition of the project to BAU are detailed in the case study in Section 5.3.

Innovation Projects	Benefits and Learnings	Dissemination and Transition to BAU
Innovation Pillar: **Climate Action** MV Standard EGIP Modular Substation (ref 81)	The project supports the connection of further renewable generation to the network by facilitating a faster connection of embedded generation, including solar, to the distribution system.	The project published its MV EGIP Standard Module Connection public consultation in December 2020 with feedback closing date of January 11th 2021 and a public webinar was held to detail the consultation and garner feedback from stakeholders. Following feedback from stakeholders in March 2021 a response paper was published responding to stakeholder feedback, see section 3.9 for more details. The project has developed and manufactured a MV Standard EGIP Modular substation and demonstrated the unit at a number of showcase event to stakeholders. The project has developed the specification, procedures and processes for installing, testing and commissioning the module and the fist units expected to be installed in 2022 and transition into BAU. The project has issued the specifications and requirements for installation to customers for their use in their applications for IPP renewable generation installations. 4 MV Standard EGIP Modular Substations are under construction by our manufacturing project partner and will be held in stock for customers who choose this option for their connection agreement
Innovation Pillar: **Climate Action** Smarter HV and MV Customer Connections (ref: 51) Close Out Report	The aim of the project was to ensure that Ireland's energy policy continue to be met economically and sustainably whilst maintaining or enhancing security of supply. Key innovations introduced by this project include the concepts of Non-Firm Access to transformer capacity which represents a meaningful change from the "connect and forget" approach within conventional planning standards, and Non-Wires Alternatives to network reinforcement, in the use of demand reduction and flexibility services to manage peak loadings as an alternative to conventional reinforcement. A key deliverable from this project was the approval of new Planning Standards incorporating these innovative concepts and approaches. Key changes to the standards and their benefits are: • Increased transparency and information on our website to provide customers with a greater understanding of the planning processes and rules. • Up to 80% of generators connecting to the distribution system will have the option of Non-Firm Access allowing more economical and faster connection methods from ECP-2.1 onwards. • The inclusion of a 30% capacity provision of HV and MV transformer capacity for expected future growth in microgeneration connections, to be applied for ECP-2.1, in situations where a non-firm distributed generation connection is under consideration at a HV Station. This interim measure supports the growth of microgeneration will provide certainty in terms of capacity for both larger distributed generators and microgeneration customers to connect to our network during this period of transition to a lower carbon future.	The project reviewed, updated and published new Distribution System Security and Planning Standards. Two new Guide documents were also developed and published as part of this project: • 'Non-Firm Access Connections for Distribution Connected Distributed Generators' Guide; and • 'Non-Wires Alternatives to Network Development' Guide. The new Standards have transitioned and embedded into BAU. Transitioned to BAU for ECP-2.1: • Non-Firm Access connection arrangements and a separate Guide document published. • Technical criteria for the assessment of Energy Storage facilities. • The provision for the expected future growth in microgeneration connections transitioned to BAU under ECP-2.1. Following a separate Public Consultation by ESB Networks in December 2020 on the capacity provision for ECP-2.2 onwards, along with further stakeholder engagement in 2021, this capacity provision was recommended to and approved by CRU for ECP-2.2 onwards. ESB Networks will review this provision in the future. The development of a Load Indices process has transitioned to BAU and was first used for PR5 submissions. This allows heavily utilised HV Stations to be identified, which can be used as an indicator for prioritising investment plans and work programmes allowing ESB Networks' to deliver on our PR5 Commitments efficiently and effectively.

Innovation Projects	Benefits and Learnings	Dissemination and Transition to BAU
Innovation Pillar: **Climate Action** Smarter HV and MV Customer Connections (ref: 51) ***(cont)*** Close Out Report	• The inclusion of technical criteria applied to the assessment of Energy Storage facilities will enable the connection of this new type of customer. • The introduction and development of Non-Wires Alternatives to delay reinforcements. • The inclusion of the future consideration of a statistically appropriate contribution from DER to capacity in Network Development Plans & Load Indices calculations to account for increased connection of DER on our network.	The update of the Distribution Code with the incorporation of Demand Connection Code requirements will enable our customers to participate in providing Demand Response Services / flexibility services to ESB Networks. The concept of Non-Wires Alternatives was developed with a published Guide document and will form part of the 'Flexibility Services' trials under our "National Network, Local Connections Programme" with trials due to begin in 2022. The development of an "F-factor Approach" for ESB Networks is an Innovation Project and work is underway to hold a public consultation on this in Q1, 2022. (See Section 4.5.4) Stakeholder Engagement was a major part of this project to listen to stakeholder needs so that we could achieve revised Standards that balance the needs of our stakeholders and enable the delivery of the Climate Action Plan targets. Ongoing collaboration with stakeholders throughout the project via workshops, conferences and public consultations was key to the success and delivery of this project. (See section 4.4.1) The Smarter HV and MV Customer Connections Innovation Project Close out Report was published on ESB Networks Website in Q2 2021. The project was also presented to internal and external stakeholders at the 2021 Autumn Innovation Webinar.
Innovation Pillar: **Network Resilience** Weather Forecasting – Network Damage Prediction (ref 54)	The project supports the use of improved weather prediction to improve our ability in forecasting damage to the network and required resource response through storm damage prediction in a new and innovative way.	The project developed a new improved daily weather forecasting notification tool to our control room. The notification tool developed has been embedded into BAU as it proved successful over the last two years and often provides the earliest indication to trigger the consideration of a requirement for additional resources due to weather events.

Table 5.2: Innovation Projects Dissemination and Transition

5.3 Transition to BAU: 630+kVA FR3 Ester Transformer (ref: 62)

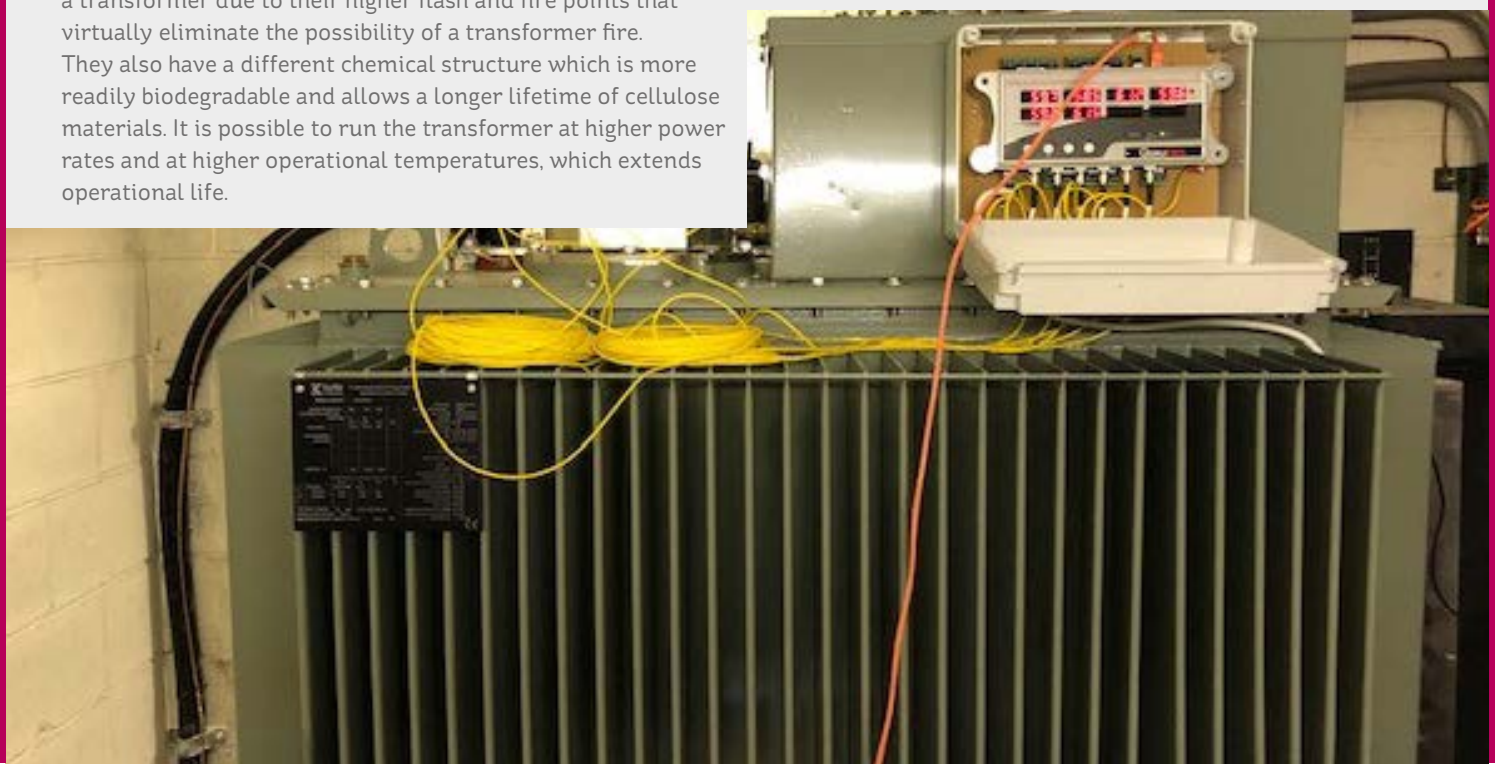
This project supports the delivery of one of ESB Networks' core objectives, which is to provide necessary infrastructure to support the transition to a clean electric future. As customers adopt more low carbon technologies and there is an increase in the electrification of heat and transport, ESB Networks will see increasing loads on the LV network. Electrification of heat and transport may result in the largest currently available MV/LV transformer (630kVA capacity) becoming inadequate for both existing and proposed installations. Upgrading an existing transformer to a larger size model to accommodate increased loads can be challenging in situations where the space is not available, except at significant cost in acquiring land and planning permission for a new second unit substation. Therefore, innovative approaches that leverage new and improved technologies and materials are needed.

The project aims to deliver a means whereby the capacity of existing designs can be increased. Under this innovation project a new innovative 630+kVA compact transformer was developed which retrofits into the existing footprint of our standard 400kVA or 630kVA transformer it is replacing and whose heat output is no greater than that which can be handled by the existing substation housing. The use of FR3 natural ester oil and thermally upgraded insulation paper means that the new transformer can be overloaded safely in existing substation housings and operate at an uprating to 630+ kVA. This means the transformer can operate at for extended periods up to 1MVA safely.

Ester liquids can allow higher operational temperature of a transformer due to their higher flash and fire points that virtually eliminate the possibility of a transformer fire. They also have a different chemical structure which is more readily biodegradable and allows a longer lifetime of cellulose materials. It is possible to run the transformer at higher power rates and at higher operational temperatures, which extends operational life.

The project team worked closely with the prototype manufacturer to develop the transformer to meet operational performance and safety requirements. In 2021 a trial site was selected where the old transformer was removed and the new protype transformer was installed and successfully tested on site. Following the successful development, type testing and field trial of the 630+kVA FR3 Ester Transformer the project was approved for transition into BAU due to the significant benefits and cost savings demonstrated as part of the project vs the traditional approach of splitting a group. As part of the project the team worked closely with internal stakeholders and the business owner throughout the development of the project to develop the technical specification, standards, processes and procedures for the transformer's installation and operation on our network. This approach based on best practice improves the sense of ownership by the business owner of the innovation being transitioned to BAU. For the same reason, the project team worked closely with the business owner to develop, agree and implement the transition plan through workshops and technical approval meetings to transition the transformer into BAU.

As part of the transition implementation the project team developed a handover pack with all the relevant documentation and gate stage approvals required for transition to the business owner. A project Close-Out report disseminating the learnings and outputs from the project was published on our website in Q4 2021. The project team completed a formal handover to the business owner in Q4 2021 who is now managing the final stages of transition to BAU, with the transformer following ESB Networks new material introduction processes. It will be as a standard stock item for use on the network later in 2022.



6 WORK WITH US ON THE INNOVATION JOURNEY

6.

WORK WITH US ON THE INNOVATION JOURNEY

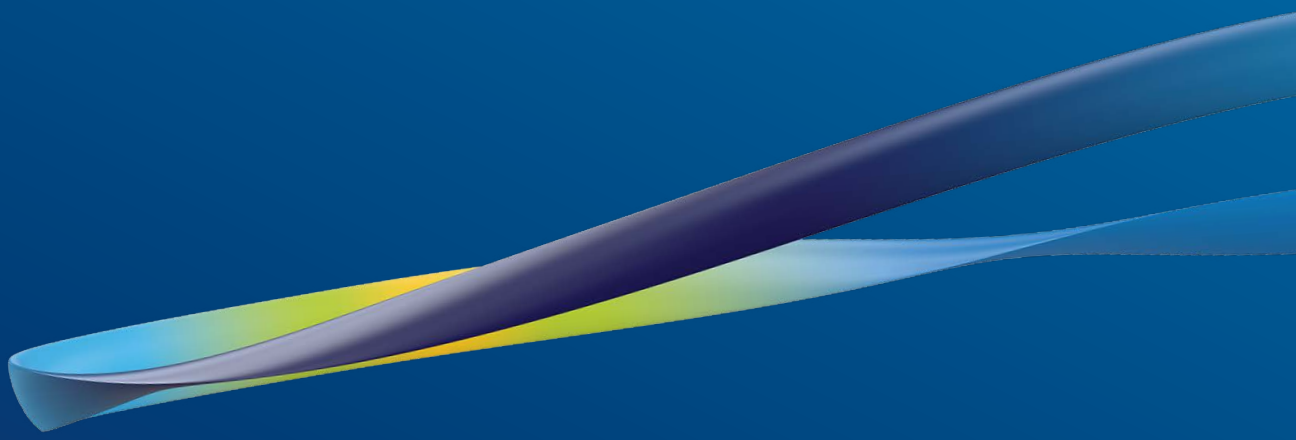
We are very clear in ESB Networks that the challenge of enabling the transition to a low-carbon Ireland cannot be delivered without extensive and collaborative innovation. ESB Networks is committed to leading the transition and knows it must continue to innovate further and faster to increase the volume 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.

Join us on the journey, this transition to the network of the future, by sharing with us your ideas, challenge our approach and continue to hold us to account. We want to hear your views on how ESB Networks delivers innovation, and whether we are focusing on the right innovation projects to connect our customers to a clean electric future.

Please send your comments and feedback to **innovationfeedback@esbnetworks.ie**

NETWORKS



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