Energy for generations

R&D STRATEGY

Strategy, Innovation & Transformation

CONTENTS

INTRODUCTION

ESB faces exceptional challenges in the energy marketplace with the traditional business model of utilities under threat and in decline.

This change is driven by rapid advances in technology, products and services, the advent of the prosumer and the need to reduce carbon emissions. The systems and processes that have made ESB successful to date will not create the platform required to make that transition to a low-carbon future. Hence, we need to refocus our attention to ensure we grow new business and offer our customers new products and services.

There are fundamental changes taking place in the energy sector in the way electricity is generated, distributed and consumed as society moves towards a low-carbon economy.

Our Innovation Strategy outlines our innovation priorities in support of our Brighter Future Strategy. Our R&D activity is a critical part of our Innovation Strategy and plays a key role in shaping the future of both the electricity industry and our business strategy.

Our Business Units have been participating in research and development over many years with much success. This R&D Strategy seeks to ensure our approach to R&D continues to serve us well as we embrace the energy transformation now well underway. It reflects the significantly increased importance of effective and efficient R&D in maintaining competitiveness and driving new growth opportunities in a rapidly changing marketplace.

Jerry O'Sullivan
Executive Director
Strategy Innovation & Transformation
ESB

EXECUTIVE SUMMARY

This strategy outlines ESB's strategic Research & Development (R&D) priorities in line with our Brighter Future Strategy.

ESB'S STRATEGIC R&D PRIORITIES ARE:

- Transition to low-carbon technologies
- Develop a safe, smart, reliable network
- Empower customers with new tools and services
- Lead the electrification of heating and transport sectors
- Enable cross-cutting technologies

OUR GUIDING PRINCIPLES FOR OUR R&D ACTIVITIES ARE:

- Our R&D domain is typically Experimental Development, where proven or near proven technologies are deployed or demonstrated in ESB's operating environments. We will not typically engage in Basic or Applied research as these are more relevant to technology or product development organisations.
- We use an objective approach to assess new technologies achieved through Technology Readiness Levels (TRLs) to evaluate and prioritise technologies that we should engage with for demonstration projects. In general, we will focus R&D activity on technology at TRL-8 or above.
- Our preferred mechanisms for engaging in R&D include working with R&D institutions, new start-up companies, technology developers, universities and research organisations such as Electric Power Research Institute (EPRI); The Economic and Social Research Institute (ESRI); The European Union; EURELECTRIC, which represents the common interests of the electricity industry at European level; The Irish Energy Research Council (IERC); Industry Research and Development Group (IRDG); Sustainable Energy Authority of Ireland (SEAI); and the international technical association for generation and storage of power and heat, VGB PowerTech.
- We will adopt best practice R&D principles including a strategic and structured approach to R&D where R&D activity is customer needs driven, aligned with ESB's Brighter Future Strategy, Strategic Technology Roadmaps and our strategic objectives.

While each business unit manages their own budgets and pipeline of R&D activities, an R&D Co-ordination Group will meet regularly to ensure co-ordination and collaboration happens effectively to improve R&D effectiveness across ESB. The Group will also prepare and issue an annual report to the Executive Director Team at ESB (EDT) outlining R&D activity over the previous 12 months and planned R&D activity over the next 12 months.

In particular, the group will seek to enhance the participation of R&D activity across ESB, support best practice and ensure value for money and commercial impact are at the heart of ESB's R&D activities.

2

WHAT DOES R&D MEAN FOR ESB?

For an activity to be classified as an R&D activity, five core criteria have to be jointly satisfied.

- **NOVEL** - must result in findings that are new to the business / industry
- **CREATIVE** - original concepts, methods, hypotheses, or ideas, excluding routine activity
- **UNCERTAIN** - uncertainty about costs or time needed to achieve the expected result
- **SYSTEMATIC** - conducted in a planned way, with detailed records being maintained
- **TRANSFERABLE AND/OR REPRODUCIBLE** - dissemination of the new knowledge gained is key

Basic research is experimental or theoretical work undertaken primarily to acquire new scientific or technical knowledge, without a specific practical application in view. *For example, basic research could include the study of new materials such as graphene.* This type of research is typically undertaken by publicly funded bodies and agencies such as universities and private research laboratories.

Applied research is work undertaken in order to gain scientific or technical knowledge and is directed towards a specific practical application. Applied research is usually undertaken either to determine possible uses for the findings of basic research, or to determine new methods or ways of creating practical applications. *For example, applied research is ongoing to develop more efficient Solar PV cells using graphene.* This type of research is best suited to product, process and technology development companies. However, we will seek applied research in the areas of environment; market design including market power; forward market and decarbonising electricity; energy policy; and regulation.

Experimental development is systematic work undertaken which draws on scientific or technical knowledge gained from research or practical experience for the purpose of achieving technological advancement, and which is directed at producing new or improving existing materials, products, devices, processes, systems or services. *For example, developing solutions to optimise Solar PV generation using battery storage and demand response technology.* Experimental development is typically concerned with testing and piloting TRL-8 & TRL-9 technologies with a view to commercialisation and capability building for early mover advantage. Experimental development also involves taking innovative technologies, processes or information technology systems developed elsewhere, and examining how they might usefully be adapted, further developed, demonstrated and deployed in an energy context.

Our R&D activity will focus primarily on experimental development with some elements of applied research and we will not pursue basic research.

3

OBJECTIVES OF R&D STRATEGY

The objectives of our ESB R&D Strategy are to deliver an R&D programme in an effective, cost-efficient way to support the growth of the business.

- Establish R&D priorities in line with ESB's Brighter Future Strategy and Strategic Technology Roadmaps
- Facilitate greater co-ordination and sharing of R&D best practice across ESB Group
- Measure and report on R&D performance and effectiveness
- Ensure value for money, through integrating lessons learned and avoiding duplication of effort
- Communicate to stakeholders on R&D priorities and progress
- Ensure Intellectual Property (IP) is proactively managed across ESB Group

4

R&D STRATEGIC PRIORITIES

ESB's Brighter Future Strategy is to lead the transition to a low-carbon future powered by clean electricity. Our R&D priorities are in line with the Brighter Future Strategy and with the five strategic objectives of the strategy.

ESB'S STRATEGIC OBJECTIVES

Put customers' current and future needs at the heart of all our activities	Produce, connect and deliver clean, secure and affordable energy	Develop energy services to meet emerging market needs	Grow the business while maintaining ESB's financial strength	Deliver a high performance culture that supports innovation and collaboration

Our R&D priorities are consistent with our Strategic Technology Roadmaps. The purpose of our Technology Roadmaps is to inform and challenge our approach in specific emerging areas in order to increase revenue, reduce cost and improve performance.

ESB'S CURRENT STRATEGIC TECHNOLOGY ROADMAPS

- **Low-Carbon Energy and Flexibility**
- **Prosumer**
- **Big Data**
- **Digital**
- **Workforce of the Future**
- **Hydrogen**
- **Future Customer**
- **Climate Action**
- **Network Resilience**

In line with ESB's Brighter Future Strategy and the Strategic Technology Roadmaps, we have identified five priority areas for our R&D focus.

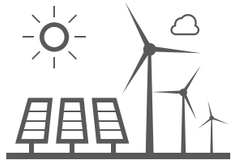
R&D STRATEGIC PRIORITIES

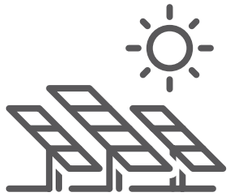
TRANSITION TO LOW-CARBON TECHNOLOGIES

We will improve the efficiency and flexibility of existing generation assets while actively seeking new sources of generation to replace existing coal and peat technologies, without impacting on affordability or security of supply. This means investing and innovating in renewable, low-carbon technologies like off-shore wind, solar, ocean, biomass, hydrogen, batteries and energy storage to manage the responsible transition away from fossil fuels. We will also improve the flexibility, system responsiveness and forecasting of renewable generation output as well as assessing the impacts of intermittent renewable generation on system stability.

DEVELOP A SAFE, SMART, RELIABLE NETWORK

We will invest in the electricity network to facilitate connecting additional amounts of renewable generation by improving network operations and network efficiency, improving communications, visibility and control of the distribution network, and improving network performance through real-time asset condition monitoring. This will increase the resilience, flexibility and reliability of the network to accommodate increasing levels of renewable and distributed energy resources and support increasing levels of electricity demand due to the electrification of heating and transport while also supporting population and economic growth. We will also facilitate energy storage and customer-side and demand-side response on the network.



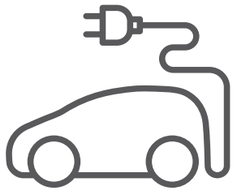


EMPOWER CUSTOMERS WITH NEW TOOLS AND SERVICES

We will bring our customers with us on the journey to a low-carbon future by giving them new tools and services that put the active consumer at the centre of the energy system. This involves the integration of technologies including solar PV, battery energy storage, EV chargers, heat pumps, assessing demand response from customers, developing new product and services offerings to meet customer needs, developing digital platform offerings and trialling and testing customer appetite for new offerings to customers.

LEAD THE ELECTRIFICATION OF HEATING AND TRANSPORT SECTORS

We will lead the electrification of the heating and transport sectors by assessing the impacts on network from customer adoption of technologies to enable the electrification of heating and transport. This includes examining different types of EV charging infrastructure and potential for demand response from EVs, and assessing the performance and optimization of heat pump technologies, as well as examining energy systems of the future.



ENABLE CROSS-CUTTING TECHNOLOGIES

There are a number of enabling technologies and regulatory and market designs that are fundamental to progressing ESB's strategic objectives. We will assess and adopt new enabling technologies such as artificial intelligence and machine learning, Blockchain technology, advanced sensors, data analytics and data science, augmented reality and virtual reality, unmanned aerial, ground and sub-sea technologies and robotics as part of our R&D Strategy.

5

TECHNOLOGY READINESS LEVELS

The majority of ESB's research focus is categorised as experimental development. Technology Readiness Levels (TRL) are used to define the maturity level to which a technology has been developed and the risks associated with attempting to incorporate the technology into an experimental development programme including demonstration projects.

As a technology taker, we will typically engage in demonstration projects with technology at TRL-8 level or above. Typically, demonstration projects at TRL-8 will be undertaken where we can gain a unique competitive advantage such as exclusive use of technology in our markets, or building early capability for first mover advantage in emerging markets.

We may consider experimenting with early technologies and extending further into the TRL-6 and TRL-7 space dependent on certain factors such as low capital intensity, working with a trusted partner or developing specific technology for our requirements. Software, electronics and IT solutions could be included here as these move quickly through the TRL levels. However, capital-intensive technologies such as floating wind, wave or energy storage solutions will not be considered for TRL-6 or TRL-7 early experimental development.

We will keep a watching brief on early TRL technologies. Where early TRL technologies are aligned with our R&D strategic priority areas, we may consider low levels of support (but not investment) for the development of these through the TRL levels. This could include engagement around utility technical specifications, perspectives around energy market opportunities, participating in the development of industry standards, or providing technical requirements for integration of the new technology into ESB operating environments.

TECHNOLOGY READINESS LEVELS

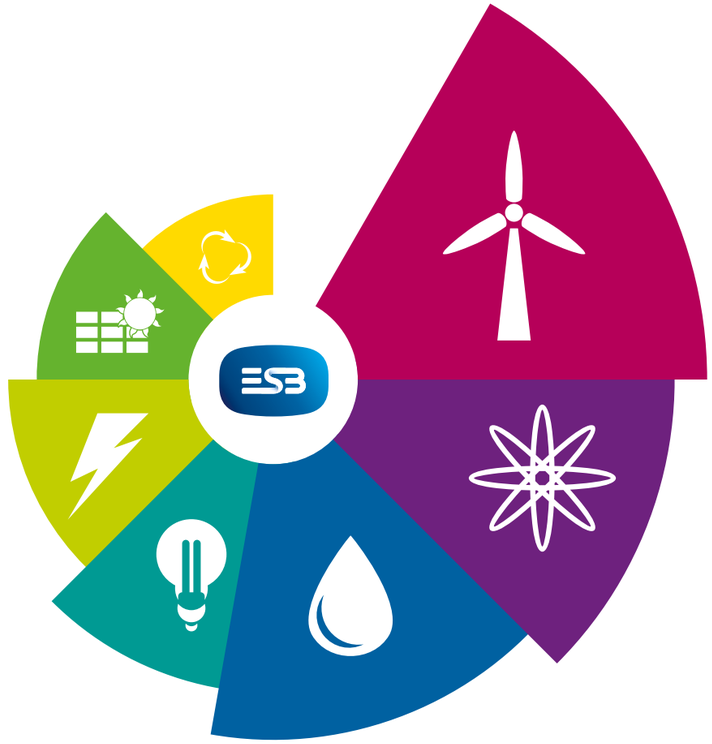
TRL	EPRI DEFINITIONS
TRL-1	Basic principles observed and reported
TRL-2	Technology concept and/or application and/or methodology formulated
TRL-3	Critical function and/or characteristic concept proven through analytical and experimental means
TRL-4	Components validated in laboratory environment; methodology validated via table-top exercise
TRL-5	Components validated in relevant environment; methodology validated in advanced detailed exercise
TRL-6	System/subsystem model or prototype demonstrated in a relevant environment; methodology demonstrated in member utility on pilot basis
TRL-7	System prototype demonstrated in an operational environment; methodology demonstrated in member utility on initial operational basis
TRL-8	Actual system completed and qualified through test and demonstration; methodology demonstrated in member utility on full operational basis
TRL-9	Actual system proven through successful operations; methodology widely adopted throughout industry

6

ESB PREFERRED R&D MECHANISMS

We invest in R&D through a number of preferred mechanisms

- Working collaboratively with utilities, industry representative groups, research organisations, government agencies and universities to progress R&D objectives
- Investing in pilot and experimental demonstration projects, testing and trialling new equipment and developing new bespoke products and service offerings for customers
- Participating in internal and external start-up accelerator programmes to gain access to new emerging technology offerings
- Validating customer needs and market assumptions



7

R&D MANAGEMENT IN ESB

ESB's current R&D activities are managed in a de-centralised fashion with central co-ordination from the Innovation Team within Strategy Innovation & Transformation aligned to the Brighter Future Strategy and Strategic Technology Roadmaps. This process provides a support platform and enables ESB to be proactive in seeking to take advantage of emerging opportunities, while also building awareness across the company around the challenges and opportunities that lie ahead. While each business unit continues to manage their own budgets and pipeline of R&D activities, an R&D Co-ordination Group meets regularly to provide assistance to ensure R&D activities are in line with this strategy and to ensure co-ordination across all Business Units. In addition, common best practice approaches are deployed to prioritise and filter projects and ensure corporate strategic objectives are delivered.

STRATEGY INNOVATION & TRANSFORMATION

Strategy Innovation & Transformation (SIT) sets clear standards and criteria for innovation to ensure there is focus on the right opportunities, and drives these to commerciality by facilitating collaboration across the value chain in line with ESB Group Strategy.

The **Emerging Technology and R&D** team within SIT monitors technology trends and market opportunities for creating new businesses. Publications such as the Emerging Technology Insights report are circulated company-wide and provide a valuable snapshot of emerging technologies of interest to ESB. Collaboration events and workshops are organised which facilitate ongoing reviews of areas of collaboration and the sharing of relevant technology or innovation process insights.

The **Innovation Pipeline** team engages with innovative energy start-up companies, multinational companies and international utilities to co-develop new business models and unlock new revenue streams beyond traditional power sales revenues. Innovation Pipeline are responsible for developing cross-cutting business opportunities of scale in addition to managing specific events such as the Free Electrons global utility accelerator programme for ESB, with 10 partner utilities committed to supporting energy entrepreneurs and start-ups to transform the energy market with next-generation ideas. Free Electrons enables ESB to secure first mover advantage with new products and services.

The **Innovation Performance** team defines and deploys standard innovation management approaches across the Group, promotes innovation thinking culture and behaviours, and supports business units through the early stage development and incubation of new products and services at X_Site. The team works collaboratively with the various innovation and new product development functions, using innovation processes, tools and techniques to enhance innovation capability across the Group.

ESB R&D STRUCTURE

BUSINESS UNITS

Each Business Unit has dedicated R&D teams that focus on activities aligned with this overall R&D Strategy and with their specific Business Unit strategy to address challenges and opportunities arising from the transition to a low-carbon future.

ESB Networks Assets has in place and has developed an Innovation team focussed on three areas, namely:

- Future Networks Development, which provides vision and identifies opportunities within the Future Network strategy for activities and potential trial or demonstration on the distribution network
- Electrification and Innovation Delivery, which is responsible for delivering a programme of pilot and demonstration trials that have been identified to fulfil the requirements outlined within the Future Networks Development strategy and other strategies across Networks.
- Innovation Transition, taking key outputs from pilots and demonstrations and to support the business to transition the new technology, service or ways of work into business as usual.

ESB Networks Innovation Strategy outlines the three innovation roadmaps that are being pursued.

Engineering & Major Projects Technology R&D team collaborates across the Group to leverage the benefits of technology R&D. They work closely with SIT and other business units to understand market challenges and opportunities to assess gaps and potential technology options. The team also collaborates across ESB to understand potential fits of technology opportunities with our strategy.

The **Customer Solutions New Business and Markets** team drives the development of new products and initiatives across Customer Solutions to meet customer needs, as well as acting as the primary coordinator with Strategy, Innovation and Transformation to feed into cross-value chain innovation activities.

Generation & Trading Strategy and IT team leads the development of Generation and Trading's long-term growth strategy through identifying a pipeline of opportunities and leveraging the full capability and input from across ESB Group to ensure delivery of our strategy. The team also drives application of IT and Digital best practices into the business by collaborating closely with Enterprise Services and Strategy, Innovation and Transformation.

Enterprise Services provides support to all Business Units in terms of advancing R&D Innovation pilot and demonstration projects in areas such as Data Analytics, Digital Acceleration and broader IT advice and support.

8

R&D CO-ORDINATION GROUP

ESB will enhance its management of R&D through a company-wide R&D Co-ordination Group who are responsible for the further development and delivery of this strategy. The R&D Group will meet quarterly with cross-business representation and its terms of reference are:

▶ Communicate R&D Strategy across ESB

- Review and communicate this R&D Co-ordination Strategy to relevant managers and teams across ESB to raise awareness of R&D activity
- Set out targets and priorities aligned to Business Unit Strategies
- Communicate R&D success stories to encourage R&D across ESB
- Ensure our research priority areas, preferred R&D types, R&D mechanisms and Technology Readiness Levels are defined and are used in the selection of R&D projects

▶ Report on R&D activities completed and future R&D activities on an annual basis across ESB

- Provide a forum for R&D co-ordination and sharing of R&D best practice across ESB
- Ensure our research, development and innovation activities are co-ordinated with strong collaboration and sharing of information while respecting licence requirements
- Facilitate a process of sharing experiences, lessons learned and a platform to explore new R&D opportunities with colleagues from across ESB

▶ Develop IP governance process

- Develop a process for managing IP and support IP management across ESB

▶ Engage with external R&D community

- Communicate our R&D priorities to external partners including third level institutions
- Support the development of closer relationships and collaborations with external R&D partners such as industry, academia, research institutions and government agencies
- Develop our knowledge and awareness of developments in external R&D community that may have commercial benefits

▶ Measure and report on R&D performance and effectiveness

- Measure cost, benefit and effectiveness of R&D investment
- Report on R&D return on investment showing R&D spend and value for investment
- Benchmark investment on R&D in relation to other utilities

▶ Exploit funding opportunities and Tax Credits to support R&D activity

- Ensure intelligence around new funding opportunities are shared and facilitate collaborations to exploit these
- Manage funding applications where relevant
- Manage R&D Tax Credit process

9

MEASURES OF SUCCESS

The success of the R&D Co-ordination Group will be based on ensuring that this R&D strategy is communicated across ESB and all R&D activities are aligned with Brighter Future Strategy and Strategic Technology Roadmaps.

- R&D activities are co-ordinated across ESB and best practice is embedded across all Business Units
- R&D resources and investments are prioritised in line with Business Units Strategies
- R&D activities are reported on an annual basis
- Funding opportunities are exploited to support R&D activities and an effective R&D Tax Credit process is in place
- Process for managing IP is in place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