SUSTAINABLE ENERGY AUTHORITY OF IRELAND

National Energy Research, Development and Demonstration Funding Programme

IMPACT REPORT 2025

Contents

Ministerial Foreword

Research and innovation are vital to support and enable Ireland's energy transition. Our Departmental Research and Innovation Strategy to 2030, published last May, highlights the emphasis we place on the role of research and innovation for delivery of national policy goals. Our vision is that by 2030, we will be harnessing research to its full potential to drive the action and innovation needed to develop a climate-neutral, sustainable future for our citizens, businesses and communities.

As well as ensuring that we harness research to inform and drive innovation and action in our own work, we also prioritise the funding of external energy research projects through our support for research activity delivered by the Sustainable Energy Authority of Ireland. This support includes funding of the SEAI National Energy Research, Development and Demonstration Funding Programme.

I welcome the publication of this inaugural edition of the SEAI National Energy Research, Development and Demonstration Impact Report. Innovative energy research supported through the RD&D Programme will strengthen delivery of priority actions set out in the Programme for Government 2025, aimed at boosting national competitiveness, tackling the climate crisis and decarbonising the economy. With Government funding and support, the RD&D programme has grown into the revitalised multi-annual programme highlighted in this Impact Report. With approximately €100m in Government funding allocated during research calls from 2018 to 2024, it has stimulated and enabled the delivery of a range of innovative energy research projects, which in turn, deliver wide impacts and benefits for the environment, economy, and society.

"I welcome the publication of this inaugural edition of the SEAI National Energy Research, Development and Demonstration Impact Report. Innovative energy research supported through the RD&D Programme will strengthen delivery of priority actions set out in the Programme for Government 2025, aimed at boosting national competitiveness, tackling the climate crisis and decarbonising the economy."

Darragh O'Brien TD
Minister for Climate, Environment and Energy

CEO Statement

Research making a difference in the energy transition

Over the last 6 years, SEAI has supported approximately 240 innovative energy research projects through our National Energy Research, Development and Demonstration funding programme, to a total funding of over €100million.

In 2018 we instigated significant change to the programme to increase its impact and strengthen the capacity of energy research and development in Ireland. This funding programme contributes to Ireland's transition to a clean and secure energy future by supporting innovation across research institutes, industry, and public sector bodies and connecting this research with policy makers in Ireland. SEAI funds excellent research, through a highly competitive, best practice review process, with the objective of addressing gaps in knowledge and providing solutions to challenges that need to be overcome to accelerate our energy transition.

Part of our role is to ensure that we connect these outputs from funded research with policymakers, citizens, businesses as well as into our SEAI programmes, to create discussions and opportunities for knowledge sharing and to ensure the best, tested and most relevant evidence is supporting all our efforts in the energy transition.

Collaboration is central to SEAI. Ireland's climate action challenge is too big for any single actor to succeed alone. We actively seek to work with all those in Irish society, listening to ideas and building relationships, helping to support all individuals, communities, and businesses in Ireland to be a part of the sustainable energy journey. We aim to position Ireland as an international leader in energy research activities.

As a society, we often do not stop to reflect on the years of research that underpin almost every new breakthrough, seeking and testing the innovation, learning from failures and ensuring it is fit for purpose. Our recent pandemic experience brought this to life for all of us, where investments into research pay such dividends as we drew together nationally in a societal response to addressing the disease. Through research we learn what works, and just as importantly what might not work, to move forward. This report helps to highlight the outputs and impact from the 2018 – 2019 National Energy RD&D Programme, to demonstrate how it is contributing to and benefitting our energy transition journey. Reading through the report, it is easy to focus on the strong numbers, but it is also important to see through the case studies how many people and technology deployments benefit from the knowledge born out of the projects. Through spotlighted projects looking at decarbonising heat, electricity and transport this inaugural impact report demonstrates just how research makes a difference in the energy transition.

William Walsh
CEO, SEAI

Executive Summary

This is the first impact report for the SEAI National Energy Research, Development and Demonstration (RD&D) funding programme, providing details on the outputs and early impacts from projects funded through the annual funding calls of 2018 and 2019. SEAI has supported energy research since 2002. The National Energy RD&D programme is a critical part of SEAI's role in coordinating and supporting energy research in Ireland.

What started as a more limited funding programme awarding for in-year projects grew in February 2018 to the National Energy RD&D funding call facilitating multi-annual funding awards. These projects have largely come to completion, recognising the impact of COVID19 on the timeline of some.

This report describes the objectives of the funding programme, in line with and contributing to national climate research priorities. The focus of the National Energy RD&D programme is to accelerate development and deployment of energy transition solutions in Ireland, supporting ways to overcome barriers to market uptake, to grow Ireland's skills, knowledge and capacity to deliver the energy transition and to provide guidance and support to policymakers. Ireland remains heavily dependant on fossil fuels to meet our energy demands. Since 2021, significant achievements have been put in place including national and EU targets and commitments for the energy transition that are enshrined in national legislation and Climate Action Plans. While many technological solutions are identified, it is critical that any barriers are understood and ways to overcome them are explored in the Irish context. Other solutions are not so clear, and research is an essential part of addressing those gaps.

The remainder of the report showcases research projects funded through the 2018 and 2019 National Energy RD&D funding calls and demonstrates how they collectively and individually delivered economic, societal, policy-related and scientific impact in key areas for the energy transition in Ireland including across electricity, heat and transport sectors. Key numbers for the programme are highlighted including that across over 100 projects over 400 publications were produced engaging with over 380 key stakeholders and the public, and resulting in over 60 software tools, platforms and models. With over 150 organisations involved in the projects, across industry and academia, the programme leveraged over €3.2m in co-funding and the projects supported over 80 PhD, masters students and post-doctoral researchers delivering critical skills for Ireland's Energy Transition. Numbers can only demonstrate part of the story though, and the report also showcases individual projects showing strength in both breadth and depth of impact.

The Projects:

Individual Awards Value & Duration

Pre-2018	**€100,000**	**< 1 year**
2018 – 2019*	**UP TO €650,000**	**4 years**

* SEAI's National Energy Research, Development & Demonstration Funding Programme is subject to the General Block Exemption Regulation (GBER, EU Commission Regulation (EC) No. 651/2014, under which Article 25 apply in respect of different categories of research, development and demonstration projects. For the period 2018-2020 SEAI's GBER notice allowed funding up to €650k and 4 years.

Section 1

The National Energy Research, Development and Demonstration (RD&D) Call Overview and Key Numbers 2018 – 2019

Number and Overall Awards Value

YEAR FUNDED	NO. OF PROJECTS	SEAI AWARDED VALUE
2018	51	€10.4m
2019	57	€11.9m
Total	**108**	**€22.3m**

Organisations Involved

157
TOTAL ORGANISATIONS ARE INVOLVED

75
AS LEADS OR PARTNERS

82
AS COLLABORATORS

THE 75 ORGANISATIONS INVOLVED AS EITHER LEADS OR PARTNERS WERE AS FOLLOWS:

42
INDUSTRY
(24 AS LEADS)

18
THIRD LEVEL
(14 AS LEADS)

15
PUBLIC OR SEMI-STATE BODIES
(7 AS LEADS)

Partnerships and Value For Money

STATE

5
Government /State co-Funders

>€1.6m
Leveraged funding

INDUSTRY

42
Industry /companies

>€1.6m
Leveraged funding

Key Outputs

400+
Publications

550+
Conference Presentations

380+
Stakeholder and Public Engagements

100+
Industry Briefings

250+
Press and Social Media appearances

60+
Software tools, platforms and models produced

Skills Pipeline

Researchers funded by the programme in 2018 – 2019

34
PhD Students

15
MSc Students / Research Assistants

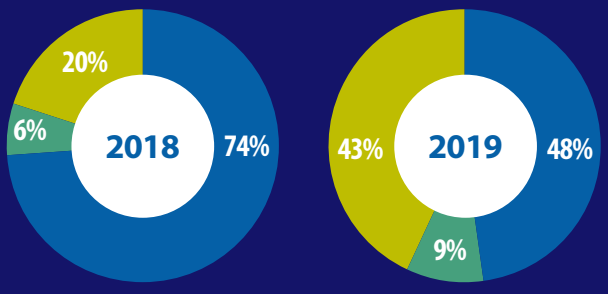
>40
Post Doctoral & Senior Researchers

Project leads representation

From 2018 – 2019

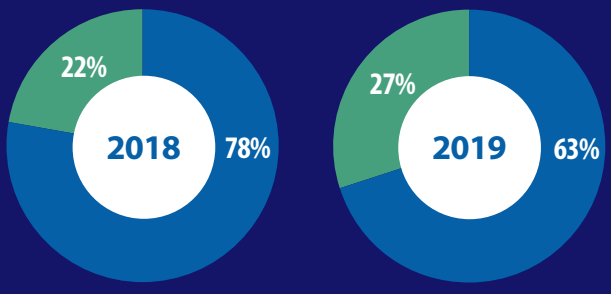
INCREASED INDUSTRY REPRESENTATION

Lead Organisation



INCREASED GENDER BALANCE

Gender



The SEAI National Energy Research, Development and Demonstration (RD&D) Funding Call 2018 – 2019

1.1 Introduction

The SEAI Statement of Strategy 2017 to 2021 outlined how SEAI would support the realisation of its vision for Ireland's energy to be sustainable, secure, affordable and clean through measures and activities focused on the transition to a smarter and more sustainable energy future.

The strategy recognised that Ireland must develop new approaches to its sustainable energy transition from technological, economic and social perspectives. It acknowledged SEAI's mandate to support research, innovation and enterprise, while developing evidence-based responses that engage all stakeholders.

Written in the context of International, European and National policy drivers, and at a time of significant economic and socio-political change, the SEAI Strategy outlined the requirement to address the following key high-level priorities relating to SEAI RD&D activities:

i. increase funding of R&D projects and test sites with national and international impact;

ii. enhance Irish engagement with Horizon 2020[1];

iii. increase delivery of demonstration and innovation projects contributing to enterprise development; and

iv. increase mapping and co-ordination of Irish energy research, leading to higher impact.

1.2 Overview of the SEAI National Energy Research, Development and Demonstration (RD&D) Funding Programme

A significant change to SEAI's RD&D funding supports was implemented in February 2018 when SEAI launched its first multi-annual National Energy Research, Development and Demonstration (RD&D) Call to support projects with a total value award of up to €650,000, over a period of 1 – 4 years. Prior to 2018, the annual call funded short in-year projects with maximum budgets of €100,000.

This RD&D Call has been running since 2018 in a multi-annual format, with projects funded in 2018 and 2019 now reaching completion, noting that the impact of COVID19 impacted the completion date for some of these projects.

This enhanced SEAI RD&D Funding Programme supported innovative and targeted actions that assisted in the delivery of a number of key national policies and strategies including the National Energy Efficiency Action Plan (NEEAP), the National Renewable Energy Action Plan (NREAP), the National Mitigation Plan goals and the 2015 Energy White Paper of the Department of Communications, Climate Action and Environment. More recently, the programme is aligned to the Climate Action Plans, The National Energy and Climate Plan 2021-2030 and the enactment of the Climate Action and Low carbon Development (Amendment) Act 2021.

1.2.1 The Objectives

The overarching objectives of the multi-award SEAI RD&D Funding Programme 2018 and 2019 were:

ACCELERATE

To accelerate the development and deployment in the Irish marketplace of competitive energy-related products, processes and systems.

SUPPORT

To support solutions that help to overcome technical and other barriers to energy market uptake.

GROW

To grow Ireland's national capacity to access, develop and apply international class energy RD&D.

PROVIDE

To provide guidance and support to policy makers and public bodies through results, outcomes and learning from supported energy projects.

[1] Horizon 2020 was the EU's €80 billion research and innovation funding programme from 2014-2020. The programme has been succeeded by Horizon Europe. All programme details and project lists are available on the Horizon 2020 website.

1.2.2 The participants and stakeholders

The programme was open to public and private sector organisations based in Ireland (including Irish subsidiaries of overseas companies) that wished to carry out projects in Ireland. Applications were accepted from companies, research performing organisations (e.g. universities, institutes of technology and publicly funded research institutions), public sector bodies and semi-state bodies based in the Republic of Ireland. The organisations could apply to the programme individually or as part of a consortium.

An extensive stakeholder engagement process was undertaken prior to the call launch in 2018 and 2019 to identify key cross-sectoral research priorities and identify further development opportunities. Engagement with various stakeholders to identify research topics resulted in the formation of co-funding partnerships with key agencies and organisations. This helps to maximise impact for the programme by identifying gaps in knowledge and challenges in the system and directing research to address these. Over the subsequent years the list of co-funding partners has continued to grow.

1.2.3 Communication and dissemination

SEAI continues to develop channels to communicate and disseminate energy research in Ireland.

National Energy Research Database

In 2019, SEAI launched the National Energy Research Database. This database created a central hub for energy research in Ireland. Users can find further details of previous energy research projects supported by SEAI and other national funding bodies. The database enables additional collaboration and communication between companies, academic institutions, research institutes and researchers who work in the energy/low-carbon technology area.

It provides a central database of energy research and competencies within Ireland to make it easier for our audience to find out what energy research is going on, where different research competencies can be found, and connect our users with the relevant contacts. This highlights Ireland's energy research strengths and assists with future research collaboration, both at a national level and internationally. Users can search for projects by topic, year funded, funding agency and keyword as well as downloading search results.

Final reports from all completed SEAI RD&D projects are published on the project page within the database, together with any public deliverables released by the project.

“Part of our role in SEAI is to ensure that we connect outputs from funded research with citizens, businesses, policymakers, as well as into our SEAI programmes, to create discussions and opportunities for knowledge sharing.”

National Energy Research and Policy Conference

The annual National Energy Research and Policy Conference encourages discussion on the role of energy research and policy in the achievement of Ireland's long-term clean energy goals. The conference provides reassurance that energy policy development and implementation is informed by the best scientific advice possible, and that researchers are aware of current and future energy policy priorities. The conference runs with a thematic focus each time, ensuring that the content targets specific themes in-line with priorities in any particular year. It also serves as an outreach and information-sharing medium, growing awareness and promoting discussion on energy research and policy in different areas of the energy sector.

This conference series was launched in 2019, and over the years has concentrated on different important topics, such as transforming Ireland's Electricity Sector, the Heat Sector and also the Transport Sector. It has also delved into social acceptance and public engagement that underpins these transformations and focused on the theme of Achieving Sustainable Energy Security.

Part of our role in SEAI is to ensure that we connect outputs from funded research with citizens, businesses, policymakers, as well as into our SEAI programmes, to create discussions and opportunities for knowledge sharing.

Collaboration is central to SEAI. Our climate action challenge is too big for any one actor to succeed alone. SEAI actively seeks to work with all those in Irish society, listening to ideas and building relationships, helping to support all individuals, communities, and businesses in Ireland to be a part of the sustainable energy revolution.

The SEAI National Energy Research, Development and Demonstration (RD&D) Funding Call 2018 – 2019 (Continued)

Project communication and dissemination plans

Communication and Dissemination is a key part of all research funded by SEAI and each project develops an individual plan on how they will maximise the impact of the project through increasing its visibility, and ensuring that project outputs reach a wide audience of relevant stakeholders.

A selection of communication channels included: television appearances, press releases, communication via social media (X, LinkedIn, applicant's website, etc), brochures/ posters/flyers, public websites, events targeting the general public (festivals, conferences, exhibitions), scientific conferences, International Energy Agency (IEA) Tasks, targeted industry liaison and coverage in specialist press.

Data management plans

Data Management Plans confirm details of where any publicly available datasets will be published. Projects host data in internal repositories or are encouraged to submit to Ireland's Open Data Portal and alternative relevant portals related to their research.

"In 2018 and 2019, SEAI funded 108 projects and provided more than €22 million to industry, companies and third- level education, public sector and semistate bodies based in the Republic of Ireland."

1.3 The 2018 – 2019 RD&D Funding Call Summary

In 2018 and 2019, SEAI funded 108 projects and provided more than €22 million to industry, companies and third- level education, public sector and semi-state bodies based in the Republic of Ireland.

A total of 75 organisations were involved as either lead or partners, 42 of which were industry, 18 third level and 15 public or semi-state bodies. Moreover, more than 80 organisations participated as collaborators in the funded projects.

Year funded	No. of projects	SEAI awarded value
2018	51	**€10.4 million**
2019	57	**€11.9 million**

Total Organisations involved	Total Organisations Leads or partners	Total organisations Collaborators
157	75	82

Total Organisations Leads or Partners Industry	Total Organisations Leads or Partners Third Level	Total Organisations Public or semi state
42	18	15

Total Project Leads Industry	Total Project Leads Third Level	Total Project Leads Public or semi state
24	14	7

2018

€203,853

Average award of projects

42

Projects are complete and 6 are still active

2019

€219,077

Average award of projects

37

Projects are complete and 14 are still active

1.3.1 Co-funders

For the 2018 and 2019 calls, the SEAI National Energy RD&D Funding Programme involved co-funding partnerships with the Department of Transport, the Department of Agriculture, Food and the Marine, Gas Networks Ireland, Geological Survey Ireland, Marine Institute, Met Éireann and ESB Generation.

Collectively these strategic co-funding partners committed €1.625 million to the Programme in 2018 and 2019.[3]

[3] Over the subsequent years the list of co-funding partners has substantially grown, for an overall financial commitment of over €5M at the time of publication in 2025

The SEAI National Energy Research, Development and Demonstration (RD&D) Funding Call 2018 – 2019 (Continued)

1.3.2 Industry cost-share

A total of 42 companies participated in SEAI-funded research projects in 2018 and 2019 as lead or partners, with 24 projects led by companies.

Industry contribution: Under EU State Aid rules, the maximum level of support that a company can be awarded is capped at 80% of total eligible project costs. Companies undertake to fund the remaining costs.

Under this arrangement the Programme leveraged over €1.6 million in direct industry investment in the funded research projects during this period.

The strong industry participation and cost-sharing model not only amplified the impact of SEAI funding but also strengthened the link between research and real-world application, fostering innovation in Ireland's energy sector.

1.3.3 Lead organisations across 2018-2019 awards

Prior to 2018, it was recognised that national funding was mainly invested in research performing organisations or 3rd level research institutes. SEAI worked with policy makers to address this imbalance and encourage greater industry participation in funded research.

From 2018-2019 out of the 45 individual entities leading projects, 24 were companies and 14 were third-level institutes (7 public and semi state). Out of the 75 entities that participated as either leads or partners, 42 were companies, 18 were third-level institutes and 15 public or semi state bodies. This was a significant increase on pre-2018 involvement.

Over the subsequent years the list of co-funding partners has substantially grown, for an overall financial commitment of over €5M at the time of publication in 2025.

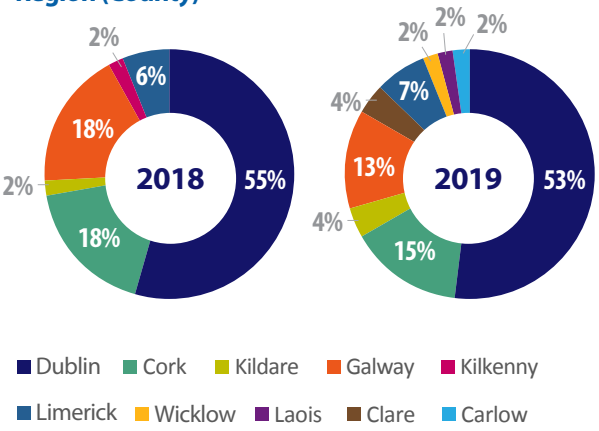
1.3.4 National and Global footprint

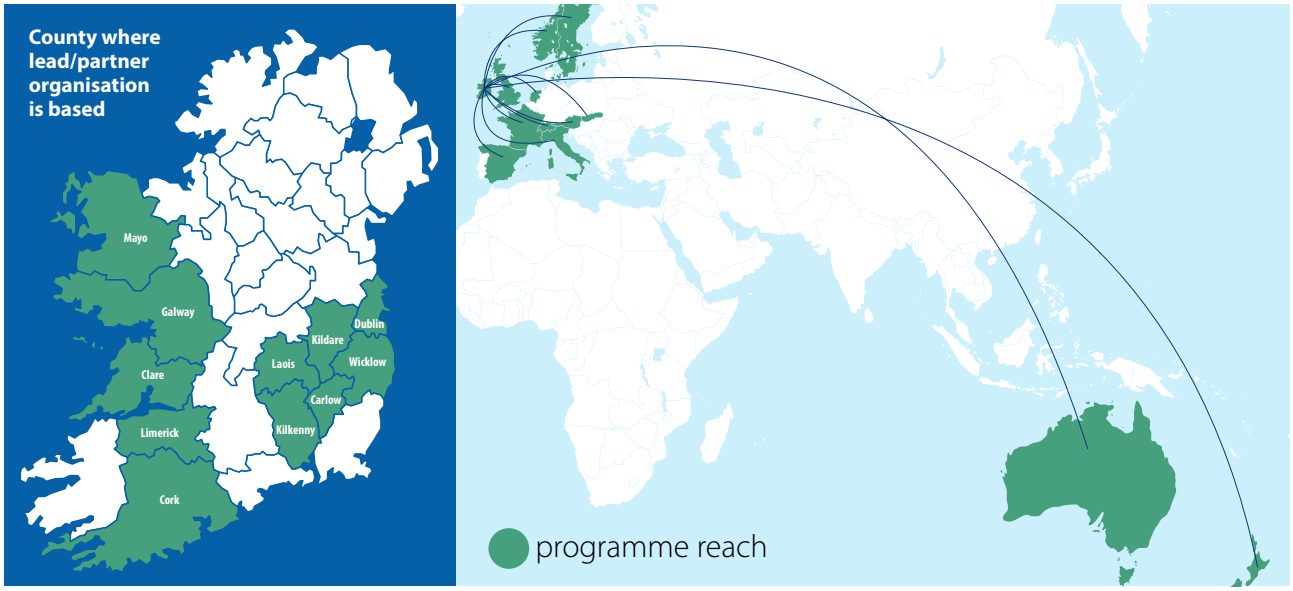
82 partners and collaborators from Ireland, UK, Italy, Sweden, the Netherlands, Slovakia, Norway, Austria, Australia, New Zealand, Spain, and Switzerland were part of RD&D projects significantly extending the reach of the programme.

County where lead/partner organisation is based

- Dublin
- Cork
- Galway
- Limerick
- Kildare
- Kilkenny
- Mayo
- Wicklow
- Carlow
- Laois
- Clare

Region (County)



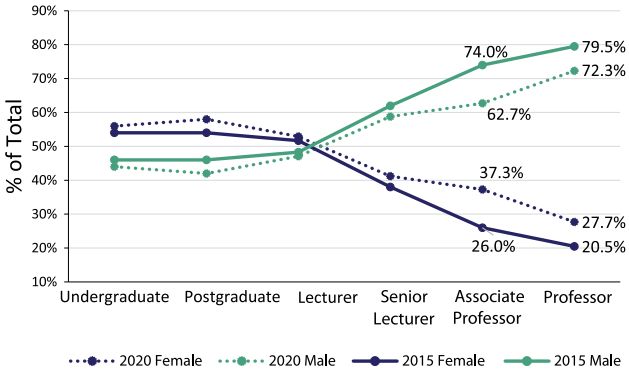


1.3.5 Gender of project leads

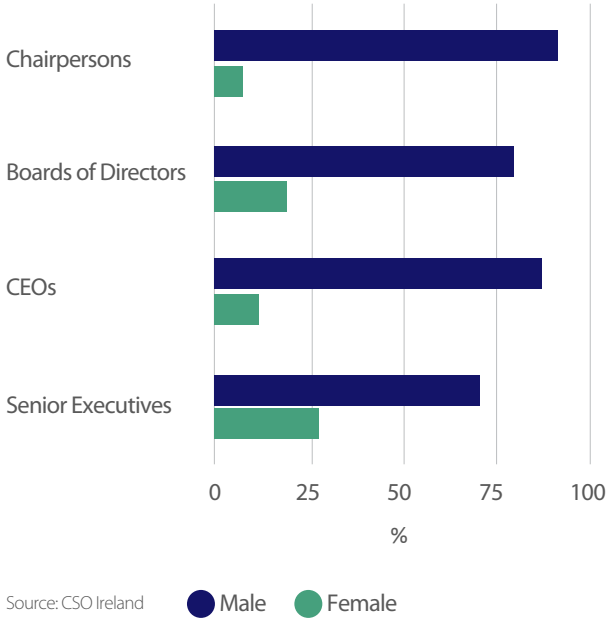
Promoting gender equality in funded research not only increases the quality and excellence of research, but also provides better data and evidence for developing targeted solutions for social and economic policies ***(Gendered Innovations 2 Report, 2020)***. The gender split between applications from project leads has remained around 20% female: 80% male since 2018.

This is reflective of gender splits in academia where 27% of all professors are female ***(Gender equality in education, 2022[4])***, this percentage was even lower at 20% prior to 2018. In industry the percentage of female Chief Executive Officers (CEOs) was 11% in 2019 ***(Gender balance in Business Survey 2019[5])***: only one in nine CEOs in large enterprises in Ireland in 2019 were women. Women occupied 28% of Senior Executive roles compared with 72% for men. The vast majority of Chairpersons were male at 93% with 7% being female. The overall composition of Boards of Directors was 80% male and 20% female.

Gender profile (% headcount) of academic staff and students in the university sector 2015 and 2020 (from: Gender equality in education, 2022, page 7)



Gender breakdown by senior roles in business, 2019 (from Gender Balance in Business Survey 2019)



Source: CSO Ireland

"SEAI recognises that this is an area for further development. A Gender Equality Plan for SEAI was developed in 2022, in line with the European Commission requirements, setting out actions and KPIs for the programme and further steps are being taken to improve the gender balance in funded energy research programmes."

[4] https://hea.ie/assets/uploads/2022/03/Gender-Equality-in-Irish-Higher-Education-2016_2021.pdf

[5] Gender Balance in Business Survey 2019 - CSO - Central Statistics Office

The SEAI National Energy Research, Development and Demonstration (RD&D) Funding Call 2018 – 2019 (Continued)

1.3.6 Skills pipeline

Prior to 2018, SEAI's research funding primarily supported short-term projects, typically lasting around six months. This approach was not well-suited to enabling in-depth studies or was not aligned with the timelines required for academic studentships.

In 2018, SEAI introduced a significant shift by extending funded project durations to up to 48 months. This change opened new opportunities for researchers at all career stages and facilitated the inclusion of funded studentships for PhD and Research Master's candidates. These long-term projects have played a critical role in capacity building within Ireland's renewable energy sector, ensuring a robust pipeline of skilled professionals to meet the growing demands of the energy transition in the coming years.

Between 2018 and 2019, 34 PhD students were recruited onto SEAI-funded projects, along with 15 Master's students and research assistants. Additionally, more than 40 senior researchers, including Post-doctoral and Research Fellows, were engaged in these projects. This collective effort not only advanced academic knowledge but also contributed to developing a workforce equipped to drive innovation and sustainable energy solutions in Ireland.

Moreover, emerging from the funded projects, several spin-outs were explored and market-ready solutions (software, process optimisation platforms) was produced. SEAI recognises the value of spin-outs, registered patents and industry skills is an area of tangible economic and societal impact and it is an area for further development.

"Between 2018 and 2019, 34 PhD students were recruited onto SEAI-funded projects, along with 15 Master's students and research assistants. Additionally, more than 40 senior researchers, including Post-doctoral and Research Fellows, were engaged in these projects."

Section 2

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects

2.1 Introduction

2.1.1 The context – Ireland's energy system in 2018

Ireland has 2030 EU energy targets on both the share of renewable energy in its energy portfolio, and the total energy demand of that portfolio. These dual targets act together to drive our commitment to decarbonise our energy system by increasing the share of renewable energy being used, and reducing the quantity of energy demand, by increasing efficient use of energy through better technology and behaviours.

In 2018, Ireland's energy system remained heavily dependent on fossil fuels, with approximately **89%** of energy coming from oil, gas, coal, and peat (fig 1a).

Ireland's renewable energy share in 2018 was **10%**, with wind energy accounting for half of all renewable energy (fig 1b).

Figure 1(a): Percentage Breakdown of Ireland's Energy Requirement

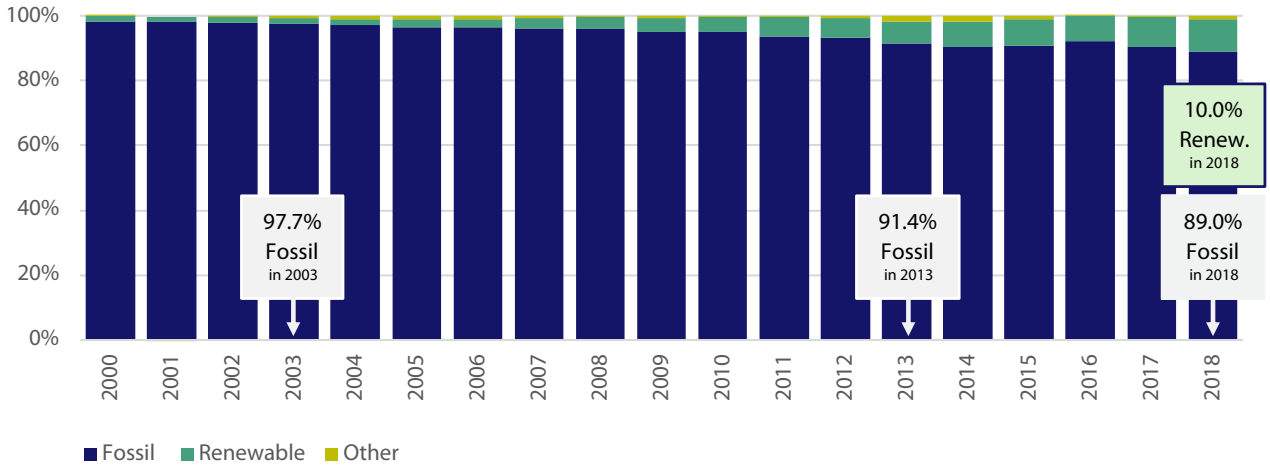
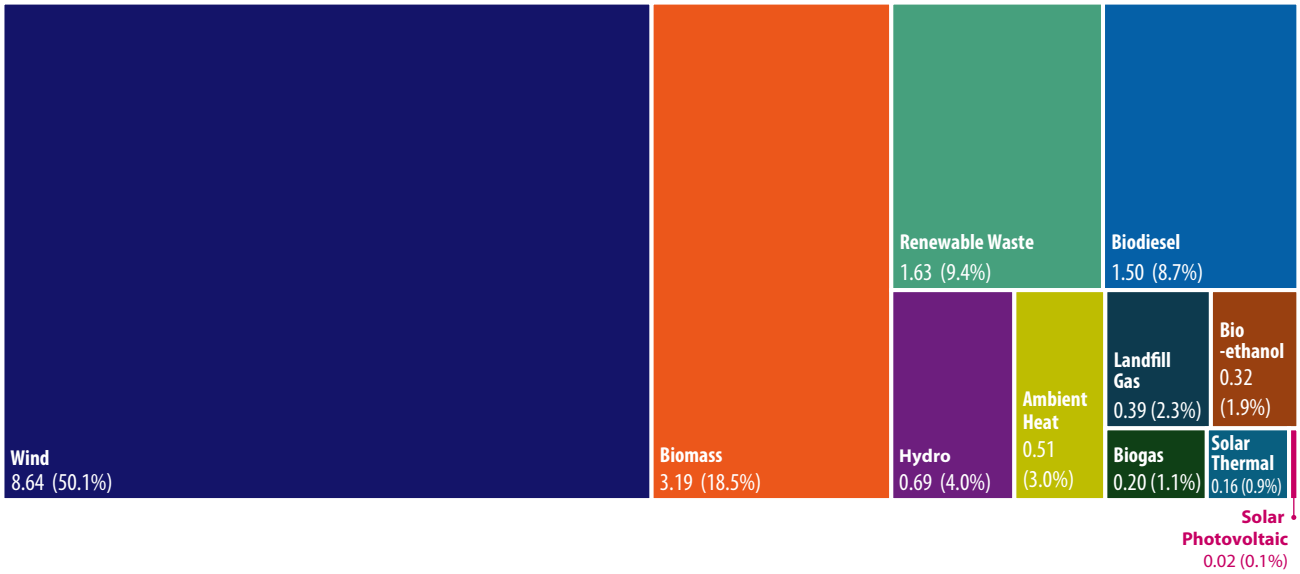


Figure 1(b): Breakdown of the TWh of renewable energy used in Ireland in 2018, expressed as TWh and %.
[Image credit Lee Carroll, Programme Manager Energy Statistics, SEAI]



*"Ireland's renewable energy share in 2018 was **10%**, with wind energy accounting for half of all renewable energy."*

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

As demonstrated in figures 2 and 3, the electricity sector represented about **27.9%** of Ireland's energy-related emissions.

The transport sector accounted for approximately **33.5%** of energy-related emissions and was particularly challenging with over **96%** of energy needs met by oil-based products.

Finally, the heat sector, responsible for around **38.7%** of energy-related emissions, was dominated by fossil fuels with oil and gas boilers providing most residential and commercial heating needs.

Figure 2: National Energy Emissions in 2018.
[Image credit Lee Carroll, Programme Manager Energy Statistics, SEAI]

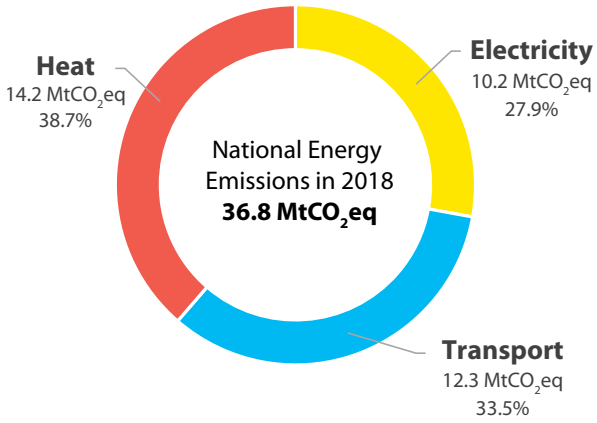
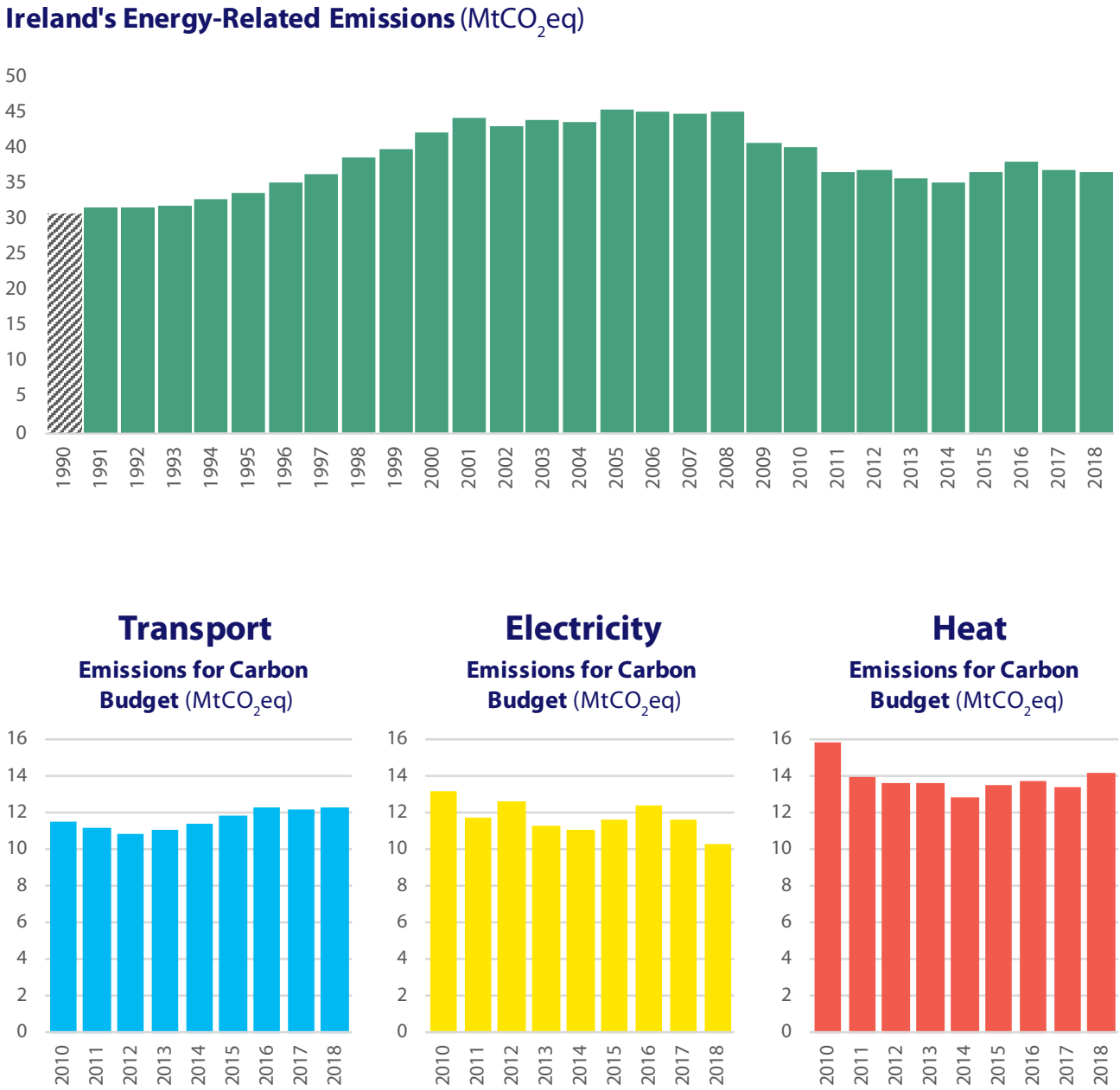


Figure 3: Ireland's energy related emissions, total (top), and split by sector, Transport, Electricity and Heat (bottom), prior to 2018. *[Image credit Lee Carroll, SEAI].*



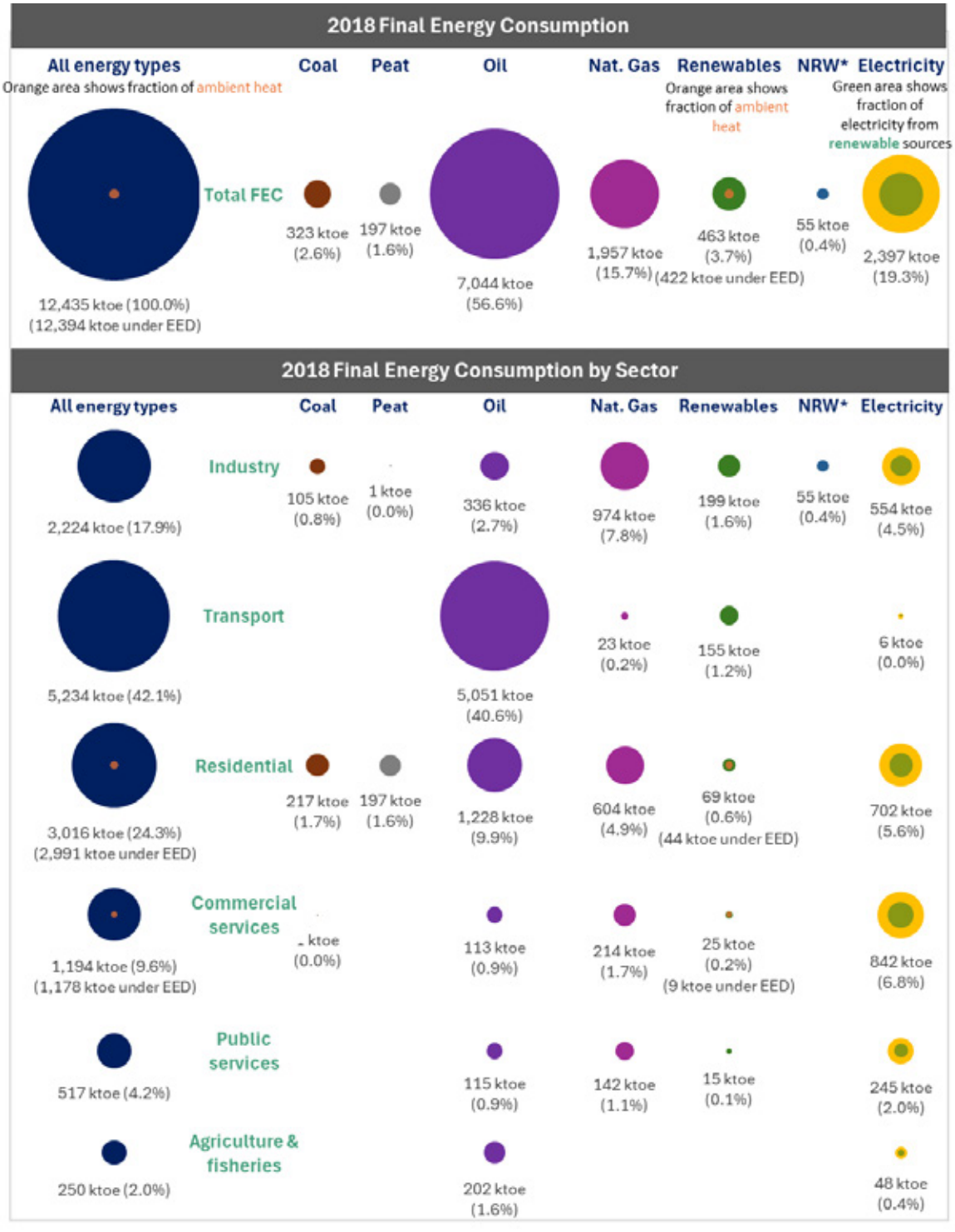
Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

2.2 Key Challenges

Ireland's 2021 Climate Action and Low Carbon Development (Amendment) Act commits to reducing greenhouse gas emissions by 51% by 2030 and to achieving economy-wide carbon neutrality by 2050. This requires immediate emissions reductions in every sector (fig 4). Meeting the 2030 targets would require a fundamental transformation of Ireland's energy system across all sectors (fig 4 and 5). This transition faced multiple technical, economic, and social challenges: integrating high levels of variable renewable energy into the grid, decarbonising heat and transport, improving building energy performance, and ensuring public acceptance of new energy technologies. The scale and complexity of these challenges demanded innovative solutions backed by robust evidence and real-world demonstration.

“Meeting the 2030 targets would require a fundamental transformation of Ireland's energy system across all sectors.”

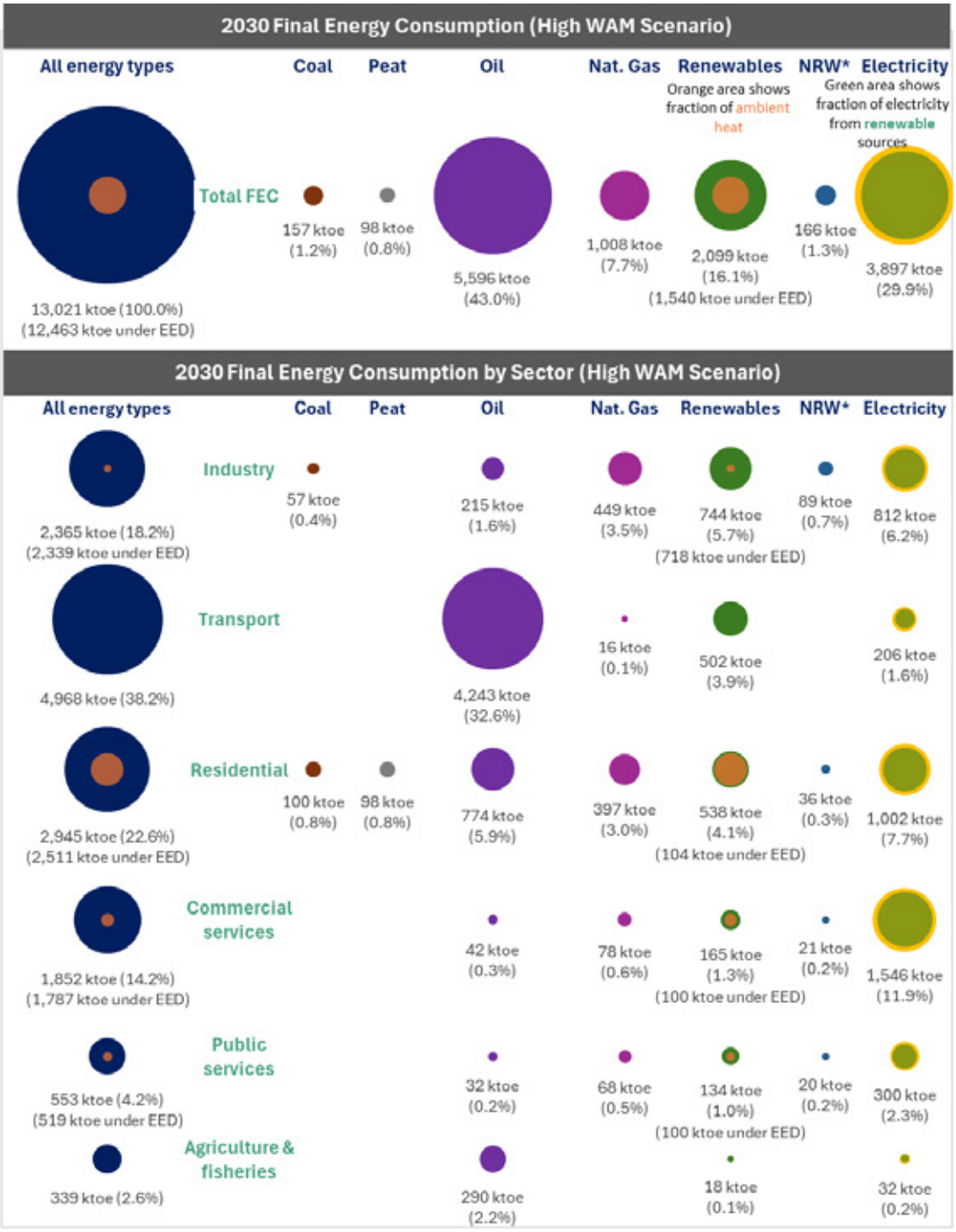
Figure 4: Energy Balance 'Bubble Plots' for 2018.
The 2018 Plots are based on measured statistics *[Image credit Cathal O'Cleirigh SEAI Senior Energy Analyst].*



Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

Figure 5: Energy Balance 'Bubble Plots' for 2030.

While the 2018 Plots are based on measured statistics, the 2030 Bubble Plots are based on future projections under the 'High - With Additional Measures' (High-WAM) scenario, which is one of the most optimistic scenarios considered. The Modelling Team have summarised their most recent projections in this report - https://www.seai.ie/data-and-insights/seaistatistics/key-publications/national-energy-projections. *[Image credit Cathal O'Cleirigh, Senior Energy Analyst, SEAI]*



2.2.1 Addressing the energy challenge

The growing urgency of climate action, combined with rapid technological advancement in areas like renewable energy, energy storage, and smart systems, created both opportunities and uncertainties for Ireland's energy transition. To navigate this complex landscape, research plays a pivotal role in identifying optimal pathways forward, developing and validating new technologies, addressing implementation barriers, and providing evidence to support effective policy making.

The impacts of such research extend far beyond technical innovation alone. As defined by the European Commission, research impact encompasses 'any change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life.' Through this lens, research supports Ireland's energy transition not only by advancing renewable technologies and improving efficiency, but also by driving behavioural change, informing policy decisions, and creating economic opportunities.

This chapter examines the diverse benefits realised from the SEAI RD&D projects funded in 2018-2019, analysing their contributions across scientific, economic, societal, and policy dimensions post completion.

“The growing urgency of climate action, combined with rapid technological advancement in areas like renewable energy, energy storage, and smart systems, created both opportunities and uncertainties for Ireland's energy transition.”

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

2.3 Impacts

2.3.1 Understanding Research Outputs, Outcomes, and Impacts

Outputs: The immediate products of research activities, such as publications, datasets, and tools.

Outcomes: The intermediate effects resulting from the use or application of these outputs, including knowledge transfer and stakeholder engagement.

Impacts: The broader, long-term changes driven by research, including economic growth, societal advancements, policy developments, and scientific breakthroughs.

The SEAI RD&D Funding Programme supports projects across all aspects of the energy transition. In section 1 we looked at the RD&D Programme 2018-2019 numbers on a page. However, research outcomes and impact are broader than just those numbers.

In those funding calls, successful projects were required to clearly demonstrate their relevance to the needs of the Irish energy sector with reference to key policy documents, including Ireland's National Renewable Energy Action Plan (NREAP) and the National Energy Efficiency Action Plan (NEEAP) 2020 targets, the National Mitigation Plan and/or the Energy White Paper.

SEAI funded projects aligned to four Impact Categories that were outlined in the call documents:

Economic
(e.g. jobs, exports, turnover growth);

Societal
(e.g. benefit to consumers);

Policy-oriented
(e.g. contribution to evidence-based policy formation and/or the legislative/regulatory framework);

Scientific
(e.g. enhancement of Irish scientific capacity and capability).

Examples of the type of impact that may fall within each impact category are given below:

Scientific/Academic impact

Creating high-quality new knowledge

Strengthening human capital in research and innovation

Disseminating knowledge and using open access channels

Societal impact

Delivering successful community-based projects and educational programmes that increase access to information and enable participatory processes to benefit the quality of life of the wider society

Addressing environmental challenges to that restore or protect ecosystems

Policy impact

Addressing Irish/EU policy priorities and global challenges through research and innovation

Strengthening the use of research and innovation in policy development

Economic Impact

Generating innovation-based solutions to challenges

Creating better jobs

Leveraging investment in research and innovation

This report captures the outputs and impacts for the SEAI National Energy RD&D programmes 2018 and 2019, under the four categories above and organised under the energy sectors of Heat, Electricity and Transport.

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

2.4 Heat Sector

2.4.1 Introduction

Energy used for heating and cooling accounts for 24% of Ireland's greenhouse gas emissions, but the current pace of decarbonisation falls short of the cuts required. Almost every sector of Ireland's economy uses heat energy, and decarbonisation efforts will need to be implemented by industry, businesses, and households. This requires a comprehensive, robust and actionable evidence base that policymakers and other stakeholders can use to make decisions (Heat and Cooling in Ireland, SEAI 2022).

SEAI funded projects related to heat decarbonisation collectively advanced Ireland's heat sector transition through complementary research spanning technology, implementation, and policy dimensions. Strong emphasis on stakeholder engagement and practical application ensured research impact beyond academia.

2.4.2 Outputs and Impact

A. Common Themes and Research Focus Areas

The Heat sector research program has demonstrated several consistent themes across its diverse portfolio of projects. At its core, the program maintained a strong focus on real-world performance and practical implementation, moving beyond theoretical studies to generate evidence from testing, deployments and demonstrations. This was complemented by comprehensive knowledge transfer and stakeholder engagement activities, ensuring research findings reached and influenced key decision-makers. The projects successfully integrated technical, social, and economic aspects, recognising that effective solutions must address multiple dimensions of the energy transition. Throughout the programme, researchers maintained a clear focus on policy relevance and practical application, while developing scalable tools and frameworks that could support wider adoption of solutions.

B. Collective Impacts

SCIENTIFIC IMPACT

The collective impact of these projects has been substantial across multiple dimensions. From a scientific perspective, the programme has significantly advanced methodological approaches in several critical areas including building performance assessment, resource mapping and modelling, technology evaluation, and environmental monitoring. Researchers generated extensive new datasets that have enhanced understanding of building energy performance, geothermal properties, biomass conversion processes, and indoor environmental quality.

Many projects contributed to international research networks, strengthening Ireland's position in the global research community while also enhancing national research infrastructure.

Key Scientific Innovation Highlights:

- Advanced methodological approaches across multiple areas:
  - Building performance assessment
  - Resource mapping and modelling
  - Technology evaluation
  - Environmental monitoring
- New datasets on:
  - Building energy performance
  - Geothermal properties
  - Biomass conversion
  - Indoor environmental quality
- Contributed to international research networks
- Enhanced national research infrastructure

SOCIETAL IMPACT

The societal impact has been significant and far-reaching across multiple communities and stakeholder groups. The research program has directly enhanced industry capacity through structured training initiatives, including a Continuous Professional Development programme that certified 89 practitioners in traditional building renovation techniques. Public understanding and acceptance of low-carbon heating technologies has improved through targeted engagement activities, reaching over 470 attendees through major conferences and hundreds more through workshops and information sessions. Projects created practical pathways for community energy transitions, particularly through the Dublin Region Energy Master Plan which engaged with local communities to develop feasible decarbonisation strategies. Critical social challenges were addressed, with research identifying specific barriers preventing vulnerable households from accessing free retrofit schemes, leading to improved program design and delivery.

Building occupant health and wellbeing were significantly enhanced through projects that monitored and improved indoor air quality in energy-efficient homes, with demonstration projects showing up to 60% reduction in issues like condensation and mold. In rural areas, particularly through bioenergy projects, the research has supported new development opportunities - for example, demonstrating how farm-based energy generation could create additional income streams while reducing environmental impacts, with some projects showing up to 96% reduction in gaseous emissions from treated farm wastes. The programme has also enhanced professional skills across multiple sectors, from energy auditors to retrofit contractors, helping create sustainable employment opportunities in the green economy. Regular engagement with residents through post-occupancy studies has provided valuable insights into how people interact with new technologies, leading to improved user guidance and better real-world performance of energy efficiency measures.

Key Societal Highlights:

- Built industry capacity through training and guidance
- Enhanced public understanding of low-carbon technologies
- Created pathways for community energy transitions
- Addressed energy poverty concerns
- Improved building comfort and health
- Supported rural development
- Enhanced professional skills

ECONOMIC IMPACT

Economically, the program has delivered significant market insights and validated multiple business opportunities. In the residential sector, research identified viable financial models for deep retrofits, demonstrating how blended finance approaches combining public and private funding could deliver reduced interest rates for homeowners while remaining commercially attractive for lenders. The development of One-Stop-Shop models has created the basis for new business opportunities for service providers, while research on heat pump performance has supported market growth by providing evidence of cost-effectiveness and return on investment. In the bioenergy sector, projects demonstrated viable business models for farm-based energy generation, with potential revenue streams from multiple sources including electricity generation, biomethane production, carbon credits, and nutrient recovery - showing potential annual returns of up to €96,000 for larger agricultural operations.

Geothermal research has helped de-risk investments by providing detailed resource mapping and assessment methodologies, enabling more accurate cost-benefit analyses for developers and supporting supply chain development in areas like drilling and heat pump installation. The research programs have also supported broader economic development by identifying skills gaps and providing frameworks for professional certification, such as the Biomass Practitioners Register. Projects looking at community-scale solutions, particularly around district heating, have identified significant economies of scale, with potential cost reductions of 25-30% compared to individual heating solutions. Market intelligence generated through monitoring and demonstration projects has been particularly valuable for technology suppliers and installers, helping them optimize their offerings and improve customer confidence in renewable heating solutions.

Key Economic Highlights:

- Identified viable business models
- Created assessment frameworks for technology deployment
- Supported supply chain development
- Generated market intelligence
- Created new revenue opportunities
- Informed investment decisions
- Enhanced funding mechanisms

POLICY ORIENTED IMPACT:

The policy impact has been substantial, with research directly informing several key national policies and regulations. Projects provided evidence that shaped Ireland's residential retrofit programs, particularly the National Retrofit Plan targeting 500,000 homes by 2030, and informed the development of Minimum Energy Performance Standards (MEPS) for the rental sector. The research supported implementation of the EU Energy Performance of Buildings Directive (EPBD), particularly around Nearly Zero Energy Buildings (NZEB) requirements and building energy rating methodologies. Several projects informed updates to Technical Guidance Documents, especially Part L (Conservation of Fuel and Energy) and Part F (Ventilation) of the Building Regulations. In the bioenergy sector, research provided evidence for agricultural emissions reduction strategies and renewable energy support schemes under the Renewable Energy Directive (RED II). Projects also shaped regional and local authority planning tools, particularly through the Dublin Region Energy Master Plan which created frameworks for spatial energy planning.

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

POLICY ORIENTED IMPACT: (CONTINUED)

The geothermal research programme informed Ireland's first policy framework for geothermal energy development, while work on innovative finance mechanisms supported the development of green mortgage frameworks and credit enhancement programs aligned with the EU's Smart Finance for Smart Buildings initiative. This science-based evidence has enabled more effective design of grant schemes and incentive programs by the Sustainable Energy Authority of Ireland (SEAI), particularly around deep retrofit supports and renewable heat deployment.

Key Policy Highlights:

- Informed regulations and technical standards
- Provided evidence for policy development
- Created planning tools and frameworks
- Supported EU directive implementation
- Enhanced understanding of barriers and solutions
- Informed incentive scheme design

C. Aggregated Outputs

Publications & Presentations:

- 34+ peer-reviewed papers
- 145+ conference presentations
- 43+ technical reports
- 25+ industry guidance documents

Technical Resources:

- 20+ comprehensive databases
- 15+ assessment methodologies
- 10+ modelling frameworks
- Multiple open-source datasets
- Interactive tools and platforms

Engagement:

- 60+ stakeholder workshops
- 29+ public information sessions
- 35+ industry briefings
- 14+ major conferences
- 4+ training programs
- 200+ certified practitioners

Media & Communications:

- 19+ project websites
- 17+ educational videos
- 35+ information leaflets
- 20+ social media channels
- 40+ press articles
- 10+ newsletters

2.5 Heat – Case Studies

Case Study 1

Indoor Air, ventilation and occupant comfoRt in Irish domestic dwellings pre and post DEep Energy reNovations (ARDEN)

Lead Organisation: *University of Galway*

Collaborator: *Department of Housing, Local Government and Heritage (DHLGH)*

The National Retrofit Plan sets out how the Government will deliver on the Climate Action Plan targets of retrofitting the equivalent of 500,000 homes to a BER of B2/cost-optimal and installing 400,000 heat pumps in existing homes to replace older, less efficient heating systems by the end of 2030.

The objective of the ARDEN research project was to evaluate indoor air quality (IAQ), thermal comfort and ventilation performance in a sample of Irish domestic dwellings pre- and post-deep energy retrofit. All dwellings were participants of the SEAI deep retrofit pilot programme and received energy upgrades to a minimum building energy rating (BER) of A3.

Twenty-six homes were recruited to participate in the ARDEN project. Indoor air pollutants including: CO2, formaldehyde, radon, NO2 and others as well as temperature and relative humidity were measured in the main bedroom and living area of the homes. Diaries and questionnaires were used to obtain information on occupant's activities during the measurement period and to collect their feedback regarding the energy retrofit.

Occupants reported a high level of satisfaction with thermal comfort post-retrofit, with only a small number of reported issues regarding overheating in summer.

However, many bedrooms were under-ventilated post-retrofit with higher concentrations of most pollutants observed in bedrooms. Although underperforming ventilation was likely to have played a role in the observed increasing trend in pollutant concentrations post-retrofit, it is unlikely to be wholly responsible. The introduction of new building materials as part of retrofit is likely to have contributed to higher formaldehyde levels. Occupant behaviour within a more airtight home (e.g. the use of wood burning stoves, candle and incense burning) and the ingress of outdoor air pollution are also possible sources.

Given the ambitious Climate Action Plan targets of retrofitting 500,000 homes to B2 or cost optimal equivalent, it is very important that there is more emphasis on pollutant source control and proper installation and maintenance of mechanical ventilation systems during retrofit.

Making homes more energy efficient should lead to more sustainable healthy homes. Occupants of mechanically ventilated homes also need to become more aware of the important role of ventilation in an energy efficient dwelling and should ensure that their systems are serviced and maintained regularly.

Since the SEAI Deep Energy Retrofit pilot in 2018, additional guidance and ventilation requirements in the Irish Building Regulations Technical Guidance Document, TGD Part F have been introduced for major renovations, which requires independent third-party inspection and validation checks on ventilations systems to ensure that the required design flow rates are met.

POLICY IMPACT

The research team worked with the DHLGH and SEAI in framing, implementing and disseminating the research project. The team contributed to the compilation of the Government of Ireland (2022) public information leaflet Why you need proper ventilation in your home which helps the public gain a greater understanding of ventilation and is a first step guide when planning upgrades.

This research project has provided a unique dataset that will inform future revisions of residential ventilation standards. As a result of funding the project lead has become a member of the Technical Committee working on the revised National Standards Authority of Ireland S.R. 54 Code of Practice for the Energy Efficient Retrofit of Dwellings.

In addition, this study had given opportunity for the project team to participate in other European projects. Statistical data from ARDEN study will be contributed to the IEA EBC Annex86 project, as part of a European meta-dataset compiled and managed by Annex86 committee, aiming at accelerating the development of better and more energy-efficient IAQ management strategies.

Read final report here.

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

Case Study 2

Retrokit 2.0 - A Cloud-Based Project Planning and Implementation Toolkit to Foster the Uptake of Deep Energy Retrofit in Housing

Lead organisation: *XD Sustainable Energy Consulting*

The Challenge

70% of Irish homes still considered in need of energy retrofit

Energy poverty affects an estimated 28% of Irish households

Poor energy performance in housing impacts health and well-being

500,000 homes to be upgraded to B2 by 2030

With SEAI funding XD Consulting developed RetroKit 2.0, a software platform that helps housing professionals to make evidence-based investment decisions for their energy upgrade projects.

POLICY, ECONOMIC IMPACT

RetroKit is now being used by local authorities, sustainable energy communities, housing associations and energy retrofit professionals both in Ireland and across Europe. Work on the RetroKit platform began in 2017 when company co-founder Xavier Dubuisson began an energy innovation project part-funded by the Sustainable Energy Authority of Ireland (SEAI). "RetroKit helps housing providers to both assess the current energy performance of their housing stock and to make the best investment decisions about how to renovate it in order to reach climate action targets.

Combining BER data, GIS, and data analytics, RetroKit's software solution uses actual energy datasets and advanced analytics to develop a highly detailed analysis of retrofitting measures that have the highest potential, are evidence-based, and which can robustly inform the development of a home energy upgrade strategy at scale.

Most recently used by Cork City Council to identify and prioritise retrofitting measures for over a hundred social housing properties in Cork City, the RetroKit software was the key tool supporting the project team in optimising budgetary inputs while supporting better energy and health outcomes for residents.

The support of SEAI for this project in 2018 was transformative in growing the company and providing a tool for commercial use in Ireland.

Read more https://retrokit.eu/

Case Study 3

Building Upon Ireland's National Renovation Strategy

Lead organisation: *Irish Green Building Council (IGBC)*

Partner organisation: *Limerick Institute of Technology*

Collaborators: *World Green Building Council; ISSO – Dutch Knowledge Centre for the Building and Building Services Sector; European Mortgage Federation; Dublin Institute of Technology; Association of Consulting Engineers of Ireland; Engineers Ireland; RIAI; Society of Chartered Surveyors Ireland; Institute of Professional Auctioneers & Valuers; Dublin City Council; ASHRAE.*

Putting Ireland on a realistic trajectory to 2050 climate targets requires a step change in the level of activity in renovation and the 'depth' of energy efficiency upgrades.

The project lead and partner built on a broad range of research and expertise to design and implement a comprehensive package of targeted and concerted actions. These were aimed at building stakeholders' capacity and appetite for renovation, while de-risking energy renovation investments.

A review conducted by IGBC and partners was published in 2019: Introducing Minimum Energy Efficiency Performance Standards in the Rental Sector.

SOCIETAL AND POLICY IMPACT

The IGBC were able to use the findings from this review to inform a Review of the Private Rental Sector conducted by the Government of Ireland in 2023 - https://www.igbc.ie/wp-content/uploads/2023/07/IGBC_Submission.pdf

This review was also used by many other bodies for their reports including Friends of the Earth – Bridging the gap between Energy Poverty and Energy renovation (March 2024), Threshold's Submission to the Revised Energy Poverty Action Plan 2024 Consultation (May 2024) and Australian Government - Minimum Energy Standards for Rented Properties an International Review (October 2020) to name a few.

Case Study 4

Fundamentals of Energy Renovation for Traditional Buildings: CPD Lecture Series 2019-2020

There are an estimated 175,000 buildings still standing in Ireland that were constructed before 1919. Thousands more were built between the two world wars. With proper care and maintenance almost all of these buildings will continue to endure.

Lead organisation: *The Heritage Council*

Partner organisation: *Carrig Conservation International*

This Continuing Professional Development (CPD) course, run by the Heritage Council, built on research conducted through a project, *Deep Energy Renovation of Traditional Buildings: Addressing Knowledge Gaps and Skills Training in Ireland*. It provided training for building professionals to overcome, in practice, the barriers inhibiting the uptake of deep energy renovation of traditional buildings in Ireland.

ECONOMIC/SOCIETAL/POLICY IMPACT

CPD certificates were issued to 89 participants who completed the course. There were a further 32 who attended some but not all lectures. Twenty-nine experts delivered 27 modules and contributed to the discussions.

Since this project completed the course is now offered as a module through the Technical University of the Shannon as part of the Digital academy for Sustainable Built Environment in collaboration with the Heritage Council.

Further research has been funded by SEAI in more recent calls in 2021 and 2022 focusing on traditional buildings. Working with the Department of Housing, Local Government and Heritage findings have been used to the Government of Ireland Improving Energy Efficiency in Traditional Buildings Guidance for Specifiers and Installers (2023) as well as the Traditional Homes Pilot 2024 which operates under the National Home Energy Upgrade Scheme operated by SEAI.

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

Case Study 5

Dublin Energy Master Plan

Lead organisation: *Codema*

Collaborators: *Dublin City Council; Fingal County Council; South Dublin County Council; Dún Laoghaire-Rathdown County Council*

Codema collaborated with the four Dublin Local Authorities to establish the first regional energy master plan in Ireland. The Master Plan provides realistic, costed pathways for the Dublin Region to achieve its carbon emission reduction targets in 2030 and 2050. These pathways have been based on detailed local-level, spatially driven energy scenario modelling and identify low-carbon technologies specific to the energy characteristics of a particular area at a local level, which has not been carried out before for any county in Ireland.

POLICY/ECONOMIC IMPACT:

This plan was disseminated widely and used by all four local authorities in the Dublin area in the development of their Local Authority Climate Action Plans, Decarbonisation Zones and in plans for Dublin District Heating. It has also been used as a tool by Sustainable Energy Communities and to inform other projects on large-scale energy storage in the Poolbeg area and on thermal energy storage options.

Read the full report on the 'Dublin Region Energy Plan'.

Source: Dublin Energy Master Plan

2.6 Electricity Sector

2.6.1 Introduction

The renewable electricity target is commonly referred to as the RES-E target. Ireland's NECP 2021-2030 includes a planned RES-E of 70% in 2030, which will ensure that renewable electricity continues to form the backbone of our renewable energy use for the coming decade and beyond. Since 2021, Ireland's Climate Action Plan has included a target to increase the share of electricity generated from renewable sources up to 80% in 2030.

SEAI invested in over 50 research development and demonstration projects in 2018 and 2019 to address this target.

The electricity sector research portfolio demonstrates remarkable breadth and depth, encompassing projects across eight key topic areas: community energy, energy efficiency, energy planning and modelling, energy storage and hydrogen, ocean and offshore, smart grids, solar, and wind energy. These projects collectively advanced Ireland's capabilities in renewable electricity generation, grid modernisation, and community engagement while building essential capacity for future developments. This has created a strong foundation for Ireland's transition to a renewable electricity system through its comprehensive coverage of technical, social, and policy dimensions. The emphasis on practical implementation and stakeholder engagement has ensured that research findings have reached and influenced key decision-makers while building essential capabilities for future developments.

2.6.2 Outputs and Impact

A. Common Themes and Research Focus Areas

The electricity sector research programme demonstrated several consistent themes across its diverse portfolio. A strong focus on digital technologies and data analytics was evident across multiple topics, particularly in smart grids, energy planning, and wind energy projects. Projects frequently emphasised real-world demonstration and validation, moving beyond theoretical studies to generate evidence from actual deployments.

The research programme maintained a consistent emphasis on community engagement and social acceptance, particularly evident in wind energy and community energy projects. This was complemented by technical innovation across various scales, from fundamental materials research in solar and battery technologies to system-level integration of renewable energy sources.

Several cross-cutting themes emerged:

- Integration of digital technologies (blockchain, AI, machine learning)
- Focus on real-world demonstration and validation
- Strong emphasis on community engagement and social acceptance
- Balance of fundamental research with practical implementation
- Development of decision support tools and frameworks
- Enhancement of modelling and forecasting capabilities

B. Collective Impacts

SCIENTIFIC IMPACT

The scientific impact of these projects has been substantial and wide-ranging across multiple technological domains. The programme significantly advanced methodological approaches in critical areas including smart grid monitoring, renewable energy forecasting, and community energy assessment. Researchers generated extensive new datasets that enhanced understanding of offshore wind resources, grid behaviour, and social acceptance factors. Many projects contributed to international research networks, strengthening Ireland's position in the global research community while enhancing national research infrastructure.

In the field of digital technologies, projects pioneered novel applications of blockchain and artificial intelligence, particularly in energy management and grid optimisation. The research programme made significant advances in materials science, developing new battery chemistries for grid storage and novel photocatalysts for hydrogen generation. In offshore and marine energy, projects advanced the technological readiness level of several wave energy converters and demonstrated innovative approaches to power take-off systems.

Key Scientific Innovation Highlights:

- Advanced AI and machine learning applications in grid management and energy optimisation
- Developed novel battery technologies and energy storage solutions
- Created new methodologies for renewable energy assessment and forecasting
- Generated comprehensive datasets on grid behaviour and renewable resources
- Pioneered blockchain applications in energy trading and management

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

SOCIETAL IMPACT

The societal impact has been significant and far-reaching across multiple communities and stakeholder groups. The research programme directly enhanced industry capacity through training of over 15 PhD researchers and numerous postdoctoral fellows, creating a pool of expertise in critical areas like smart grids, renewable energy, and energy storage. Public understanding and acceptance of renewable energy technologies improved through targeted engagement activities, reaching over 1000 participants through trials, demonstrations, and information sessions.

Projects created practical pathways for community energy development, particularly through tools and platforms that supported local energy initiatives. Critical social challenges were addressed, with research identifying specific barriers to community acceptance of wind energy projects and developing frameworks for improved engagement. The programme has also enhanced professional skills across multiple sectors, from grid operators to renewable energy developers, helping create sustainable employment opportunities in the green economy.

Key Societal Highlights:

- Trained 15+ PhD researchers and multiple postdoctoral fellows
- Engaged over 1000 participants in trials and demonstrations
- Developed comprehensive frameworks for community energy initiatives
- Created practical tools for community engagement
- Enhanced professional skills across multiple sectors

ECONOMIC IMPACT

Economically, the programme has delivered significant market insights and validated multiple business opportunities. Several projects developed commercially viable products, from smart grid monitoring tools to community energy platforms. These innovations have created new business opportunities for Irish companies in the growing renewable energy sector. The research led to multiple patent applications and the formation of several spin-out companies, particularly in areas like smart grids and wind energy technology.

In the smart grid sector, projects demonstrated potential for multi-million Euro annual savings through reduced curtailment and improved asset utilisation. Wind energy projects identified opportunities to reduce operating costs through improved control and maintenance strategies. The programme also supported broader economic development by identifying skills gaps and providing frameworks for professional development, particularly in emerging areas like offshore wind and energy storage.

Key Economic Highlights:

- Multiple patent applications filed across various technologies
- Formation of several spin-out companies
- Identified significant cost savings in grid operations
- Created new business opportunities in renewable energy sector
- Developed commercially viable products and platforms

POLICY ORIENTED IMPACT

The policy impact of these projects has been particularly significant, providing evidence-based support for multiple aspects of Ireland's energy transition. The research directly informed several key national policies and regulations, particularly around community benefit schemes, offshore wind development, and grid modernisation. Projects provided crucial input to planning guidelines for local authorities, particularly around community energy initiatives and wind farm development.

The research programme supported implementation of the Climate Action Plan, particularly around the 70% renewable electricity target for 2030. Several projects informed the development of the Renewable Electricity Support Scheme (RESS), especially regarding community benefit schemes and social acceptance. In the smart grid sector, projects provided evidence that shaped regulatory frameworks around grid modernisation and flexibility services.

Key Policy Highlights:

- Directly informed national renewable energy policies
- Shaped community benefit schemes and engagement frameworks
- Provided evidence base for grid modernisation strategies
- Supported implementation of Climate Action Plan targets
- Informed development of RESS auctions and guidelines

C. Aggregated Outputs

Publications & Presentations:

- 100+ peer-reviewed journal papers
- 200+ conference presentations
- 40+ technical reports
- 20+ book chapters

Technical Resources:

- 25+ software tools and platforms
- 15+ comprehensive datasets
- 10+ assessment methodologies
- Multiple demonstration projects

Engagement:

- 100+ stakeholder workshops
- 50+ public information sessions
- 30+ industry briefings
- 20+ major conferences
- 1000+ trial participants

Media & Communications:

- 25+ project websites
- 20+ educational videos
- 40+ information leaflets
- Multiple social media channels
- 50+ press articles

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

2.7 Electricity – Case Studies

Case Study 1

CAO IRL Coupled Atmosphere Ocean Wave Forecasts for Ireland

***Co-funded** with the Marine Institute and Met Éireann*

***Lead Organisation:** University of Galway*

With the majority of renewable energy in Ireland being weather-dependent (wind and solar), researchers have been working on ways to improve forecasting capabilities in order to benefit effective renewable energy usage.

The Irish Centre for High-End Computing (ICHEC) in University of Galway led this project focused on creating an integrated solar, wind and wave energy forecasting system for Ireland.

The current weather forecast model used by Met Éireann is the Harmonie-Arome model, which provides regional atmospheric data such as temperature, humidity and wind direction and speed. At the Marine Institute, the Simulating Waves Nearshore (SWAN) model is used for forecasting wave parameters. To calculate wave boundaries, this model uses the WaveWatch 3 framework. The Marine Institute also uses the Regional Ocean Modelling System (ROMS) to forecast ocean state parameters such as ocean temperature, salinity, sea level and ocean currents. These models (ocean, atmosphere and wave) are run independently each day with different initial and boundary conditions.

When forecasting agencies compile information for a global weather forecast, they use a combination of climate models referred to as coupled global circulation models (CGCMs) to enable more accurate regional weather forecasts.

The research project aimed to develop a coupled forecasting model that uses Harmonie-Arome (atmosphere), WaveWatch 3 (wave) and ROMS (ocean) in Ireland. To do this, an Oasis3-MCT coupler was used, which allows synchronised exchanges of coupling information between numerical codes representing different components of the climate system.

These coupled forecasting models are normally more accurate and efficient but have large computing requirements.

ECONOMIC/POLICY IMPACT:

The WaveWatch 3 framework is now running operationally on the Met Éireann high-performance computing server. A two-way coupled model of Harmonie-Arome and WaveWatch 3 has been successfully implemented to predict wave parameters and winds over Ireland and the surrounding ocean, while the ROMS standalone ocean model has been tested for ocean state forecasting.

This coupled (atmosphere-wave) forecasting system is the first of its kind for Ireland and will have significant implications for renewable energy applications by providing improved weather forecasts and an integrated solar, wind (onshore and offshore) and wave energy forecasting system. The coupled model will result in better forecasts for weather and ocean state, and in turn, for renewable energy forecasts on the desired time scales and heights.

The results were shared and communicated with the EU community including Met Norway, KNMI-Netherlands, SMHI-Sweden, ECMWF-UK and Meteo France.

Decision making during high weather events such as storms have been improved.

“

The WaveWatch 3 framework is now running operationally on the Met Éireann high-performance computing server. A two-way coupled model of Harmonie-Arome and WaveWatch 3 has been successfully implemented to predict wave parameters and winds over Ireland and the surrounding ocean, while the ROMS standalone ocean model has been tested for ocean state forecasting.

”

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

Case Study 2

Robust Real-Time Wind Power Prediction and Early, Accurate Estimation of Downtime for Irish Wind Farms in an Integrated Single Electricity Market (Wind-PEarlAED)

Lead Organisation: *University College Dublin*

Partner: *Trinity College Dublin*

Collaborators: *WFSO Ltd., Cork and Electroroute*

This project improved operations and maintenance (O&M) of onshore wind turbine farms in Ireland through bespoke data analytics, focusing on early and accurate downtime prediction and improved short term wind forecasts. The results are transformative and allow for real-time capabilities. The methods are adaptable to uncertain, imperfect or poor data and signify a philosophical shift from individual numbers of probabilistic estimates. The project combines bespoke fundamental methods, their feasibility study and demonstration using authentic, real-data from several wind farms in Ireland. Improved methodologies developed were calibrated and implemented via novel software tools and a wide range of scenarios of implementation and data conditions were considered. Guidelines and recommendations for selecting, implementing and interpreting the methods and their results were presented.

The results from the most authoritative evidence base around the topic for Ireland and is also a global benchmark. Errors, performance metrices and uncertainties were calibrated and investigated extensively for appropriate comparison of different methods and approaches, along with limitations. It also allows for transparency of methods. The results lead to better O&M, with impact on addressing increased wind turbine availability, reduction in operational costs and reduction in uncertainties around short term energy prediction. The results also link with evolving and burgeoning aspects around monitoring of wind turbines and create a multi-disciplinary approach leading to a wider impact on such challenges. Finally, the project demonstrates how such industry-aware and contemporary solutions and insights can be developed within a 'public good' framework through National funding.

IMPACT

The work made researchers, traders, policy-makers and asset owners aware of the combined rewards that can be obtained from improvements in O&M along with trading advantages. This will influence how decisions are taken in future and the policy orientations for Ireland by involving academia and industry within a 'public good' framework in the long term.

The results have been published and presented widely with significant interest from national and international audiences.

Offshore Renewable Energy (ORE) generation capacity targets from 2030 to 2050

'Ireland's offshore renewable energy (ORE) targets are ambitious. Building on 2030 targets of 5 Gigawatts (GW) of grid-connected offshore wind plus an additional 2GW of non-grid connected offshore wind in development, by 2040, we aim to deliver 20GW of ORE, and by 2050, this rises to 37GW, which is approximately six times our current peak electricity demand.'

Future Framework for Offshore Renewable Energy 2024

Generation Capacity

5 GW

2030 Target

20 GW

2040 Target

37 GW

2050 Target

Case Study 3

Building upon Copernicus Earth Observation services to augment wind measurement coverage of the OREDP offshore renewable energy assessment areas

Lead: *University College Dublin*

The objectives of this project focused on the investigation of contemporary open data and frameworks to increase wind measurement coverage of the Irish Continental Shelf (ICS) region, for renewable energy assessment of offshore Areas of Interest (AOI). The key project results and outcomes include the creation of a new ICS wind data catalog, which consists of a collection of Level-3 analysis-ready, cloud-optimized (ARCO) data sets, featuring up to 21 years (2001 - 2021) of available in situ, reanalysis, model, and satellite observation wind data products from multiple providers.

Scalable processing of offshore data products has been achieved with novel framework usage providing catalog data-proximate computing, enabling efficient analysis with large data sets. Analysis of Irish AOIs, including wind speed extrapolation and power density estimation, has been performed using illustrative candidate offshore wind farm locations in the Irish Sea and north Celtic Sea, generating reproducible comparisons of reference and test data sets. An interactive wind atlas prototype has also been developed, which demonstrates processing of high spatial and temporal resolution data. Project outputs including the data catalog and source code have been distributed using a new website and other public hosting options.

Case Study 4

I-MORE: Informing and Mapping the Offshore Renewable Environment

Lead organisation: *Gavin & Doherty Geosolutions (GDG)*

Partner organisations: *University College Cork (UCC); University College Dublin (UCD); Geological Survey Ireland (GSI)*

Collaborators: *IWEA; Commissioners of Irish Lights*

I-MORE acted as a pilot study to demonstrate the potential for early-stage national survey campaigns to provide baseline data to inform marine spatial planning and optimised offshore wind developments. With this pilot study, the I-MORE project generated state-of-the-art research results, provided several technical recommendations on data integration, and general recommendations to accelerate offshore wind development in Ireland.

> *"The project compiled early-stage site information on geological and geotechnical conditions and assessed different approaches to integrating these data to form robust ground models."*

The project compiled early-stage site information on geological and geotechnical conditions and assessed different approaches to integrating these data to form robust ground models. It collated, acquired and analysed a wealth of seafloor data that can be used directly in the identification and de-risking of sites for the development of offshore renewable energy. Outcomes of this pilot study demonstrated the benefit of integrating pre-existing datasets to de-risk site selection and its direct impact for Designated Maritime Area Plan (DMAP) boundary selection as part of the national spatial strategy for offshore wind. In addition to the impact for Irish offshore wind development, the I-MORE technical outcomes are expected to benefit the international community. The novelty of the project lies in the generation of geotechno-stratigraphic model and synthetic Cone Penetration Test (CPT) using the Machine Learning method.

POLICY AND ECONOMIC IMPACT

The data gathered, recommendations and techniques developed in both these projects are directly relevant to the current DMAP process and Offshore Renewable Energy Development Plan II (OREDP II) in terms of identifying and de-risking sites for development.

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

2.8 Transport Sector

2.8.1 Introduction

"Achieving a targeted 51% reduction in transport emissions by 2030 will require a complete reset of our behaviours."

Behaviour change programmes aim to reduce carbon emissions from the transport sector without large scale infrastructure investments. Instead, they involve changing peoples' day to day travel behaviour by, for example shifting their use of mode to one with lower emissions (e.g. public transport) or to an active transport mode (e.g. walking or cycling). There is also an opportunity to modify peoples' behaviour with respect to how they use their private car. This includes reducing the number of trips by modifying the need to travel and/or using cleaner fuels and/or better maintenance and more efficient use of existing fuel types.

This portfolio of projects funded in 2018 and 2019 has created a strong foundation for Ireland's transition to sustainable transport. The research has delivered practical solutions while building essential capacity and knowledge for future developments in transport decarbonisation.

2.8.2 Outputs and Impact

A. Common Themes and Research Focus Areas

The transport projects funded under this programme collectively addressed critical challenges in decarbonising Ireland's transport sector. The research portfolio covered three main thematic areas: electric vehicle integration and charging infrastructure, heavy goods vehicle emissions reduction, and alternative fuel development.

A significant portion of the projects focused on electric vehicle charging optimization and infrastructure deployment. These projects developed novel approaches for integrating charging infrastructure with existing facilities like street lighting and building energy systems. They also created advanced algorithms for predicting and managing charging demand in shared facilities like university campuses and public parking areas.

Several projects specifically targeted emissions reduction in the heavy goods vehicle sector, which represents a particularly challenging area for decarbonisation. These projects assessed various mitigation measures, from alternative fuels to operational efficiency improvements, providing valuable insights for policy development and industry transition planning.

The development and assessment of alternative fuels, particularly advanced biofuels and electrofuels, formed another key research theme. Projects in this area investigated production pathways, technical feasibility, and implementation requirements for novel fuel types that could support transport decarbonisation.

B. Collective Impacts

SCIENTIFIC IMPACTS

The scientific impact of these projects has been substantial, with over 25 peer-reviewed publications advancing knowledge in areas like charging optimisation, emissions modelling, and alternative fuel production. The research has developed novel methodologies that are being adopted internationally, particularly in the areas of smart charging systems and fleet transition planning. For example, new algorithms for predicting parking occupancy and optimizing charging infrastructure placement have been published in high-impact journals and presented at major international conferences.

Key Scientific Innovation Highlights:

1. Technical Solutions:
   - Novel biofuel production methods from waste
   - Integrated charging-lighting infrastructure
   - Smart charging algorithms for fleet applications
   - Advanced emissions modelling frameworks
2. New Methodologies:
   - Multi-objective optimization for charging infrastructure
   - Machine learning for parking prediction
   - Alternative fuel assessment frameworks
   - Fleet transition planning tools
3. Data & Modelling:
   - Irish transport fleet characteristics
   - Vehicle usage patterns
   - Emissions baselines
   - Infrastructure requirements
   - Charging behaviour analysis

SOCIETAL IMPACT

From a societal perspective, the projects have made significant contributions to building Ireland's capacity in transport decarbonisation. Over 15 researchers have been trained through these projects, creating a pool of expertise in critical areas like electric vehicle integration and alternative fuel development. The projects have also engaged extensively with local communities and stakeholders, particularly through demonstration projects and public awareness activities.

Key Societal Highlights:

1. Infrastructure Development:
   - New charging solution designs
   - Infrastructure placement optimization
   - Integration with existing facilities
   - Community charging frameworks
2. Capacity Building:
   - Training of 15+ researchers
   - Development of technical expertise
   - Industry-academia collaboration
   - International research partnerships
3. Public Engagement:
   - Multiple demonstration projects
   - Public awareness activities
   - Stakeholder consultation
   - Knowledge sharing platforms

ECONOMIC IMPACT

The economic impact extends beyond the direct employment of researchers. Several projects have developed commercially viable products, such as integrated charging-lighting systems and smart charging management platforms. These innovations have created new business opportunities for Irish companies in the growing electric vehicle infrastructure market. The projects have also identified potential cost savings through optimised infrastructure deployment and efficient fleet management strategies.

Key Economic Highlights:

1. Direct Benefits:
   - Research employment
   - New product development
   - Commercial opportunities identified
   - Export potential created
2. Cost Reduction Potential:
   - Optimised infrastructure investment
   - Reduced fleet operating costs
   - Lower emission reduction costs
   - Efficient resource utilization
3. Market Development:
   - New business models validated
   - Commercial products developed
   - Market opportunities identified
   - International market potential

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

POLICY ORIENTED IMPACT

The policy impact of these projects has been particularly significant, providing evidence-based support for multiple aspects of Ireland's transport decarbonisation strategy. They have developed practical frameworks for assessing infrastructure requirements, evaluating technology options, and planning transition pathways. This research has directly informed policy development at both national and local levels, particularly in areas like charging infrastructure deployment and heavy goods vehicle emissions reduction.

Specifically:

Key Policy Highlights:

- The research on heavy goods vehicles has directly informed Ireland's approach to reducing emissions from this sector, demonstrating potential CO2 reductions of up to 94% through various mitigation measures. This work has supported the development of policies around fleet renewal and alternative fuel adoption.
- Studies on electric vehicle charging infrastructure have provided crucial input to planning guidelines for local authorities, particularly around the integration of charging facilities with existing infrastructure like street lighting. This research has helped shape approaches to public charging deployment across Ireland.
- The projects examining electrofuels and advanced biofuels have contributed to Ireland's alternative fuel strategy, providing detailed analysis of production pathways and implementation requirements. This has informed policy decisions around renewable fuel obligations and infrastructure development.
- Research on smart charging and grid integration has supported the development of guidelines for managing increased electrical demand from transport electrification, helping to inform both transport and energy policy.
- Several projects have provided specific recommendations for policy frameworks to support transport decarbonisation, including detailed cost-benefit analyses of different technology options and implementation pathways.

The international dimension of these impacts is notable, with several projects establishing collaborations with leading research institutions and industry partners across Europe. This has positioned Irish research at the forefront of transport decarbonisation efforts and created opportunities for knowledge exchange and technology transfer.

C. Aggregated Outputs:

Research Outputs:

- 25+ journal publications
- 20+ conference presentations
- 8+ PhD researchers trained
- 15+ new algorithms/models
- Multiple datasets created

Technical Achievements:

- 5+ prototype systems
- Multiple demonstration projects
- New analysis tools
- Technology validation studies

Engagement:

- 30+ industry partners
- 10+ local authorities
- International collaborations
- Policy maker engagement

“The international dimension of these impacts is notable, with several projects establishing collaborations with leading research institutions and industry partners across Europe.”

2.9 Transport – Case studies

Case Study 1

DiSTRaCT: moDal ShifT Reduce Carbon in Transport

***Co-funding** from Department of Transport*

***Lead organisation:** Trinity College Dublin*

In this project potential reductions in CO2 emissions from transport were estimated for four measures involving changes to peoples' daily travel behaviour. These included increased availability of EVs in work places, remote working, online shopping and car tyre pressure monitoring. Using survey data, international literature and best practice examples, the likely success of these measures was assessed. Potential implementation models were developed and the likely cost against the reduction in CO2 emissions were calculated.

- Average saving of 0.154 tonnes of CO2 equivalent per worker saved per annum by remote working one day a week.
- Home-shopping was shown to have potentially the greatest impact on reducing emissions.
- Over 75% of carbon emissions associated with traveling to work by the survey sample were associated with employees working for SMEs. This is likely due to higher average distance of commuting for this cohort and reliance on car journeys due to lack of alternatives.

POLICY IMPACT

The project provided an evidence base to support policy development and implementation in reducing carbon emissions from transport and specifically the relative merits of different types of programmes in Ireland.

The results of this research project have informed the National Sustainable Mobility Policy (2022) prepared by the Department of Transport and the Government of Ireland Climate Change Assessment Volume 4: Realising the Benefits of Transition and Transformation (2023) as well as leading to further research focusing on the government's avoid-shift-Improve Transport agenda.

Road freight transportation is a key enabler of economic activity in Ireland, but the industry is mostly dependent on fossil fuels for its energy source, which presents a challenge in realising a low-carbon future. Ireland's Climate Action Plan aims to achieve net-zero emission by 2050 (NZE2050), which presents the imminent need for addressing the issue of tackling vehicular emission from the Irish Heavy-Duty Vehicles (HDV) fleet.

Case Study 2

Mitigation of Air Pollution Impacts of Irish Heavy-Duty Vehicles (MAP-HDV)

***Co-funding** from Department of Transport*

***Lead organisation:** Trinity College Dublin*

***Collaborator:** Irish Road Haulage Association*

The MAP-HDV project investigated a series of pollution mitigation measures to reduce emissions from vehicles and improve energy efficiency, including increased use of renewable energy in the Irish HDV fleet. The project aims and objectives were linked with and relevant to the Irish energy sector, SEAI, the Irish transport sector and the Environmental Protection Agency (EPA). The project was aligned with multiple important national policies and planning frameworks, and the EU Green Deal.

The project provided emission levels, the impacts of different mitigation measures and the effect of them in the Irish context. The potential of loading, after-treatment technologies, alternative fuels, speed and acceleration, and road conditions for reducing emissions and fuel consumption from HDVs were analysed using VECTO (a vehicle energy consumption calculation tool) and COPERT (a computer model to calculate emissions from road traffic) as simulation tools.

The most promising measures in mitigating pollution from HDVs were the use of alternative fuels, optimisation of loading and implementation of after-treatment technologies.

POLICY AND ECONOMIC IMPACT

This project formed part of the National Mitigation Plan Actions (2018) for the Department of Transport.

The project informed the Report on the Implementation of the Alternative Fuels Infrastructure Directive (2014/94/EU) submitted to the European Commission by the Department of Transport in November 2019 as requirement of Article 10(1) of the Alternative Fuels Infrastructure Directive (AFID).

Research also contributed to Section 2. Sustainability & Decarbonisation of the policy document Ireland's Road Haulage Strategy 2022 - 2031 (Department of Transport, 2022). This policy acknowledged that the haulage sector is a challenging sector to move towards decarbonisation, given that 99% of heavy goods vehicles are currently diesel fuelled). However, the new Strategy - along with other measures and supports which will be put in place - will help drive the shift to zero emissions in heavy goods vehicles while strengthening the viability of the sector.

Outputs and Impacts of the 2018 and 2019 SEAI RD&D Projects (Continued)

2.10 Electric vehicles – Case Studies

A key part of the decarbonisation of transport is a large-scale transition to electric vehicles (EVs). However, for such a change to happen, sufficient EV charging infrastructure needs to be in place. The national delivery of EV charging infrastructure needs to do much more than simply meet existing demand. It must anticipate future requirements and stay ahead of them. It is vital that appropriate EV charge points are available to all, in every part of the country. This will reassure car users of the feasibility of switching to EVs to meet national carbon reduction targets.

To respond a group of projects were funded in 2019 looking at charging strategies and a plug-in Electric Vehicle (EV) fleet in Ireland.

Case Study 3

Charging Strategies and Infrastructure Design for Transition to Electrified Fleets

Lead organisation: *University College Cork (UCC)*

This project addressed the fundamental questions of what type of non-residential charging infrastructure and charging strategies are required to support a plug-in Electric Vehicle (EV) fleet in Ireland. In addition, the project determined ways to maintain a fully integrated charging system from renewable energy sources.

This involved three main outputs

1. Building a model that describes optimal design procedures of non-residential charging infrastructure, while minimising the expenses from an EV fleet owner perspective.
2. Developing charging strategies for increased use of renewable energy resources without compromising EV user experience and convenience.
3. Exploring technical challenges and benefits in an Irish context while transitioning to electrified fleets.

Case Study 4

Electric Vehicle Potential within Existing Technical Standards and Commuting Patterns

Lead organisation: *ESRI*

This project identified geographical areas with a high density of potential adopters of electric vehicles (EVs), beneficial for the targeted or localised promotion of EVs. It focused on those who commute to work by car and live in a household with two or more cars; it reported that 42% could switch one of their vehicles to an EV without range anxiety.

High-density areas of potential EV adopters were found in cities such as Dublin, Cork and Limerick. Some rural areas in Meath, Kilkenny and Kerry also contained hotspots of potential EV adopters. It was estimated that the direct emission reductions achieved by penetration of 8% and 42% of EV adopters are 7% and 37%, respectively. The project also estimated that an increase of EVs in Ireland to 180,000 by 2025 could be achievable. Combining EV adoption with modal shifts in transportation outlined in CAP 2021 would accelerate the decarbonisation of the sector.

POLICY IMPACT

These informed the Electric Vehicle Charging Infrastructure Strategy 2022-2025 (Department of Transport, 2023) for the delivery of a national EV charging network, and the practical steps that will be taken to deliver this network across the country.

Section 3
Spotlight Section

Additional Case Studies

Net Zero Energy Buildings NZEB101

A new understanding of how A-rated homes actually perform

Project Name: *The nZEB101 Project*
Project Duration: *3 yrs*
Total Project Costs: *€321,011*
Year Funded: *2018*

As home owners and residents across Ireland strive to reduce their carbon footprint, we rely on the Building Energy Rating (BER) system to help us achieve nZEB compliance. We all know that A-rated homes are the most energy efficient — but how do they actually perform in the reality of daily use, compared to expectations?

Regulations have already been established to ensure that all new homes built in Ireland must be nearly Zero Energy Buildings (nZEB). Specifically, the Energy Performance of Buildings Directive (EPBD) requires that new dwellings must be nZEB compliant (meaning a typical BER of A2) from 2020. To meet that requirement, Ireland is now embarking on the unprecedented mass market implementation of low-energy homes.

But as we make progress with this plan — designed to both improve the energy performance of homes and reduce Ireland's greenhouse gas emissions — what are the lessons we need to learn to make sure it achieves its potential? How do energy efficient homes actually perform when it comes to their daily use, compared to expectations?

SEAI funded the nZEB101 project in 2018 under the RD&D programme to gather answers to that question; to uncover data from a large sample of homes built and retrofit to high nZEB standards to observe how they performed in reality. The report was prepared by University College Dublin (UCD) and drew on research carried out from 2018 to 2022, with Lead Researcher Oliver Kinnane (UCD Associate Professor in Sustainable Building Technology) overseeing a collaborative effort between academic experts and low-energy dwelling professionals.

Specifically, the nZEB101 project aims to:

1. compare the designed and estimated energy use of the sample homes to in-use data, assessing the achievement of targets related to the nZEB standard;
2. monitor and analyse the in-use performance of heat pump technology and the fabric of nZEBs.

The findings of nZEB101 were extremely revealing. It found that most of the A-rated homes monitored are under-performing when it comes to the BER design expectation by an average of one band.

This observation will inform the design of new low-energy homes across the country and will help SEAI to identify and promote ways in which issues can be addressed.

"We need to put a huge amount of research and money into making our homes more efficient," said Lead Researcher Oliver Kinnane. "They are a major contributor to our national carbon emissions, responsible for around 37%. nZEB101 was about trying to be very fundamental, to evaluate how heat pumps and low energy systems are working and how we can properly investigate their performance. We aimed to shine a light on whether the systems are achieving the efficiencies that we expect them to achieve."

The project found that while occupants report high levels of satisfaction with A-rated homes, "comfort take back" is often evident — something that counteracts the energy-efficient qualities of their homes. "Comfort take back" takes place when occupants of energy efficient homes increase internal temperatures following the installation of energy efficient measures; it's a factor that must be taken into account when designing low-energy houses.

Other nZEB101 project findings include:

- interior temperatures are higher than values listed in the Dwelling Energy Assessment Procedure (DEAP);
- the fabrics of nZEBs often under-perform, with measured U-values at multiples of the expected or design U-value;
- heat pumps are commonly operating with lower efficiencies than those proposed by manufacturers for the products, with a typical Coefficient of Performance (COP) of 2.5;
- the embodied carbon of retrofit to nZEB standard is in the range 125-250 kgCO2/m^2 of floor area.
- The nZEB101 project's recommendations include the implementation of:
- a whole life carbon approach to the evaluation of A-rated homes;
- post-occupancy evaluations of retrofit and new builds (with responsibility for performance shared between the architect and contractor);

- widespread up-skilling of heat pump installers with greater care and checking of installation;
- on-site testing of building fabrics using heat flux sensors, at the time of retrofit or new build works;
- guidelines for tenants on how best to operate energy efficient homes and their technologies
- stricter building controls;
- revision of the DEAP methodology to account for more realistic internal (and external) temperatures.

The data gathered by the nZEB101 project will ensure that we capture the necessary design and operations lessons to inform future design — not just for project participants, but for industry as a whole. By taking an ambitious and multi-stranded approach, nZEB101 delivers significant return on investment. For further information, visit the SEAI project page.

About Oliver Kinnane Lead Researcher

Oliver Kinnane, Ph.D. M.Arch. B.E. is Associate Professor at the School of Architecture, Planning and Environmental Policy at University College Dublin (UCD) and academic lead of its Building in a Climate Emergency Research Lab. He is founder of the MSc in Architecture, Urbanism and Climate Action. His research is focused on building construction, conservation and operation and improving the performance of the built environment at large; to date, he has written over 100 peer-reviewed published articles on these topics. Oliver leads multiple funded research projects, including four SEAI RD&D projects; FabTrads: hygrothermal testing of traditional building fabrics, MacAirH: evaluating heat pump performance in-use, Re-CUGI: investigating models of compact urban growth and the now completed nZEB101; analysing the performance of nZEB dwellings).

Project Partners

Michael Bennett and Sons is a Wexford-based construction company that specialises in passive homes, eco-friendly energy solutions, road construction and maintenance, surface dressing, civil engineering, urban renewal and floors alleviation.

South East Energy Agency (formerly 3CEA) is the Energy Agency for Carlow, Kilkenny, Wexford and Waterford. It works via partnerships to deliver energy-saving projects for the local authorities, communities and individuals in the Southeast.

Nilan develops and manufactures premium-quality, energy-saving ventilation and heat pump solutions that are beneficial to the environment and provide a healthy indoor climate and low-level energy consumption.

MosArt is an architectural firm that provides design, sustainability services and educational training. As a leading advocate of passive housing, it sets industry standards, delivers exceptional buildings and fosters strong client relationships.

"SEAI research funding supports research and innovation across the energy sector to help build a cleaner and more secure energy future. We invest in projects in Ireland and identify areas of priority for Ireland and Europe, helping to enhance the world's knowledge economy."

Additional Case Studies (Continued)

Smart Electric Buses

Using AI to optimise the electrification of Ireland's bus network

Lead organisation: *University College Cork (UCC)*
Project Name: *The Smart Electric Buses Project*
Project Duration: *3 yrs*
Total Project Costs: *€202,250*
Year Funded: *2019*

Electric buses are a vital element of our efforts to make Ireland more sustainable and less reliant on fossil fuel. Moving to a zero-emission fleet will take us closer to our goal of reducing our emissions in line with the European Green Deal. However, battery-powered buses require charging stations in order to operate; the location and frequency of these charging stations and the need for clean energy to power them is the subject of an ongoing University College Cork research project funded by the SEAI. Dr Alejandro Arbelaez, Professor Ken Brown and their team used AI technologies to establish efficient clean energy supply patterns and to identify suitable locations for electric bus charging stations in a bid to achieve maximum efficiency.

Efforts to make public transportation more sustainable are firmly under way, with many European countries moving away from diesel-powered fleets in favour of the introduction of electric buses (eBuses). With EU legislation designed to reduce emissions by at least 40% (from 1990 levels) by 2030 in place, sustainable public transport systems both reduce our reliance on fossil fuels and our need for personal vehicles. Ireland's National Transport Authority (NTA) has pledged that by 2025, about a third of the nation's urban bus fleet will be zero-emission.

Electric buses offer us a vision of an emission-free and more environmentally-friendly future, with more peaceful inner cities. They provide a means of transporting large numbers of people, while reducing noise and pollution in urban areas. Transitioning to electric buses is not without its challenges: unlike diesel-powered buses, eBuses must recharge their batteries at regular intervals and need to reach charging stations to do this.

A SEAI-funded research project has set about addressing two important issues that face the implementation of a sustainable and efficient electric transportation network: limited driving range and battery charging/ discharging time. The Smart Electric Buses project, which began in 2019, was launched by Dr Alejandro Arbelaez at University College Cork (UCC) School of Computer Science, with Dr Alejandro Arbelaez and Professor Ken Brown as Project Leads.

Standard electric buses can travel up to 200km on a full charge, while charging times vary — ranging from a couple of minutes (with fast-charging stations rated at 450 kWh) to hours (with slow-charging stations rated at 30 kWh). In order to address these limitations, Dr Alejandro Arbelaez' team made use of multiple Artificial Intelligence (AI) technologies to optimise critical components for the move to an eBus system.

"I believe that electric buses are going to be the main transportation system of the near/mid future, so we need to have a way to smoothly transition diesel buses into electric buses," explained Project Lead Dr Alejandro Arbelaez.

> *"Everyone is kind of afraid of moving towards electric vehicles in general — the main reason for that is because electric vehicles cannot travel long distances. We need to look for ways to transition that are going to be effective; if it's not efficient, it's going to be very expensive to make the switch."*

The UCC team worked on new algorithms to find opportunities to optimise gaps in the running of an effective electric bus system. One distinct focus of their work was figuring out a prediction pattern (using constraint programming, mixed integer linear programming and meta-heuristic search) for the availability of clean energy to power the electric buses, as relying on coal-fired power is not an option for a zero-emission fleet. The second focus was identifying suitable locations for the required charging stations — for example, should there be one main charging station located at the depot (to which each bus would have to return), or would smaller micro-charging stations (that would provide small 30-second power top-ups) at every bus stop work better? For each scenario, the team balanced cost versus efficiency and also took into account the impact each scenario might have on a bus network's timetable.

"If you don't plan and analyse this data properly, you could end up buying buses with massive big batteries that are way more powerful than needed, which increases the cost of supplying the bus network as the buses become very expensive." noted Project Lead Professor Kenneth N Browne.

"We may be able to cut the deployment costs by getting a better mix of bus sizes and batteries, if it's possible to plan the different routes and the different charging stations."

The data compiled within this project will ensure that decision-makers in Ireland (and internationally) have all the information they need to make the transition to an electric bus fleet as smooth as possible. Budgetary restrictions and clean energy limitations will place constraints on Ireland's use of electric buses, but by reviewing the many in-depth scenarios that Dr Arbelaez, Professor Browne and their team have simulated, the system can be built for maximum efficiency. For further information, visit the SEAI project page.

About Dr Alejandro Arbelaez Lead Researcher

Dr Alejandro Arbelaez received his PhD in computer science from Université Paris-Sud XI in 2011 for his work on applying learning-based techniques to solve combinatorial problems. He also holds an engineering degree from Universidad Javeriana (Cali, Colombia). After finishing his PhD he worked as a PostDoctoral Researcher at the University of Tokyo (2 years) and University College Cork (3.5 years).

Dr. Arbelaez has over 40 publications and he has presented his work at several conferences in the fields of artificial intelligence and computer science.

About Professor Kenneth N Browne Lead Researcher

Professor Ken Brown joined UCC Computer Science Department as a senior lecturer in 2003. Prior to that he was a lecturer at the University of Aberdeen, a Research Fellow at Carnegie Mellon University, and a Research Associate at the University of Bristol. His research interests are in the application of AI, optimisation and distributed reasoning, with a particular focus on wireless networks. He is a Co-Principal Investigator/ Group Leader at Insight: Centre for Data Analytics.

Appendix

Electricity

Project Entity	Lead Applicant	Lead Organisation
Reliable and Efficient Photo-electrochemical Water Splitting for Hydrogen Fuel	Robert O'Connor	Dublin City University (DCU)
Mapping Webtool to Support the Preparation of Local Authority Renewable Energy Strategies	Ainhoa González	University College Dublin (UCD)
Enhanced Controllers to Improve Wind Farm Efficiency	Breiffni Fitzgerald	Trinity College Dublin (TCD)
Role of Heterogenous Energy Storage in Paris Aligned Scenarios for the Irish Energy System	Barry McMullin	Dublin City University (DCU)
Digi Blocks	Susan Rea	Munster Technical University (MTU)
Robust Real-Time Wind Power Prediction and Early, Accurate Estimation of Downtime for Irish Wind Farms in an Integrated Single Electricity Market (Wind-PEarlAED)	Vikram Pakrashi	University College Dublin (UCD)
CAO IRL Coupled Atmosphere Ocean Wave Forecasts for Ireland	Basanta Kumar Samala	University of Galway (UG)
FREMI (Forecasting Renewable Energy with Machine Intelligence)	David Noronha	SSE Airtricity
Community Engagement in Wind Energy: Innovative approaches to achieving a social license (Co-Wind)	Bernadette Power	University College Cork (UCC)
Using Surplus Energy to generate Hydrogen (USE H2)	Mary Pryce	Dublin City University (DCU)
The True Cost of the Energy – Water Nexus in Manufacturing.	David McCormack	Irish Manufacturing Research (IMR)
Low Cost Monitoring and Control of Small Scale Renewables	Paddy Finn	Electricity Exchange DAC.
Agricultural Energy Optimisation Platform (AEOP)	Michael D. Murphy	Munster Technical University (MTU)
Trinity Smart Grid	Igor Shvets	Trinity College Dublin (TCD)
Dundalk Virtual Energy Microgrid (DVEM)	Paul MacArtain	Dundalk Institute of Technology (DkIT)
Identifying the relative and combined impact and importance of a range of curtailment mitigation options on high RES-E systems in 2030 & 2040	Rory Mullan	Mullan Grid Consulting
Next generation modular energy generating greenhouse (NGMEGG)	Charles Spillane	University of Galway (UG)

Project Entity	Lead Applicant	Lead Organisation
Thin film tech for smart windows	James Rice	University College Dublin (UCD)
Enhancement of Inertial Stabilisation of the Electricity Grid using Local Electrochemical Processes for Load Levelling	Robert Lynch	University of Limerick (UL)
Social acceptability of wind farms and electricity export: a discrete choice econometric approach	Thomas van Rensburg	University of Galway (UG)
EnergyPOLITIES: Politico-institutional framing of collective engagements with the energy system	Niall Dunphy	University College Cork (UCC)
Optical Antennas and the Purcell effect: towards efficient solar concentration	Daragh Byrne	Dublin City University (DCU)
Quantifying Light Loss across Ireland and Identifying Patterns of Energy Use	Brian Espey	Trinity College Dublin (TCD)
Using blockchains to facilitate renewable power generation: forecasting, hedging and tokenisation applications	Paul Cuffe	University College Dublin (UCD)
The Aeration In-Use Factor: The in-use aeration energy efficiency of two technologies in the wastewater treatment industry	Eoghan Clifford	University of Galway (UG)
Support tools for community renewable energy	Niall Dunphy	University College Cork (UCC)
Developing Site Investigation Methodologies and Constraint Mapping Products for Offshore Renewable Energy (DeSIRE)	Mike Long	University College Dublin (UCD)
OPFLOW	Val Cummins	University College Cork (UCC)
Identifying and overcoming societal barriers to sustainable energy adaptation	Muireann Á. Lynch	Economic and Social Research Institute (ESRI)
Testing and classification of high-performance materials to protect wind turbine blades from leading-edge erosion by droplet impingement	Trevor Young	University of Limerick (UL)
I-MORE: Informing and Mapping the Offshore Renewable Environment	Paul Doherty	Gavin and Doherty Geosolutions Ltd.
Increasing energy efficiency of minerals processing operations by advanced sensor-based sorting of ores (ENEROS)	Igor Shvets	Trinity College Dublin (TCD)
National Artificial Intelligent Dairy Energy Application (NAIDEA)	Dr. Michael D. Murphy	Munster Technical University (MTU)

Appendix (Continued)

Project Entity	Lead Applicant	Lead Organisation
Building upon Copernicus Earth Observation services to augment wind measurement coverage of the OREDP offshore renewable energy assessment areas	Sheila McBreen	University College Dublin (UCD)
Closed Cycle Power Take Off for OWC Wave Energy Devices	Craig Meskell	Trinity College Dublin (TCD)
Developing Real Time Contingency Analysis and Network Optimisation Control Centre Tools and Capabilities	Marie Hayden	Smart Wire Grid Europe Limited (Smart Wires)
Development of damping parameters for Irish Offshore Wind Farms	David Igoe	Trinity College Dublin (TCD)
Enabling Smart Home Energy Responses (ESHER)	Ruth Kerrigan	Integrated Environmental Solutions (IES) R&D
GKinetic Submersible Testing	Vincent McCormack	GKinetic Energy
An Electricity-to-Fuels Research and Deployment Platform for Ireland	Stephen Dooley	Trinity College Dublin (TCD)
Improving Energy Efficiency using Behaviourally Informed Smart Technology: A Lab, Online and Large-Scale Field Trial	Deirdre Robertson	Economic and Social Research Institute (ESRI)
sECUre: eStablishing Energy Community Utilities for Remote Energy grids	Ruth Kerrigan	Integrated Environmental Solutions (IES) R&D
Droplet Impact Erosion Mill (DIEM)	Brendan Duffy	Technical University Dublin
Real Time State Estimation Demonstration on Irish Distribution Network	Paul Manning	Novogrid
Offshore Aquaculture Renewable Power Solutions (OARPS)	John Fitzgerald	Impact9
SuperMarineOne	Robert O'Connor	Supernode
Low-Cost Sustainable Battery Systems for Enhanced Grid Penetration of Intermittent Renewable Energy	Tadhg Kennedy	University of Limerick
Offshore Wind Farm Projects Community Acceptance and Stakeholder Engagement - Best Practice Handbook	Gary Keegan	Construction Support Services (CSS) Ltd.
Laser Ablation for Wind Turbine Blade Contaminant Classification, Quantification and Removal	John Costello	Dublin City University (DCU)
TurbinePredict	Aidan Gleeson/ Ronan O'Meara	MHL EnergyPro Ltd
LOHCell – Simplified on-demand utilisation of renewable energy stored by a virtual hydrogen carrier	Michael Brandon	Dublin City University (DCU)

Project Entity	Lead Applicant	Lead Organisation
Building a Social Licence to Operate: co-designing a near-neighbour - developer engagement process, and refining it to create win-win wind energy projects.	John Aston	AstonEco
BEYOND: Blockchain based Electricity trading for the integration of National and Decentralised local markets	Shafi Khadem	IERC, University College Cork (UCC)

Heat

Project Entity	Lead Applicant	Lead Organisation
Exergyn Heat Pump	Kevin O'Toole	Exergyn
Reducing Energy Consumption in Air Filtration Systems (RECAFS)	Aonghus McNabola	Trinity College Dublin (TCD)
Indoor air quality, ventilation and occupant comfort in Irish domestic dwelling's pre and post Deep Energy renovations	Marie Coggins	University of Galway (UG)
FactHP - In Use Factors for Heat Pumps and other energy technologies in Residential Buildings	Seamus Hoyne	University of Limerick (UL)
Urban Building Energy Model	Gerald Mills	University College Dublin (UCD)
Enhancing and Assessing the Impact of Novel Circular Economy Sectors in the bioeconomy	Cathal O'Donoghue	University of Galway (UG)
Dublin Region Energy Masterplan	Declan McCormac	Codema
Retrokit 2.0 - A Cloud-Based Project Planning and Implementation Toolkit to Foster the Uptake of Deep Energy Retrofit in Housing.	Xavier Debuisson	XD Consulting
Building Upon Ireland's National Renovation Strategy	Marion Jammet	Irish Green Building Council (IGBC)
Assessment of VentilAtion effectiveness via a Longitudinal indoor environmental study in 'A' rated Irish Dwellings: VALIDate	Miriam Byrne	University of Galway (UG)
BIO-RPISM: biofuel production, digestate purification and CO2 sequestration with highly productive auto-floating microalgae technology	Xinmin Zhan	University of Galway (UG)

Appendix (Continued)

Project Entity	Lead Applicant	Lead Organisation
Continuous Commissioning to Create High Performance Buildings	Tony O'Keeffe	Inferrit Limited
DesignForIU: Comparison of certified versus operational performance of energy efficient technologies	Paul D O' Sullivan	Munster Technical University (MTU)
Assessment Methodology Building Energy Ratings (AMBER)	Ruth Kerrigan	Integrated Environmental Solutions (IES) R&D
Exploration of Air Source Heat Pumps for Ireland's Residential Heating Needs	Paula Carroll	University College Dublin (UCD)
GEBTechTM (Green Energy Boosting Technology): A novel treatment for farm slurries to reduce greenhouse gas emissions and to generate energy	Ruairi Friel	Westway Health
nZEB_101	Oliver Kinnane	University College Dublin (UCD)
Energy Renovation of Traditional Buildings – CPD roll-out	Colm Murray	The Heritage Council
Agri Bio Circular Economy (ABC Economy)	Fionnuala Murphy	University College Dublin (UCD)
Slurres Pilot	JJ Leahy	University of Limerick (UL)
Biomass Practitioners Register	Sean Finan	Irish BioEnergy Association (IrBEA)
Identifying non-financial barriers to energy efficiency residential retrofits in low income households	John Curtis	Economic and Social Research Institute (ESRI)
Health Impact Assessment of Deep Energy Renovations on Irish Domestic Dwellings - HAVEN	Marie Coggins	University of Galway (UG)
ThermoWell: Thermal Resource Extraction from a Standing Column Well	James McAteer	Gavin and Doherty Geosolutions Ltd.
ShallowTHERM	Riccardo Pasquali	GeoServ

Project Entity	Lead Applicant	Lead Organisation
High Value Sustainable Renewable Fuels and Bio-Products from Forest Residues in Ireland	Rory Monaghan	University of Galway (UG)
Feasibility of Carbon Capture Utilisation and Storage (CCUS) in Ireland	Rory Monaghan	University of Galway (UG)
Developing Economic solutions for on-farm Anaerobic Digestion technologies under Irish conditions (EcoAD)	Jerry Murphy	University College Cork (UCC)
HEAT CHECK (Heating and Temperature Characteristics in Irish Buildings)	Jamie Goggins	University of Galway (UG)
Farm Level Economic, Environmental and Transport modelling of alternative feedstock solutions for regional anaerobic digestion plants in Ireland (FLEET)	Fiona Thorne	Teagasc
Project RESILIENCE	Paul D O' Sullivan	Munster Technical University (MTU)
Practical, commercially-focussed research to further develop an innovative financial solution for residential retrofits	Laura Heuston	Sustainability Works
DIG: De-risking Ireland's Geothermal Energy Potential	Brian M. O'Reilly	Dublin Institute for Advanced Studies (DIAS)

Appendix (Continued)

Project Entity	Lead Applicant	Lead Organisation
ALIVE - Assessing Indoor Environmental Quality and Energy Efficiency In a range of Naturally-Ventilated Buildings: A Multi-Disciplinary Approach	Miriam Byrne	University of Galway (UG)
Development of novel antimicrobial cocktails to mitigate GHG emissions from stored slurries and manures	Aoife McCarthy	Glasport Bio

Transport

Project Entity	Lead Applicant	Lead Organisation
Fundamental Information for Technology Commercialisation of Lignocellulosic Waste to Liquid Transportation Fuels by Acid Hydrolysis	Stephen Dooley	Trinity College Dublin
DiSTRaCT: moDal ShifT Reduce Carbon in Transport	Brian Caulfield	Trinity College Dublin (TCD)
Desktop study to assess potential mitigation measures that would reduce CO2 and/or air pollutant emissions from the existing Irish heavy duty vehicle fleet	Brian Ó Gallachóir	University College Cork (UCC)
Mitigation of Air Pollution Impacts of Irish Heavy Duty Vehicles (MAP-HDV)	Bidisha Ghosh	Trinity College Dublin (TCD)
Electric vehicle potential within existing technical standards and commuting patterns	John Curtis	Economic and Social Research Institute (ESRI)
A roadmap for the deployment of electrofuels for the decarbonisation of heat and transport in Ireland	Rory Monaghan	University of Galway (UG)
Smart Electric Buses	Alejandro Arbelaez/ Ken Brown	University College Cork
Growing Energy Efficiency in the Car Market (GREENCAR)	Eleanor Denny	Trinity College Dublin (TCD)
Charging strategies and infrastructure design for transition to electrified fleets	Jimmy Murphy	University College Cork
EV Charge	Theresa Keady	EC Charging
EVCHIP - Electric Vehicles Charging Platform for Community Demand Response Aggregators	Andrew Keane	University College Dublin

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