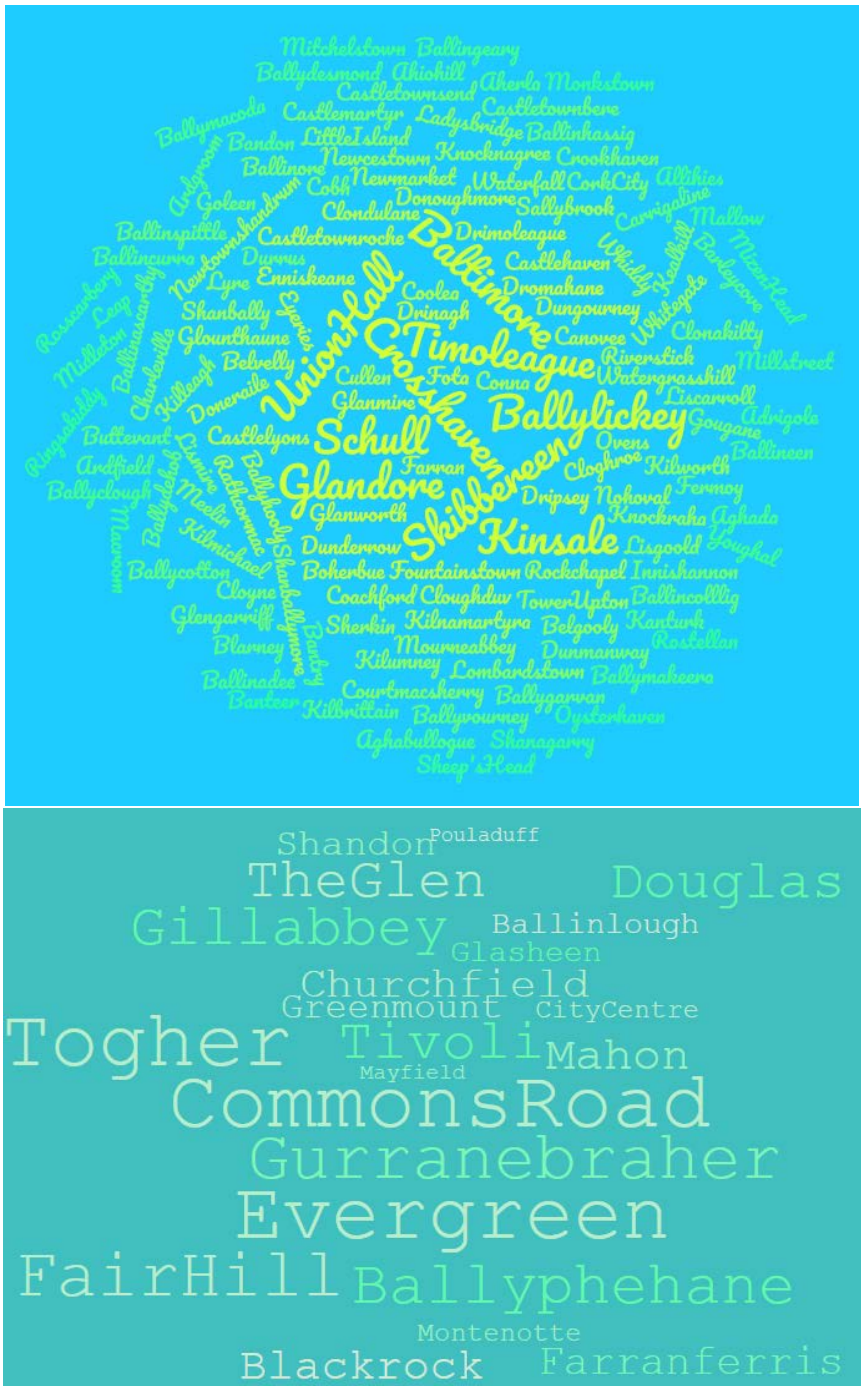
ENERGY CHAMPION CLG (ENERGY CORK)
ENERGY MASTER PLAN – CORK CITY and COUNTY

Report on Baseline Energy Balance, Renewable Energy Potential and Register of Opportunities



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SURVEY&DESIGN SERVICES

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1 Introduction and Overview

Energy Champion (Energy Cork), a registered member of the Sustainable Energy Authority of Ireland's (SEAI) Sustainable Energy Communities (SEC) Network, has entered into a three-year Partnership Agreement with SEAI. The objectives of the SEC program are to:

- Increase energy efficiency
- Use renewable energy
- Develop decentralised energy supplies

Step 2 of this 5-step process involves the preparation of an Energy Master Plan (EMP) for the SEC territory (Study Area) to establish the baseline energy consumption for an agreed year, and the formulation of a Register of Opportunities that will deliver significant energy demand reductions and contributions from renewable energy sources. In this particular case, the Study Area consists of all of Cork City and County (pop.519,032). For the purposes of this study, the city boundary is assumed to be that in place up to 2019.

Energy Champion has set the EMP baseline year at 2016. They would also like to commit to ambitious energy demand reduction and renewable contribution targets by 2030. From the analysis detailed below, the projected achievable out-turns for these targets by 2030 are 34.6% energy demand reduction and 53.51% renewable energy contribution.

The main suggested energy demand reduction actions involve:

- a medium energy retrofit of 75% of all dwellings in the city and county
- energy retrofit of buildings in the non-residential section to deliver 40% energy demand reduction
- deployment of EV/CNG vehicles, modal shift and efficient driving in the transport sector
- the above actions have the potential to deliver 42.2%, 37.8% and 17% respectively of the overall energy demand reduction target of 34.6%.

The main suggested renewable energy contribution actions involve:

- deployment of heat pumps in 75% of all dwellings in the city and county (as part of the medium retrofit mentioned above).
- deployment of currently contracted onshore wind generation capacity of 285.36MW. (For the purposes of this study, deployment of additional onshore wind generation capacity, in excess of the currently contracted capacity of 285.36MW, was not considered).
- 20% renewable gas on gas grid by 2030.
- Biofuels Obligation Scheme
- deployment of PV by non-residential sector to deliver 30% of electricity demand
- the above actions have the potential to deliver 20.6%, 14.3%, 10.4%, 6.7% and 6.5% respectively of the overall 2030 energy demand.
- It is projected that the currently-deployed renewable generation capacity of 488.1MW will meet 16% of the 2030 energy demand.

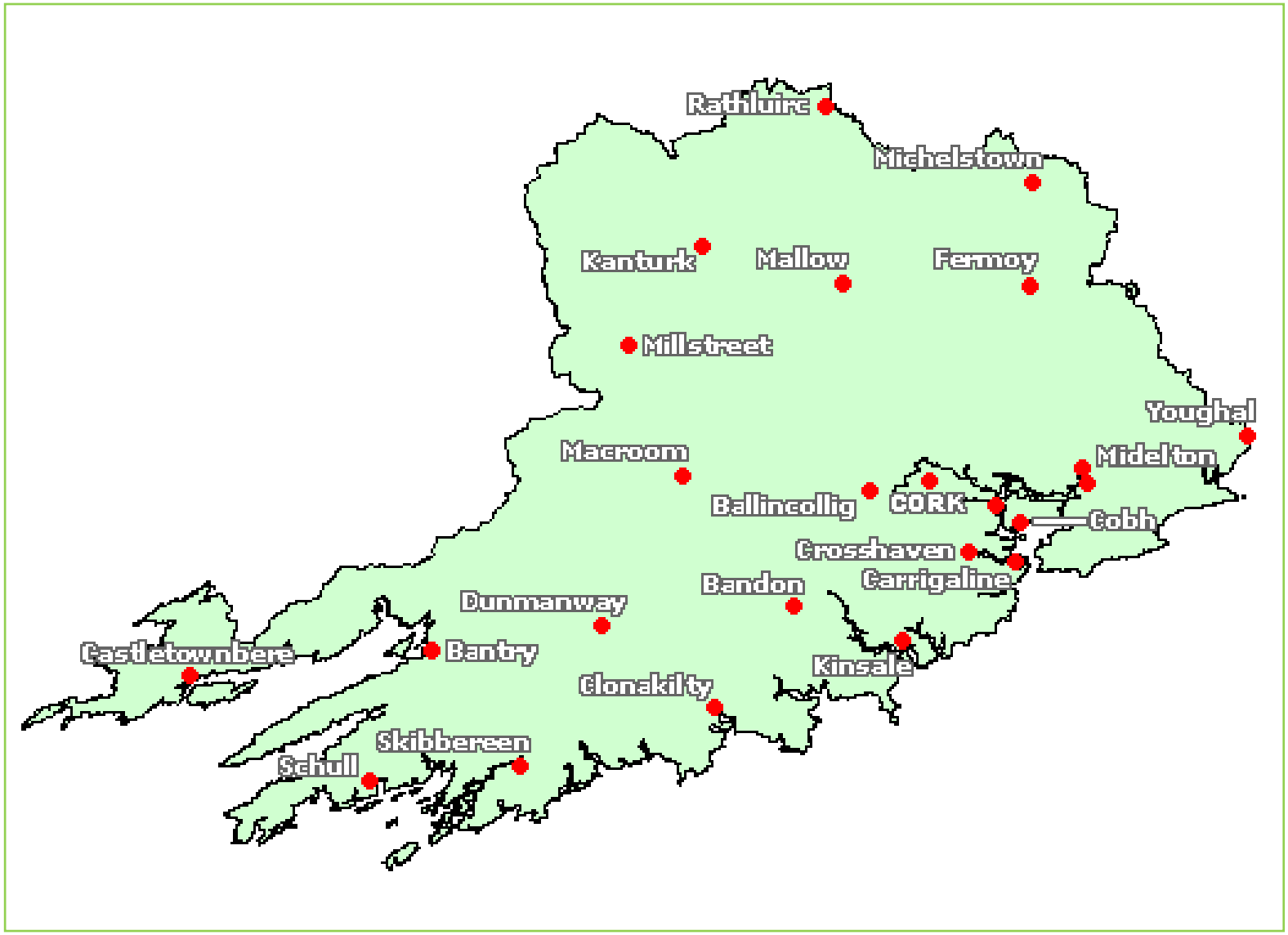
The view was taken that offshore wind, wave and tidal power renewable technologies are not likely to be deployable on the southern seaboard by 2030. This is primarily due to the long lead-times involved. However, it is also submitted that initial roll-out of such technologies in Ireland is likely to be located closer to the high electricity demand that exists adjacent to the Irish Sea on the eastern seaboard; tamer weather conditions also prevail on the eastern seaboard which is more conducive to early adoption of this relatively developmental technology.

The projected capital expenditure required to deploy the required energy demand reduction and renewable contribution measures amounts to €8,225.5M and €1,664.7M respectively. This latter amount does not include provisions for expenditure in relation to grid-scale onshore wind, grid-scale PV or renewable gas initiatives.

It is projected that the energy demand reduction and renewable technology initiatives detailed below can deliver an annual energy spend saving of €476M approx (excluding increases in fuel/carbon prices or impacts of carbon fines).

The baseline energy balance is prepared on the basis of final energy usage (delivered energy), by fuel type, (using the methodologies detailed in Section 3 hereunder) for each of the following sectors:

SECTORS	
1	Residential Buildings
2	Non-Residential Commercial and Public Buildings (schools, health facilities, etc)
3	Municipal and Local Authority (this section includes local authority buildings, transport, public lighting, water supply & wastewater services)
4	Fisheries and Agriculture
5	Transport (excl local authority transport)



TOWNS IN COUNTY CORK

The Baseline Energy Balance and Register of Opportunities for the residential and non-residential sectors are prepared on the basis of standard occupancy. Standardised occupancy is the approach used in calculating energy usages in Ireland's Building Energy Rating programmes and CIBSE benchmarking. It enables a fair "like with like" comparison between baseline and retrofitted buildings and enables use of energy modelling tools in calculating the associated savings.

The impacts of seasonality are not considered.

In respect of the Register of Opportunities, the three main actions that will deliver the required energy demand reduction are:

1. Medium-depth energy retrofit of 75% of all dwellings (42.31% of overall energy demand reduction).
2. Energy retrofit across the non-residential buildings sector to achieve 40% energy demand reduction (37.89% of overall energy demand reduction).
3. Deployment of EV's/CNG vehicles (cars, busses, trucks) and also electric rail on the main Cork/Dublin line (16.83% of overall energy demand reduction).

The methodologies outlined in this document could potentially be shared with SEC's throughout the City and County, in order to help build knowledge and capacity within such community groups. It will also assist them to get an understanding of the types of measures and impacts that an energy transition within their territory will require.

Given the enormity of the scale of interventions required to delivery change, it is submitted that the following barriers need to be addressed as a matter of urgency (nationally and locally):

1. CALLS TO ACTION: Current inertia must be overcome in order to accelerate activity and create a non-reversible momentum towards change in energy performance of buildings; creation of new and novel channels of communications (preferably bottom-up, rather than continuation of top-down channels), as well as minimisation of market uncertainties, will be crucial.
2. HUMAN CAPITAL: There are serious supply chain issues in terms of trained personnel (professional and trades-based) which are very significant impediments in the drive towards broad and deep retrofit.
3. HUMAN CAPITAL: Resources to monitor and maintain new technologies are currently noticeably scarce – this is a major barrier to deployment of new technologies.
4. FINANCIAL CAPITAL: It is apparent that mobilization of the necessary financial capital to fund the required sea-change in retrofit activity will be a major issue among property-owners. Innovative interventions by the energy supplier community, and energy technology suppliers, will be required to deploy performance-based solutions with appropriate distribution of risk.

It should be noted that Energy Cork is already involved in a number of very worthwhile initiatives:

- **Drive4Zero**. This project aims to facilitate enhanced uptake of EV's in the following manner:
  - *Zero car fuel costs* through increased deployment of free charging units at places of employment
  - *Zero car parking costs* at certain car-parks.
  - *Zero interest-rate financing* & *zero deposit financing* for purchase of certain EV's
- **Ireland's Greenest Bus Fleet**. This project initially aims to introduce 20 no. CNG fueled busses, and a re-fueling infrastructure, to the Bus Eireann city bus fleet in Cork for use on certain bus

routes. The longer-term aim is to integrate the entire city service bus fleet to CNG fuel, subject to funding availability. The adoption of a CNG bus fleet will create a pathway for the use of Renewable Natural Gas (RNG) as a transport fuel, thus enabling near carbon-zero public bus transport. The current projection is that there will be 20% renewable on the gas grid by 2030.

2 Legislation and Policy Background

2.1 EU LEVEL

ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE

A revised Energy Performance of Buildings Directive was published by the EU in Summer 2018 and must be transposed into law in EU Member States by March 2020. The main changes will be:

- ~ Targets: Member States must achieve decarbonized building stock by 2050 using a cost-effective combination of energy efficiency and decarbonized energy supply. This must be guided by national milestones for short-term (2030), mid-term (2040) and long-term (2050) objectives.
- ~ ICT/Smart Technologies: Promotion of ICT/smart technologies, communications and building automation/control systems. The "smart readiness factor" will measure the building's ability to use ICT to adapt building operation to the needs of the grid. This should help occupants understand energy usage and savings achieved by installed smart technologies.
- ~ E-Mobility: Promotion of electromobility (i.e. promotion of electric cars)
- ~ Renovation Strategies: The reference to national long-term building renovation strategies has been moved to and strengthened in the EPBD (this originally resided in the Energy Efficiency Directive). "Each Member State shall set out a roadmap with measures and domestically established measurable progress indicators, with a view to the long-term 2050 goal of reducing greenhouse gas emissions in the Union by 80-95% compared to 1990".
- ~ Financing: The EPBD seeks to mobilise financing/investment from public and private sources.

ENERGY EFFICIENCY DIRECTIVE (2012)

A 2016 update of this Directive establishes a set of binding measures towards helping the EU to reach a 30% energy efficiency target by 2030. National measures to be adopted include the following:

- ~ Energy distributors/sales companies to drive 1.5% energy savings per year through energy efficiency measures
- ~ Public sector to procure energy efficient buildings, products and services
- ~ Governments to carry out energy efficient renovations to at least 3% of the buildings they own/occupy per year
- ~ Easy and free access to energy data to be provided to energy consumers
- ~ Incentivize energy audits for SME's
- ~ Mandatory energy audits for large companies

RENEWABLE ENERGY DIRECTIVE

A 2016 update of this Directive requires the EU to fulfill at least 27% of its total energy needs with renewables by 2030.

EU CLIMATE AND ENERGY FRAMEWORK

This Policy sets the following 2030 targets (from 1990 levels):

- ~ At least 40% GHG emission reductions (binding)
- ~ At least 27% share for renewable energy (binding)
- ~ At least 27% improvement in energy efficiency (endorsed)

2.2 NATIONAL LEVEL

CLIMATE ACTION AND LOW CARBON DEVELOPMENT ACT (2015)

This is the first ever climate legislation in Ireland and provides a statutory basis for the national objective of transitioning to a low carbon economy by 2050. It enshrines the commitment of the State to GHG mitigation and adaptation measures as well as providing approval for the plans underpinning this transition, namely the National Mitigation Plan and National Adaptation Framework.

IRELAND'S TRANSITION TO A LOW CARBON ENERGY FUTURE 2015-2030

This White Paper sets out the framework to guide energy policy to 2030, with the long-term vision of reducing GHG emissions by 80%-95% by 2050 (compared to 1990 levels). The Plan envisages the Citizen being at the center of the required energy transition: the change "from passive consumer to active citizen" and citizen engagement are key principals of this Plan.

NATIONAL ENERGY EFFICIENCY ACTION PLAN (NEEAP4) 2017-2020

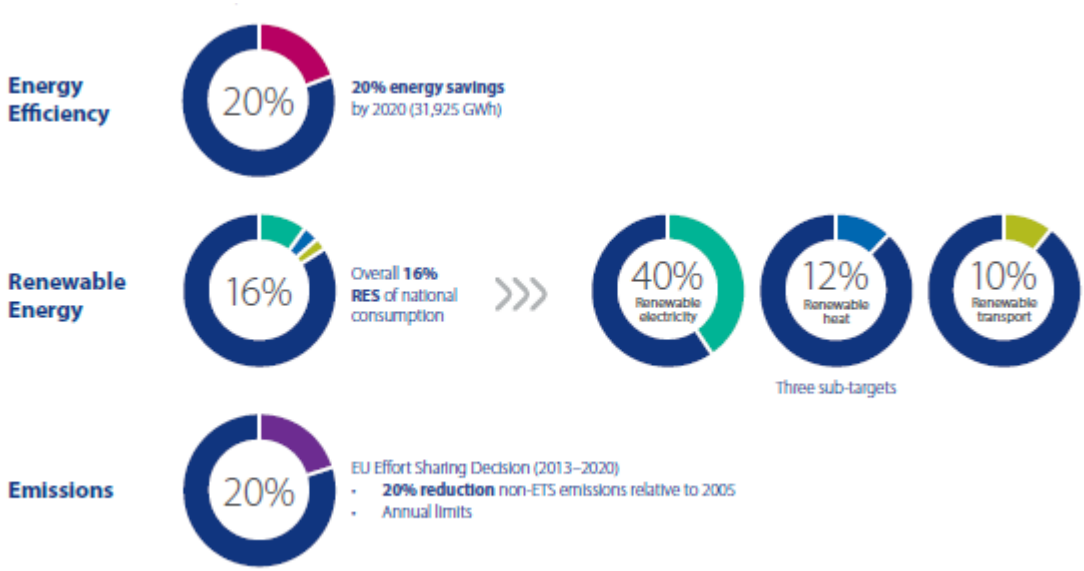
NEEAP4 sets a target of 20% improvement in energy efficiency by 2020 and a more ambitious target of 33% in respect of the public sector. It sets out the scale of energy and emission savings achieved per sector by 2016 and projects the levels of savings envisaged by 2020 under various scenarios. It also sets out details of measures and programs that will deliver towards the savings targets in each sector.

NATIONAL MITIGATION PLAN 2017

This first whole-of-government plan sets out the multiple measures requires across several Government Departments to enable the required transition "to a low carbon, climate resilient and environmentally sustainable economy by 2050". In particular, it sets out measures to facilitate the decarbonization of electricity generation, built environment, transports and agriculture/forestry/land use.

NATIONAL RENEWABLE ENERGY ACTION PLAN 2010

This sets out national targets in respect of the share of energy from renewable sources to be consumed in transport, electricity and heating/cooling in 2020.



National Headline Energy and Emissions Targets Source: Ireland's Energy Projections, 2017 (SEAI)

CLIMATE ACTION PLAN 2019

This document openly acknowledges, at the very outset, that "Ireland is way off course" in respect of arresting it's GHG emissions. Furthermore, this gap-to-target is currently widening due to recent growth in emissions. This plan commits to detail the changes required to provide a pathway to 2030, which will be consistent with achieving a net zero emissions target by 2050. The following sets out a number of the objectives included in the Plan:

- Electricity
  - Increase share of renewable electricity from 30% to 70%, with peat and coal plants closing
  - Support scheme for micro-generation
- Buildings
  - Introduce stricter requirements for new buildings and substantial refurbishments
  - 500,000 homes to be upgraded to B2 (BER)
  - Heat pumps to be fitted to 400,000 existing homes
  - Increase attention to Energy and Carbon ratings in all aspects of managing property assets
- Transport
  - Target of 950,000 EV's on road by 2030
  - Make the economy less transport-intensive
  - Increase biofuel content for motor fuels
  - Conversion of public transport fleet to zero carbon alternatives
- Agriculture
  - Deliver verifiable GHG abatement through improved farming practices
  - Carbon abatement through increased forestry planting and soil management
- Enterprise and Services
  - Embed energy efficiency, replacement of fossil fuels, careful management of materials and waste across all enterprises and public service bodies.
  - Create centres of excellence for the adoption of low carbon technologies
- Waste and the Circular Economy
  - Reduction strategies for plastics, food waste and resource use
  - Increased levels and quality of recycling
  - Reduced reliance on landfill

2.3 LOCAL LEVEL

CORK COUNTY DEVELOPMENT PLAN 2014

ENERGY (Chapter 9.1)

Cork plays a strategic role in energy provision in Ireland, in terms of conventional fossil fuel power stations and hydroelectric plants: in 2010, it produced 24% of Ireland's energy end-use requirements.

Whitegate, in East Cork, nationally plays a strategic role in energy supply with 25% of all national energy produced in one square mile. Also, 90 per cent of the oil reserves held in the state are stored here and elsewhere in the Cork region. The Kinsale Field off the south west coast of Cork was, until relatively recently, the States sole natural gas field. This is also the location of Ireland's only strategic gas storage facility with gas imports used to refill this storage facility in addition to site production.

"Energy generation and energy related activity in Cork is likely to change significantly over the coming years as the oil finds in Cork become operational and as the move to a low carbon economy increases".

The Whitegate area, on the eastern shore of Cork Harbour has a nationally important role in this sector and is the location for three gas–fired power stations. Whitegate is also the location of the country's only oil refinery - the refinery has potential to facilitate the delivery of national bio substitution targets; it also has additional potential for future gas storage and carbon capture facilities.

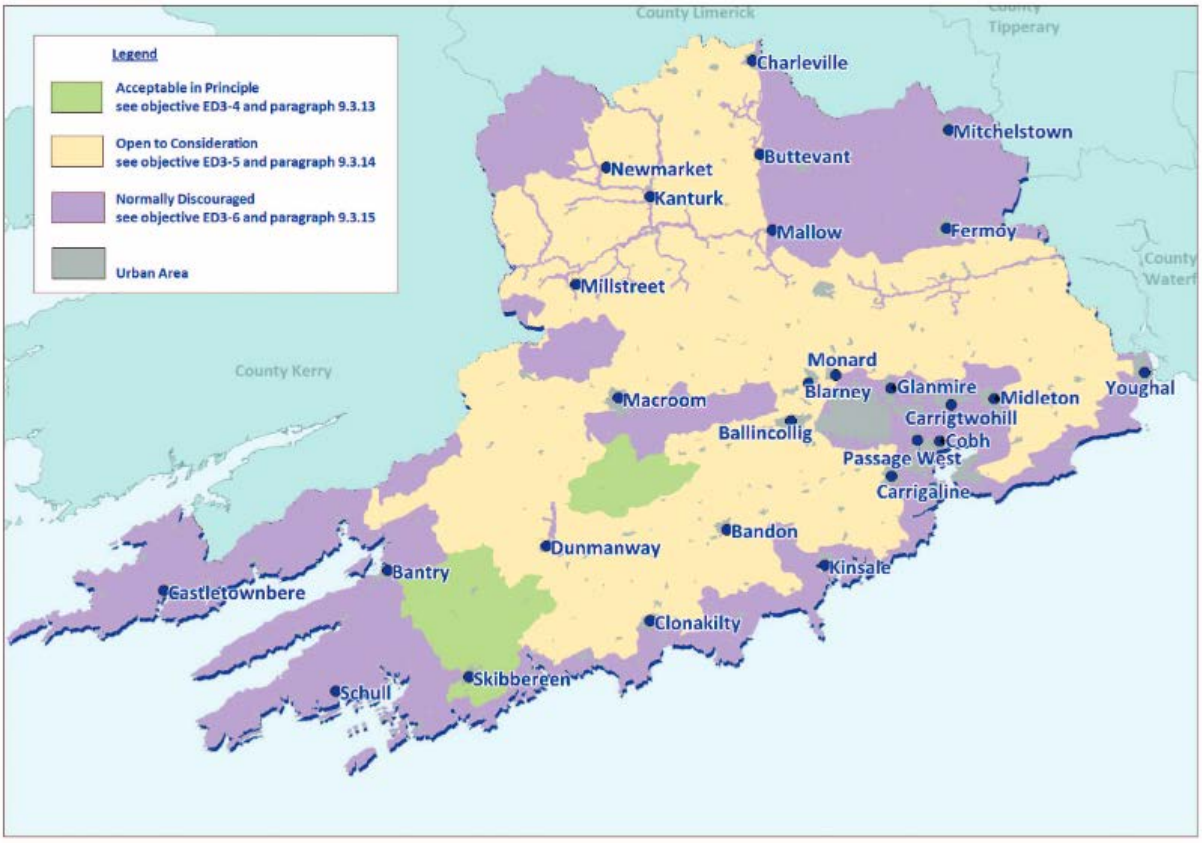
RENEWABLE ENERGY (Chapter 9.2)
The development of renewable energy sources is central to overall energy policy in Ireland. This Plan aims to support the sustainable development of renewable energy sources.

In order to highlight the benefits of a move towards reduced greenhouse gas emissions, the Council will require all renewable energy developments to indicate clearly the overall net carbon benefit arising from their proposed developments.

Through the delivery of a low carbon energy framework, the County Council aims to attract inward investment to the County and the wider Southwest Region. County Cork is well positioned to become self-sufficient in renewable energy. It is important therefore that Cork County sets out its ambitions with regard to renewable energy in this context and shows its ability to help contribute to achieving these national targets. This would build on successes to date in the provision of renewable energy from hydro power and onshore wind energy generation.

This Plan sets out a plan-led approach to onshore wind energy development in County Cork and identifies suitable areas for sustainable wind energy development.

County Cork has the largest wind energy capacity in the Country at present with 283MW from 20wind farms which is approximately 13.8% of Ireland's overall wind energy production. The wind farms are currently concentrated in three main locations in the county; south of Millstreet in the Derrynasaggart Mountains; east of Millstreet in the Boggeragh Mountains and South of Dunmanway. There is considerable potential for additional wind energy capacity if all the granted and pending wind farm developments are constructed. *(This data is now out-of-date as evident from findings below).*



COUNTY DEVELOPMENT PLAN 2014 (Figure 9.3) WIND ENERGY STRATEGY MAP

County Development Plan Objective
ED 1-2: Future Development of the County's oil and gas reserves

Ensure secure, reliable and safe supplies of electricity, gas and oil in order to maximize their value, maintain inward investment, support indigenous industry and create jobs.

County Development Plan Objective
ED 1-1: Energy

Ensure that through sustainable development County Cork fulfils its optimum role in contributing to the diversity and security of energy supply and to harness the potential of the county to assist in meeting renewable energy targets.

County Development Plan Objective
ED 3-4: Acceptable In Principle

Commercial wind energy development is normally encouraged in these areas subject to protection of residential amenity particularly in respect of noise, shadow flicker, visual impact and the requirements of the Habitats, Birds, Water Framework, Floods and EIA Directives.'

This policy refers to optimal locations for wind farm development (north of Skibbereen and south of Macroom)

County Development Plan Objective
ED 3-5: Open to Consideration

Commercial wind energy development is open to consideration in these areas where proposals can avoid adverse impacts on:

- Residential amenity particularly in respect of noise, shadow flicker and visual impact;
- Urban areas and Metropolitan/Town Green Belts;
- Natura 2000 Sites (SPA and SAC), Natural Heritage Areas (NHA's) or adjoining areas affecting their integrity.
- Architectural and archaeological heritage;
- Visual quality of the landscape and the degree to which impacts are highly visible over wider areas.

This policy refers to almost 50% of the County area.

County Development Plan Objective
ED 4-1: Hydro-Electricity

Encourage the sustainable development of hydroelectric power generation and small hydro power developments, especially when developed in combination with other forms of renewable energy infrastructure, such as wind energy, in accordance with the requirements of the Habitats, Birds, Water Framework, Floods, SEA and EIA Directives.'

By virtue of their nature, proposals for development of hydro electric schemes are unlikely to be suitable for locations within sites designated for nature conservation, or for the protection of fisheries.

County Development Plan Objective
ED 4-2 Ocean and Off Shore Wind Energy

Support the appropriate development of ocean and off-shore wind energy production off the Cork Coast by ensuring adequate provision of land based infrastructure in line with national policy in a manner that is compatible with environmental, ecological and landscape considerations.

County Development Plan Objective
ED 4-3: Bioenergy

Support and encourage the development of the bio-energy sector and facilitate its development for energy production, heat storage and distribution.

Encourage the development of commercial bioenergy plants; on brownfield sites which are adjacent to industrial areas or on lands which are reserved for industrial uses or on brownfield sites in rural areas.

Commercial bioenergy plants should be located close to the energy source and the point of demand, where they can be served by public roads with sufficient capacity to absorb increased traffic flows and adjacent to transport corridors.

Visual, noise and odour impacts on adjacent residential property will be key considerations when assessing any such proposals.

County Development Plan Objective
ED 5-1: Building Energy Efficiency and Conservation

Encourage innovative new building design and retrofitting of existing buildings where possible, to improve building energy efficiency, energy conservation and the use of renewable energy sources in accordance with national regulations and policy requirements.

CORK COUNTY SUSTAINABLE ENERGY ACTION PLAN 2010 - 2020

The Actions proposed within this Plan are largely inwardly focused on activities within the control of Cork County Council only, and have been identified under the following headings:

- ~ Procurement
- ~ Transport
- ~ Water Production
- ~ Wastewater Treatment
- ~ Buildings/ICT
- ~ Public Lighting
- ~ Fleet

CORK CITY DEVELOPMENT PLAN 2015 - 2021

This is the main strategic planning policy document for the city of Cork and is set within the framework provided by the National Spatial Strategy 2002-2020 and South West Regional Planning Guidelines 2010-2022. It has also been prepared having regard to a number of policies/guidelines including the National Climate Change Strategy 2007-2012 and The National Climate Adaptation Framework.

"The vision for Cork City over the period of this Development Plan and beyond is to be a successful, sustainable regional capital and to achieve a high quality of life for its citizens and a robust local economy…"

GOAL 4

PROMOTE SUSTAINABLE MODES OF TRANSPORT AND INTEGRATION OF LAND USE AND TRANSPORTATION

At the national level there is a mandate to reduce emissions caused by fossil-fuelled transport, to reduce use of the private car for commuting and to increase journeys by public transport, walking and cycling. These objectives are central to the land-use and transport strategies in this plan and as well as having the significant societal benefits of a better quality environment can also give health benefits and cost-savings to the individual citizen. Achieving national targets is a long term objective which will require a move to more sustainable land use planning and a significant upgrade to public transport in the greater city area. This strategic goal is particularly addressed in Chapter 5. Transportation.

GOAL 6

TACKLE CLIMATE CHANGE THROUGH REDUCING ENERGY USAGE, REDUCING EMISSIONS, ADAPT TO CLIMATE CHANGE AND MITIGATE AGAINST FLOOD RISK

A key aim of the Plan is to reduce emissions that lead to global warming through sustainable energy usage in transport and buildings. It also aims to mitigate and adapt to the challenges of climate change such as the increased risk of flooding, through the design, layout and location of appropriate land-uses. This is particularly addressed in Chapter 12. Environmental Infrastructure and Management and Chapter 16. Development Management.

CORK CITY SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN 2018

This document sets out to establish a framework within which strategic national and local targets on energy and energy related carbon emissions can be addressed in a Sustainable Energy and Climate Action Plan. The objectives of the plan are primarily under the topic of Energy Efficiency and Conservation. In particular, 6 themes were identified that relate directly to the National Energy Efficiency Action Plans: Residential Buildings, Municipal Buildings, Tertiary Buildings, Public Lighting, Transport and Local Electricity/Heat/Cold Production.

A total of 23 no. Mitigation Actions were identified to enable achievement of the required 40% CO_2 emission reduction target by 2030. These Actions are further categorized into actions required over the 2018-2022, 2018-2026 and 2018-2030 periods, to reinforce the criticality of early and ongoing progress if the stated emission reduction target is to be met. A number of the approaches in the Cork City SECAP are relevant to, and used in, the development of this EMP.

CORK METROPOLITAN AREA TRANSPORT STRATEGY (CMATS) 2040

This draft transport strategy for the Cork Metropolitan Area (CMA), which is currently in a consultation period, is being developed by the National Transport Authority, Cork City Council and Cork County Council. The key premise of the strategy is that the population of the CMA is projected to increase by 50% to 60% by 2040 (current CMA population 305,000[1]). The current transport mode shares are: car (74%), walking (20%), public transport (5%) and cycling (1%). The key proposed strategies of CMATS are as follows:

- LAND USE
  - Increased density of future residential and employment developments in central locations
  - Consolidated development in the short term that can avail of exist transport infrastructure
  - Encouragement of mixed-use development to minimize travel distances
  - Encouragement development in locations that prioritises walking and cycling, while also enabling efficient public transport provision
- WALKING (90M annual trips)
  - A 63% increase in walking trips, with a focus on the AM peak period
  - 24,000 daily car trips transferred to walking
  - Age-friendly town centres; safer routes to school
- CYCLING (19.5M annual trips)
  - 24,000 daily car trips transferred to cycling, with a focus on the AM peak period
  - Development of primary, secondary, inter-urban and greenway cycling network
  - Enhancement of bicycle-sharing & end-of-trip facilities
- BUS CONNECTS (carrying 85M passengers pa)
  - Target of carrying 49,000 passengers in AM peak period
  - Creation of Douglas and Summerhill North bus corridors (3-minute frequency)
  - Creation of cross-city, orbital and radial routes.
- SUBURBAN RAIL (16M passengers pa)
  - 62km suburban rail network between Midleton, Cobh and Mallow
  - Development of 8 no. new stations

[1] CSO, 2016

- LIGHT RAIL (46M passengers pa)
  - Development of 17km of east-west routes Ballincollig-Cork City Centre-Kent Station-Cork Docklands-Mahon Point
  - 27 no. trams, 5-minute intervals
- ROADS
  - 50km National Road network improvements, Dunkettle Interchange upgrade, M28 (Cork-Ringaskiddy), N27 (Cork Airport) dedicated public transport corridor, Cork North Ring Road, N40 demand reduction management
  - 70km Regional Road improvements, Northern & Southern Distributor roads, HGV restrictions in City Centre
- PARKING
  - No car-parking requirement for new development
  - Reduction of on-street car-parking
  - Provision of 6 no. park & ride sites

3 Baseline Energy Usage (2016)

3.1 Introduction

The Baseline Energy Usage (BEU) for 2016 in the Study Area includes the key sectors of the local economy i.e. residential, non-residential (private tertiary/public/industry), local authority, agriculture/fisheries and transport. The energy usage profile of each sector was developed using bottom up data that reflect local conditions, wherever possible. Where localized data was insufficient, we leveraged sectorial national energy usage statistics published by SEAI and CSO, and applied socio-economic multipliers reflecting the size of local sectorial activity.

3.2 Methodology and Findings – Residential Sector

The approach to dwellings is based on use of the RetroKit Version 1.0 www.retrokit.eu software analysis tool. RetroKit was developed by XD Sustainable Energy Consulting Ltd (XDC) to make optimal energy retrofit investment decisions on a multi-unit dwelling stock basis, across a region or community. RetroKit extracts Building Energy Rating assessment data and carries out analysis to:

- ~ Determine the baseline energy performance of housing stock in terms of energy use and expenditure, CO2 emissions and BER rating, at whole stock level and per relevant dwelling cohorts;
- ~ Model and compare a range of energy retrofit scenarios, with a view to establishing optimal energy retrofit packages for the stock, considering technical requirements as well as financial and environmental criteria.

RetroKit results can be used towards formulating an energy retrofit action plan, defining packages of energy conservation measures tailored to each element of the stock.

The type of analysis for Cork City and County is based on each of the housing stocks broken down into city and county using CSO SAP MAP (small area population maps) data, coupled with typical archetype dwellings based on countywide and citywide BER data from SEAI.

RetroKit is then used to carry out baseline building energy calculation for each archetypal dwelling to derive the total delivered and primary energy, energy costs, CO2 emissions, and renewable energy contribution per dwelling.

For the purposes of the Register of Opportunities (see Section 6 below), RetroKit uses the baseline energy information to develop a set of retrofit scenarios (Shallow, Medium and Deep) in order to establish the optimum approach to meet a significant energy reduction target. The following is a summary of the various measures:

- ~ Shallow: Basic air tightness, insulate cavity and ceiling, cylinder lagging jacket, LEDs, wood stove
- ~ Medium: Shallow, plus fully zoned controls, factory insulated cylinder, air source heat pump
- ~ Deep: Medium, plus advanced air tightness, demand-controlled ventilation, EWI and floor and rafter insulation, triple glazing, external doors, insulated pipework, underfloor heating, PV system

In the case of this study area, the medium energy retrofit scenario was proven to be cost-optimal.

Findings (based on standard occupancy):

- ~ Total Final Energy Consumption (Residential) = 4,734.02GWh (34.39% of Total Final Consumption)
- ~ Estimated Energy Cost = €476.72M
- ~ Total Emissions (Residential) = 1,391.00ktCO_2eq. (34.81% of Total Emissions)

- ~ Total Final Energy Consumption (Residential – Cork City) = 1,066.9GWh (22.5%)
- ~ Total Final Energy Consumption (Residential – Cork County) = 3,667.1GWh (77.5%)

3.3 Methodology and Findings – Non-Residential (Private Tertiary, Public/Schools, Non-ETS Industry)

Energy usage in this sector tertiary sector is based on the combination of several data sources:

- ~ Anonymised data from the non-domestic Building Energy Rating (NDBER) assessment database for Cork County and Cork city (separately) from which were derived average figures for treated floor area and the relative proportions of non-electrical fuel usages for buildings/facilities belonging to a certain category (e.g. schools, warehouses, retail units, etc.).
- ~ An inventory of the all the non-residential buildings/facilities within the study area. In the case of Cork City, this is from Cork City Council rates data provided during the Cork City SECAP study. In the case of Cork County, this is from the CSO (for the entire county) giving a summary list of the number of different types of enterprises, with the number of buildings of each type from city rates data subtracted so the non-city area can be identified on its own.
- ~ TM46 benchmarks for different building types used to rationalise energy estimates derived from the countywide BER data. TM46 benchmarks delivered energy usage per m^2 for a range of building types. The BER data average specific energy per m^2 for each fuel type under each building type are adjusted using the TM46 /m2 benchmarks. Relative difference of electricity vs non-electricity is based on national SEAI figures.
- ~ The above data are combined to determine usage of different fuel types in different building types, and then scaled to city and non-city to calculate total usage of each fuel in non-domestic buildings. The split between public / tertiary-private / industrial depends on the building type.
- ~ Schools energy data from SEAI's public sector programme, and total list of schools and pupil count based on Department of Education and Skills data for the city and county. Where any school does not report on SEAI's system, the energy per fuel type per pupil is calculated based on the available data to generate a complete data set.
- ~ For both city 3rd level education and city hospitals, the primary data source is SEAI's M&R reporting facility. Where data is not available, then fuel usage per bed (hospitals) and per student (3rd level) is calculated to generate a complete data set.

Findings (based on standard occupancy):

- ~ Total Final Energy Consumption (Non-Residential) = 4,506.01GWh (32.73% of Total Final Consumption)
- ~ Estimated Energy Cost = €463.87M
- ~ Total Emissions (Non-Residential) = 1,432.95ktCO_2eq. (35.86% of Total Emissions)

- ~ Total Final Energy Consumption (Non-Residential – Cork City) = 1,040.7GWh (23.1%)
- ~ Total Final Energy Consumption (Non-Residential – Cork County) = 3,465.3GWh (76.9%)

Consideration of energy consumption in the ETS sector (Emission Trading Scheme) is outside the scope of this report. However, for information purposes, a final energy consumption figure of 1,099GWh has been estimated for County Cork (City & County areas) for the ETS sector, which represents just under 20% of the total final energy consumption in the Non-Residential Sector.

3.4 Methodology and Findings – Municipal and Local Authority

3.4.1 Cork City Council

- ~ Figures primarily taken from SEAI public sector monitoring and reporting system to identify overall fuel uses and Electricity vs thermal vs transport usage.
- ~ Figures on SEAI system expressed as primary energy converted to delivered energy.
- ~ Split of electricity to identify street lighting based on calculations from Cork City SECAP work (2018).
- ~ As part of the Cork City SECAP work (2018), BER data was available for 3,252 of the total City Council housing stock of 8,948. Results of this study are provided in the document "Cork City Sustainable Energy and Climate Action Plan" (January 2018).

3.4.2 Cork County Council

- ~ Figures primarily taken from SEAI public sector monitoring and reporting system to identify overall fuel uses and Electricity vs thermal vs transport usage.
- ~ This is combined with data directly from Cork County Council showing energy required for different end uses.
- ~ Figures on SEAI system expressed as primary energy converted to delivered energy.
- ~ BER or other energy data on the County Council housing stock was not available.

3.4.3 Irish Water

- ~ National Irish water electricity usage from M&R (SEAI) reporting system.
- ~ Scaled to Cork County from CSO data for number of meters in Cork and average consumption per meter relative to national figures.
- ~ This is then scaled down to Cork city and non-city based on their relative populations.

Findings:

- ~ Total Final Energy Consumption (Municipal and Local Authority) = 144.83GWh (1.05% of Total Final Consumption)
- ~ Estimated Energy Cost = €22.88M
- ~ Total Emissions (Municipal and Local Authority) = 60.40ktCO_2eq. (1.51% of Total Emissions)
- ~ Total Final Energy Consumption (Municipal and Local Authority – Cork City) = 48.9GWh (33.8%)
- ~ Total Final Energy Consumption (Municipal and Local Authority – Cork County) = 95.9GWh (66.2%)

3.5 Methodology and Findings– Fisheries and Agriculture

3.5.1 Fisheries

- National diesel for fisheries sourced from SEAI Energy in Ireland.
- Figures from Dept Agriculture, Fisheries and Marine (DAFM) provided registered addresses of all fishing boats nationally.
- Fishing boats > 10tonnes and registered in Cork County were identified (assuming main fishing ports are outside of city for refuelling purposes).
- Engine rating (kW) of all boats > 10 tonnes nationally and in Cork were identified to determine ratio of national energy usage in fishing fleet relative to that in Cork.

3.5.2 Agriculture

- National electricity and diesel usage for agriculture and fisheries sourced from SEAI Energy in Ireland.
- Gross Added Value (GVA) for agriculture and fisheries sourced from CSO[2], minus GVA from sea fishing landings, to give state agriculture GVA only. Likewise, for SW region, to give GVA for agriculture in state and SW region.
- Then GVA is used to scale energy from state to SW region.
- Scale from SW region (Cork/Kerry), to scale to Cork alone, based on CSO Number of farms classified by economic size (SO).
- This provides energy usage in agriculture for Cork alone (diesel and electricity).

Findings:

- Total Final Energy Consumption (Fisheries) = 53.05GWh
- Estimated Energy Cost (Fisheries) = €3.30M
- Total Emissions (Fisheries) = 14.00ktCO_2.

- Total Final Energy Consumption (Agriculture) = 344.72GW
- Estimated Energy Cost (Agriculture) = €31.26M
- Total Energy Related Emissions (Agriculture) = 108.49ktCO_2.

- Total Final Energy Consumption (Fisheries and Agriculture combined) = 397.77GWh (2.89% of Total Final Consumption)
- Estimated Energy Cost (Fisheries and Agriculture combined) = €34.56M
- Total Emissions (Fisheries and Agriculture combined) = 122.49ktCO_2eq. (3.07% of Total Emissions)

[2] CSO RAA01 (GVA by region, year and statistic)

3.6 Methodology and Findings – Transport

3.6.1 Private car

- ~ Worked out per year based on average age of cars and diesel and petrol annual avg. car efficiency in L/100km (similar approach to Cork City SECAP work).
- ~ Average car age in a given year based on figures worked out in previous SECAP report for Cork City.
- ~ Efficiencies per year and overall averages for diesel and petrol in kWh/km and gCO2/km.
- ~ Electric car efficiencies derived from SEAI EV data.
- ~ Traffic in kM and number of private cars is derived from CSO transport omnibus for Cork (including City and County).
- ~ Split of distances by fuel type based on national data from CSO.
- ~ Efficiency per kM used for each of diesel, petrol and electric cars.
- ~ RES-T biofuel value used to split petrol and diesel into unblended fossil fuel + biofuel.
- ~ Number of cars for Cork City derived from CSO SAP MAP data. Average distance travelled by Cork City cars is assumed to be similar to another city (Dublin). Accordingly, calculation of the fuel usage for Cork City cars is based on above efficiency figures, city car-population and distances travelled.
- ~ Number of cars for Cork County (non-city) is derived from CSO SAP MAP data. Average distance travelled by Cork County cars is based on the total County distance travelled, less the distance travelled by City cars (see above). Fuel usage for Cork County cars based on above efficiency figures, county car-population and distances travelled.

3.6.2 Small Public Service Vehicles (PSVs), such as taxi's etc

- ~ Distance travelled (kM) by small PSVs is taken from CSO transport omnibus for Cork (including city and county).
- ~ Split of fuel type based on national data from CSO.
- ~ Engine efficiencies etc assumed to be same as private cars to derive usage of each fuel.
- ~ RES-T biofuel value used to split petrol and diesel into unblended fossil fuel + biofuel.
- ~ Distances travelled in City by small PSVs assumed to be as per Dublin, and the number of small PSVs in City is assumed to be the same per capita as Dublin. Fuel usage for Cork City by small PSVs is based on above efficiency figures and these Cork City small PSV population and distances travelled.
- ~ The remaining number of small PSVs outside Cork City is the total number of PSV's (sourced from the county CSO omnibus figure), less the number in Cork City. The average distance travelled by Cork County small PSVs is based on total distance travelled, less distance travelled by City small PSVs as derived above. Fuel usage for Cork County (non-city) by PSVs is based on the above efficiency figures and these Cork County small PSV population and distances travelled.

3.6.3 Freight (Heavy and Light Goods Vehicles)

- ~ Million tonne KM (MIO T.KM) data is obtained from the CSO transport omnibus, scaled down from southwestern region to Cork (City/County) based on the number of hauliers in the county.
- ~ National energy for freight based on SEAI Energy in Ireland (including LGVs and HGVs).
- ~ The energy per MioTKM derived for the State is applied to Cork (City+County) MioTKM, to derive the total Cork freight energy, scaled using CSO data on number of hauliers in the county. (Note

that earlier (2011) national freight energy usage from SEAI didn't include LGVs. 2016 figure included LGVs and HGVs).

- ~ The number of hauliers, scaled to Cork City vs County, is derived using the number of employees in transportation sector taken from SAPMAP data. The number of hauliers is used to scale down energy usage, from total county to city vs non-city.
- ~ Freight vehicles assumed to use diesel (blended from pure diesel and biofuel component from RES-T for 2016).

3.6.4 Public Transport and Large PSV's (busses etc)

- ~ Bus Eireann city data is taken directly from data provided by Bus Eireann (Dec 2017), including volume of diesel to derive MWh. This is then split into diesel (fossil) and biofuel based on RES-T.
- ~ Bus Eireann county data directly from data provided by Bus Eireann (March 2019), including volume of diesel to derive MWh. This is then split into diesel (fossil) and biofuel based on RES-T.
- ~ Other Large PSVs:
    - o Efficiency of large PSVs is based on State energy usage, the number of national large PSVs and the associated distance travelled.
    - o The number of large PSVs in city and county is split based on the number of employees in the transport sector (CSO SAP MAP data). The number of Bus Eireann busses is subtracted from this figure to give the number of large PSVs (non-Bus Eireann).
    - o The fuel usage of large PSVs is based on the above efficiencies, the number of PSV's in the county and the distances travelled. The split into diesel and biofuel is based on RES-T.
- ~ Irish Rail (county only, as train distance travelled in the city is miniscule)
    - o Based on data received from Irish Rail April 2019 for CO_2 from trains in Cork County.
    - o Used to derive diesel (blended), which is then split into unblended diesel and biofuel based on RES-T.

Findings:

- ~ Total Final Energy Consumption (Transport) = 3,984.27GWh (28.94% of Total Final Consumption)
- ~ Consumption breakdown by transport category: public transport (3.32%), all other transport (excl municipal fleet) (96.68%)
- ~ Estimated Energy Cost (Transport) = €474.88M
- ~ Total Emissions (Transport) = 989.26ktCO_2eq. (24.76% of Total Emissions)

- ~ Total Final Energy Consumption (Transport – Cork City) = 796.2GWh (20%)
- ~ Total Final Energy Consumption (Transport – Cork County) = 3,188.0GWh (80%)

3.7 Summary of Final Energy Consumption and Related Emissions

Sector/User Group	Final Energy Consumption (GWh)	CO_2 Emissions (kt)
Residential	4,734.02	1,391.00
Non-Residential	4,506.01	1,432.95
Municipal and Local Authority	144.83	60.40
Fisheries and Agriculture	397.77	122.49
Transport	3,984.27	989.26
TOTALS	**13,766.90**	**3,996.10**

TABLE 1: Final Energy Consumption, per user group

It is estimated that the total Final Energy Consumption increases from 13,766.90GWh to 14,866.9GWh when ETS-related energy consumption is included.

Sector/User Group	Final Energy Consumption (GWh) - CITY	Final Energy Consumption (GWh) - COUNTY
Residential	1,066.95 (22.5%)	3,667.07 (77.5%)
Non-Residential	1,040.68 (23%)	3,465.33 (77%)
Municipal and Local Authority	48.95 (33.7%)	95.88 (66.3%)
Fisheries and Agriculture	0 (0%)	397.77 (100%)
Transport	796.24 (20%)	3,188.03 (80%)
TOTALS	**2,952.82 (21.4%)**	**10,814.08 (78.6%)**

TABLE 2: Final Energy Consumption, per user group (City v County)

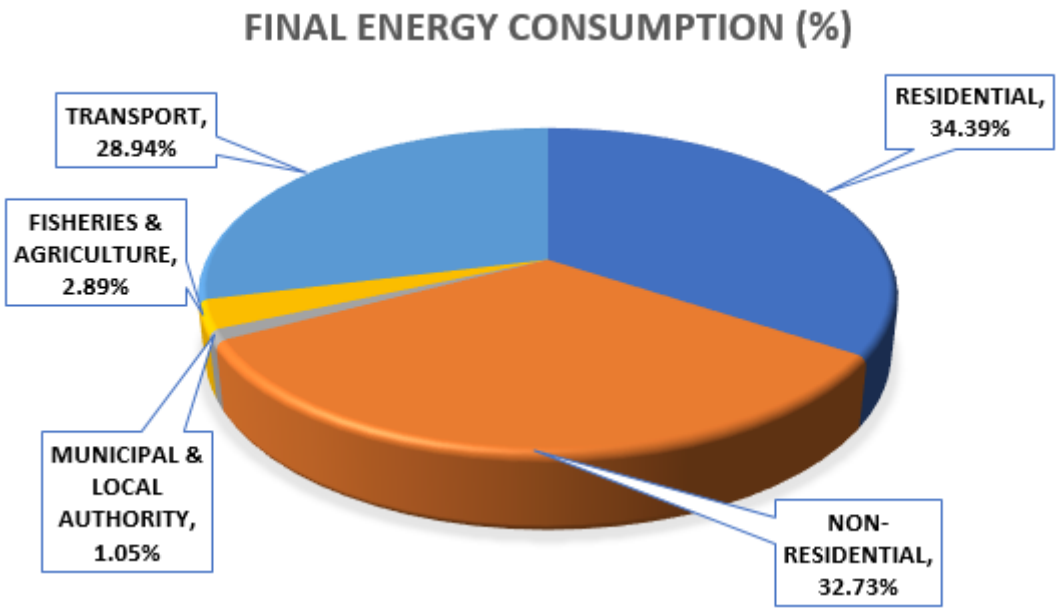


FIGURE 1: Final Energy Consumption, per user sector (CITY & COUNTY) (%)

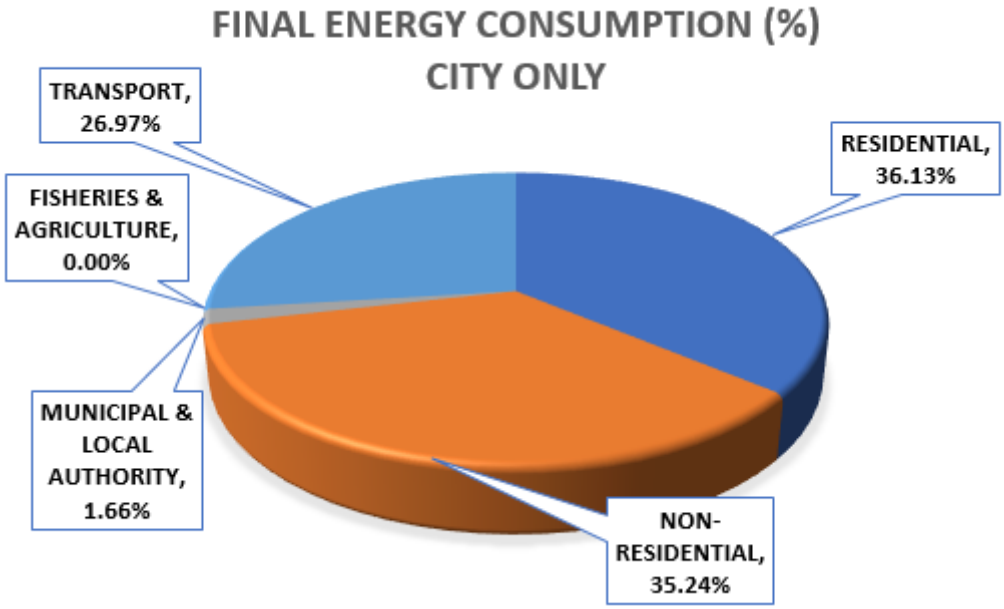


FIGURE 2: Final Energy Consumption, per user sector (CITY ONLY) (%)

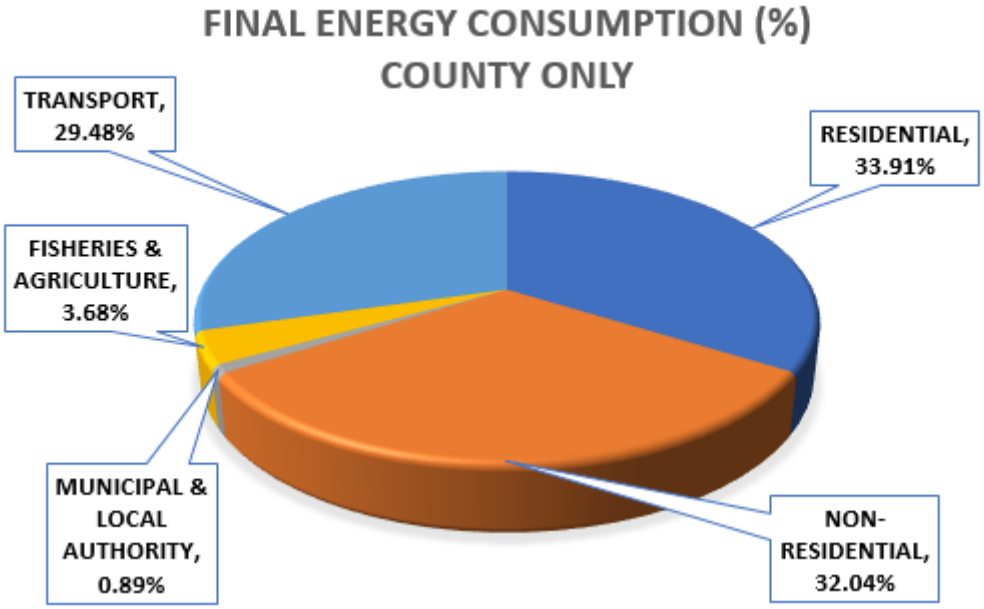


FIGURE 3: Final Energy Consumption, per user sector (COUNTY ONLY) (%)

~ Energy consumption data in the residential sectors has been acquired predominantly on a bottom-up basis. It should be noted that these calculations are based on standardised DEAP occupancy metrics as used in Building Energy Rating calculations. As is evident from Figure 1 above, the proportion of final energy consumption attributable to the residential sector at 34.39% is above average in this study area, compared to a national residential share of 23.2% in 2016. By way of illustration: the average dwelling in Ireland in 2016 consumed 13,885kWh of

direct fuels and 4,638kWh of electricity, **18,524kWh in total**[3]. However, the corresponding 2016 figures for the study area are 17,990kWh and 4,600kWh respectively, **22,590kWh in total.** The breakdown of this consumption by sub-area is 20,730kWh & 23,196kWh for city and county dwellings respectively. One possible reason for this is that energy from solid fuel in the county is 16%, compared to 13% in the city (14% national average)) - solid fuel heating systems are typically a less efficient means of converting delivered fuel to heat than electricity or other fuels. Furthermore, the proportion of pre-1970 dwellings in the City area is particularly high at over 55%, compared to the national average of 31% - older dwellings typically use more energy per m2 in standardised calculations referenced above.

- The proportion of final energy consumption attributable to transport is quite low in this study area at 28.94% (26.97% in City area, 29.48% in County area): the proportion of final energy consumption attributable to transport nationally in 2016 was 42.4%[4].
- The proportion of final energy consumption attributable to Non-Residential and Municipal/Local Authority is 33.78%; this compares well with the national final energy consumption attributable Industry and Commercial/Public in 2016 of 32.5%[5].
- The proportion of final energy consumption attributable to Fisheries and Agriculture is 2.89%; this is somewhat higher than the national final energy consumption attributable to this sector in 2016 of 1.9%[6].
- Total Final Consumption per capita in the study area in 2016 is calculated at 26.52MWh approx., 6.6% lower than the national average Total Final Consumption per capita nationally in 2016 of 28.39MWh approx.
- Validation of results: while several automatic checks are carried out throughout baseline development calculations to ensure data is correctly used within the calculations, it is worth outlining some comparisons with external / existing data:
  - Non-Residential buildings proportion of electricity total is 40% in Cork City and 39% in Cork County. The national average is 39%, thereby showing close correlation to calculated figures.
  - Non-Residential buildings calculated gas usage in the entire county was compared to CSO data (non-domestic) for the county and is within 6% of the metered figure. Note that the metered figure includes ETS, whereas this is not included in the calculated figure. Therefore, ETS tallies for Cork are estimated and discounted as part of this process.
  - The calculated total delivered energy for Cork City is 13% greater than that calculated in the Cork City SECAP (after a simple approximation is used on the SECAP data to bring it from 2011 to 2016 based on the change to national energy usage during the same period).
  - The calculated total primary energy for Cork SEAP 2010 (County only) is within 5.9% of the figure calculated in this new Cork Energy Master Plan baseline
  - Simple check of national energy usage scaled by population relative to Cork: while the national figure (scaled) is 11% greater than the calculated figure, this is offset somewhat as it includes ETS.

[3] SEAI: ENERGY IN THE RESIDENTIAL SECTOR – 2018 REPORT
[4] SEAI: ENERGY IN IRELAND – 2017 REPORT
[5] SEAI: ENERGY IN IRELAND – 2017 REPORT
[6] SEAI: ENERGY IN IRELAND – 2017 REPORT

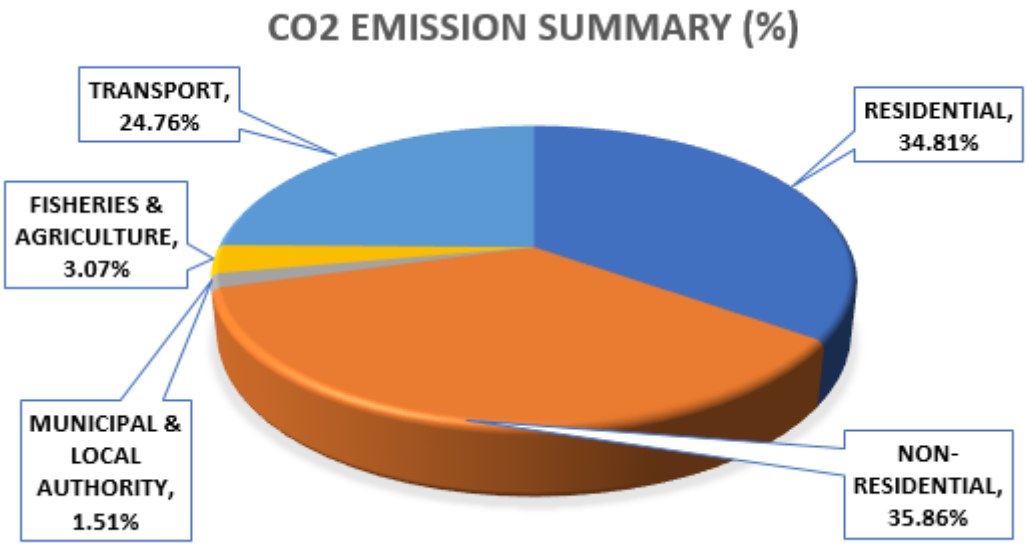


FIGURE 4: CO_2 Emissions, per user sector (City & County) (%)

3.8 Summary of Final Energy Fuel Mix and Energy Costs

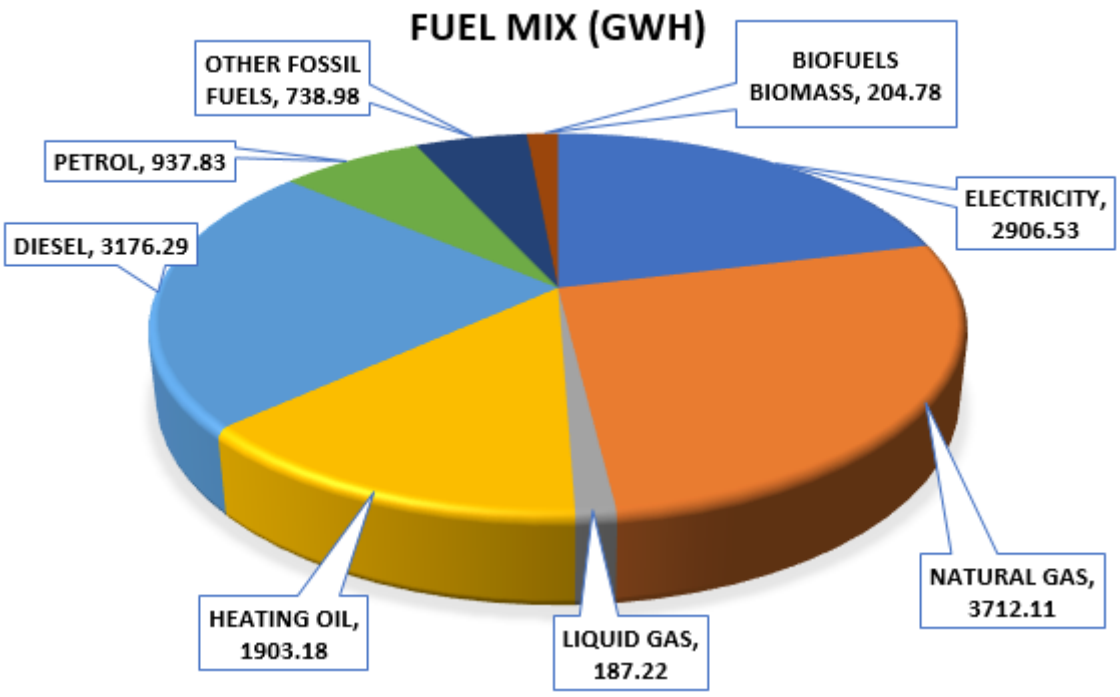


FIGURE 5: Final Energy Consumption (GWh), by energy carrier

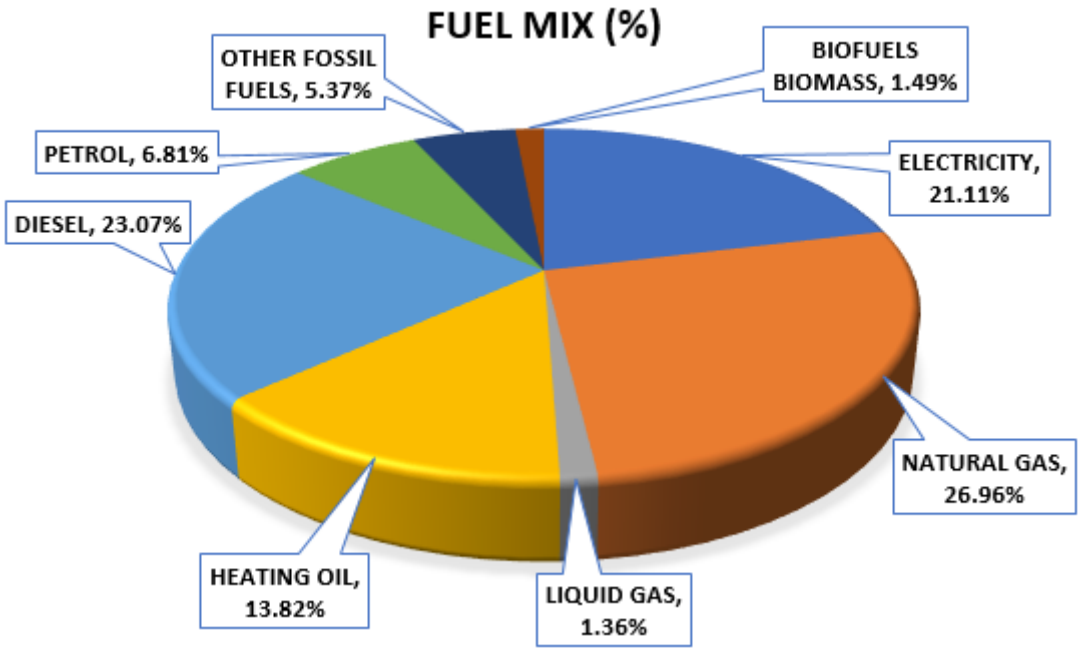


FIGURE 6: Final Energy Consumption (%), by energy carrier

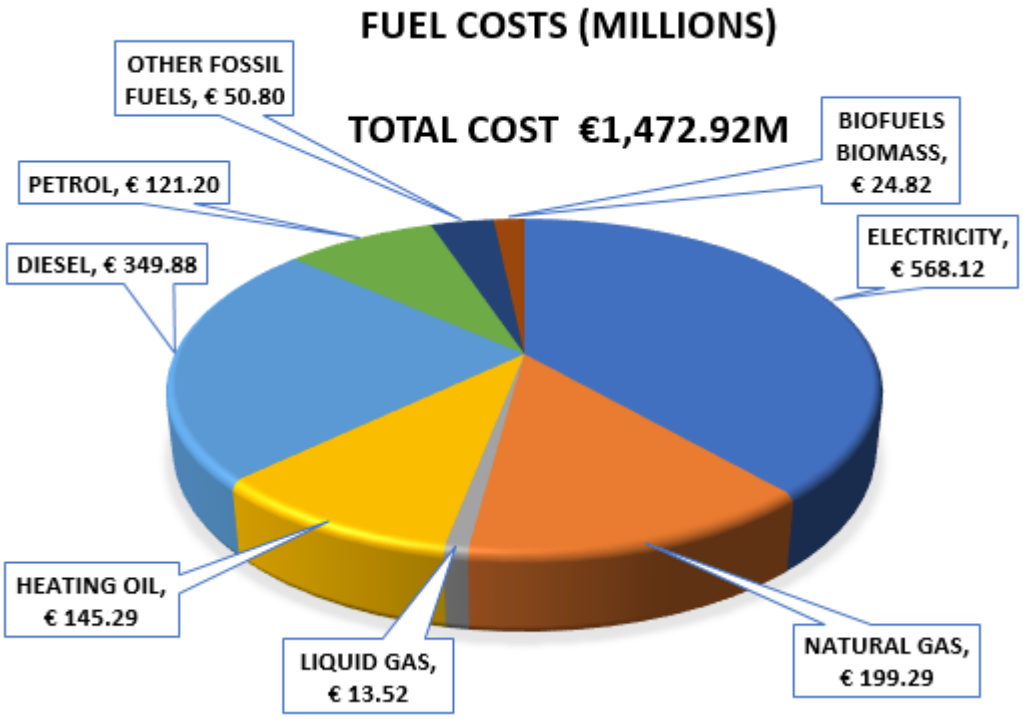


FIGURE 7: Fuel Cost, by energy carrier

4 Contribution of Renewable Technologies (Existing)

There is considerable existing deployment of renewable generation capacity, primarily onshore wind. There is also a significant amount of capacity powered by hydro & bioenergy sources. As is evident from the wind resource map below (see Appendices), there are multiple opportunities for further deployment of onshore wind into the future. However, other than currently contracted generation capacity, it is considered likely that further development of onshore wind generation will not be extensive once offshore deployment becomes economically feasible.

4.1 Grid-Connected Onshore Wind Power Plants (Fully Connected)[7]

TSO CONNECTED ONSHORE WIND (Fully Connected)			
LOCATION	**MAX EXPORT CAPAC. (MW)**	**2016 NATIONAL CAPAC. FACTOR.[8]**	**OUTPUT (GWh)**
Coomacheo	41.23	27.6%	99.68
Coomacheo	18	27.6%	43.52
Boggeragh	57	27.6%	137.81
Knockacummer	100	27.6%	241.78
Boggeragh (Connected June 2016)	65.7	27.6%	79.43
		TOTAL	**602.22**

DSO CONNECTED ONSHORE WIND (Fully Connected)			
LOCATION	**MAX EXPORT CAPAC. (MW)**	**2016 NATIONAL CAPAC. FACTOR.[9]**	**OUTPUT (GWh)**
Kealkil Wind Farm	8.5	27.6%	20.55
DePuy 3MW	2.5	27.6%	6.04
Garranereagh, Bandon	8.75	27.6%	21.16
Ballybane, Ballylickey	19.55	27.6%	47.27
Kilvinane, Bandon	4.5	27.6%	10.88
Pluckanes, Kilbarry	0.85	27.6%	2.06
Crocane, Midleton	1.7	27.6%	4.11
Carraigcannon, Boggeragh	20	27.6%	48.36
Lahanaghthill, Dunmanway	4.25	27.6%	10.28
Ballybane, Ballylickey	11.5	27.6%	27.80
Knocknatallig, Charleville	18.3	27.6%	44.25
Knockearagh	4.5	27.6%	10.88
Taurbeg, Glenlara	26	27.6%	62.86
Ballybane, Ballylickey	8.4	27.6%	20.31
Reenascreena, Dunmanway	4.5	27.6%	10.88
Bawnmore, Macroom	24	27.6%	58.02

[7] ESB NETWORKS: TSO CONNECTED RENEWABLES (01-June-2019)
[8] SEAI: ENERGY IN IRELAND REPORT 2018
[9] SEAI: ENERGY IN IRELAND REPORT 2018

Dromdeeveen, Glenlara	10.5	27.6%	25.39
Coomatallin, Dunmanway	5.95	27.6%	14.39
Gneeves, Knockearagh	9.35	27.6%	22.63
Currabwee, Dunmanway	4.62	27.6%	11.17
Milane Hill, Dunmanway	5.94	27.6%	14.36
Janssen, Barnahely	2	27.6%	4.84
		TOTAL	**498.47**

4.2 Grid-Connected Hydroelectric Power Plants

TSO CONNECTED HYDRO POWER PLANTS (Fully Connected)			
LOCATION	**MAX EXPORT CAPAC. (MW)**	**2016 NATIONAL CAPAC. FACTOR.[10]**	**OUTPUT (GWh)**
Lee - Inniscarra	15	33%	43.36
Lee – Inniscarra	4	33%	11.56
Lee- Carrigadrohid	8	33%	23.13
		TOTAL	**78.05**

DSO CONNECTED HYDRO POWER PLANTS (Fully Connected)			
LOCATION	**MAX EXPORT CAPAC. (MW)**	**2016 NATIONAL CAPAC. FACTOR.[11]**	**OUTPUT (GWh)**
Bruree Hydro, Charleville	0.132	33%	0.38
ESB Valoren, Ballylickey	0.768	33%	2.22
Owenbeg, Ballylickey	0.80	33%	2.31
Ashgrove Mill, Knockearagh	0.60	33%	1.73
Coolfadda, Bandon	0.079	33%	.23
Borlin Valley, Ballylickey	0.365	33%	1.06
Glenlough, Ballylickey	0.41	33%	1.19
Lee Rd., Cork	0.265	33%	.77
Slaheny, Ballylickey	0.485	33%	1.40
		TOTAL	**11.29**

[10] SEAI: ENERGY IN IRELAND REPORT 2018
[11] SEAI: ENERGY IN IRELAND REPORT 2018

4.3 Grid-Connected Power Plants (Bioenergy)

DSO CONNECTED GENERATION PLANTS – BIOENERGY (Fully Connected)			
LOCATION	**MAX EXPORT CAPAC. (MW)**	**2016 NATIONAL CAPAC. FACTOR.** (est)	**OUTPUT (GWh)**
Timoleague (Biogas)	1.10	30%	3.97
Adamstown, Knockearagh (Biomass)	3.00	30%	10.84
Portgate, Barnahely (Biomass)	0.10	30%	.36
Graingers, Bandon (Biomass)	2.70	30%	9.76
CMP, Bandon (Biogas)	6.00	30%	21.68
		TOTAL	**46.61**

4.4 SUMMARY – CONTRIBUTION FROM RENEWABLE TECHNOLOGIES

	GWh	**Share**
TSO ONSHORE WIND	602.22	41.78%
DSO ONSHORE WIND	498.47	34.58%
TSO HYDRO	78.05	5.41%
DSO HYDRO	11.29	0.78%
DSO BIOENERGY	46.61	3.23%
DEMAND-SIDE BIOFUELS and BIOMASS (see Figure 5 above)	204.78	14.21%
TOTAL	**1,441.42**	

The total renewable contribution of 1,441.42GWh (2016) represents 10.47% of the overall energy demand of 13,766.90GWh (2016) per Table 1 above. This compares to a national renewable energy contribution of 9.5% in 2016[12].

[12] Energy in Ireland (1990-2016) SEAI

5 Register of Opportunities

The following tables list the proposed actions under User Sector headings for the 2019-2030 period for Energy Demand Reduction and Renewable Energy Contribution respectively. In particular, we have set out a series of recommendations/proposals under the following sectors:

- ~ Residential
- ~ Non-Residential
- ~ Municipal and Local Authority
- ~ Fisheries and Agriculture
- ~ Transport

ENERGY DEMAND REDUCTION ACTIONS	COST	PROJECTED ENERGY DEMAND REDUCTIONS (GWh/a)	EXISTING ENERGY DEMAND (GWh/a)	% REDUCTION
RESIDENTIAL ACTIONS (2019-2030)				
1. Deployment of medium-depth retrofit of 75% of dwellings	€3,820.43M	2,012.75	4,734.02	43%
NON-RESIDENTIAL ACTIONS (2019-2030)				
1. Deployment of energy retrofit measures to deliver 40% reduction in energy demand across entire non-residential sector	€3,421.16M	1,802.40	4,506.01	40%
MUNICIPAL and LOCAL AUTHORITY ACTIONS (2019-2030)				
1. Public lighting: 30% energy demand reduction by replacing 17,044 lamps with LED lighting	€8.86M	9.13	30.43	30%
2. Water services: 30% energy demand reduction	€42.1M	18.29	60.97	30%
3. Municipal Buildings, etc: 30% energy demand reduction	€19.85M	10.46	34.87	30%
(Municipal Transport included below)				
FISHERIES and AGRICULTURE ACTIONS (2019-2030)				
1. 30% energy demand reduction across agriculture sub-sector	€106.80M	103.42	397.77	26%
TRANSPORT ACTIONS (2019-2030)				
1. Deployment of EV's, CNG (cars, busses, trucks) and electric rail (Actions T3, T18, T19 NMP)	€25.90M/yr	346.14		
2. Modal shift to non-motorised and public transport – Cork City only (Actions T1, T2 NMP)	€40.38M/yr	107.99		
3. Smart Driving Program across all sectors (Action T22 NMP)	€0.91/yr	354.86		
Total - Transport		809.08	4,002.85	20%
TOTAL - OVERALL		**4,765.53**	**13,766.9**	**34.6%**

RENEWABLE ENERGY CONTRIBUTION ACTIONS	COST	PROJECTED RENEWABLE ENERGY CONTRIBUTON (GWh/a)
RESIDENTIAL ACTIONS (2019-2030)		
1. Deployment of heat pumps in 75% of dwellings (as part of medium energy retrofit)	Incl.	993.91
2. Deployment of roof-top PV in 30% of dwellings (4.14kWp ea)	€756.8M	184.48
NON-RESIDENTIAL ACTIONS (2019-2030)		
1. Deployment of roof-top PV to meet 30% of electricity needs (assumed 4.14kWp ea)	€754.83M	314.76
2. Deployment of biomass boilers, displacing 10% of remaining natural gas, LPG and oil demand	€49.48M	164.92
MUNICIPAL and LOCAL AUTHORITY ACTIONS (2019-2030)		
1. Deploy PV, battery storage to meet 40% of reduced electricity demand	€71.78M	29.93
FISHERIES and AGRICULTURE ACTIONS (2019-2030)		
1. Deploy PV, battery storage to meet 20% of reduced electricity demand in agriculture sub-sector	€31.84M	11.19
TRANSPORT ACTIONS (2019-2030)		
1. Increase blending of biofuels in diesel and petrol from 5% (2016) to 11% (2030), per SEAI "National Energy Projections 2030); CNG presumed to be 20% renewable by 2030.	Cost Neutral	320.78
LARGE-SCALE ACTIONS (2019-2030)		
1. Deployment of 160MW PV farms (in total)		163.36
2. GNI commitment towards 20% renewable gas by 2030 (impacts on residential and non-domestic sectors only)		502.03
3. Deployment of all 285.36MW existing TSO- and DSO-contracted onshore wind generation capacity		689.93
TOTAL		**3,375.29**

6 Commentary on Register of Energy Demand Reduction Opportunities

6.1 Residential

Energy Demand Reduction Action 1 – deployment of large-scale medium depth energy retrofit of 75% of all residential stock. Early prioritisation should be given to retrofitting the least energy efficient stock.

This sector offers the most potential for overall energy demand reduction in the study area. It is also more conducive to modelling of the impacts of energy retrofit measures on energy usage (as mentioned above, such impacts have been modelled using the RETROKIT software package); also, the availability of financial incentives and mature market technologies facilitates ready roll-out of the required measures.

In particular, proposed medium-depth energy retrofits will include the following:

- ~ Wall insulation upgrade
- ~ Flat and sloping ceiling insulation upgrade
- ~ Air tightness measures, incl chimney draught limiter
- ~ Air-water heatpump, incl insulated DHW cylinder and full heating controls
- ~ Wood log stove (in lieu of open fire)
- ~ LED lighting

The foregoing measures have the potential to reduce 2016 energy demand in this sector by 42.52%.

The estimated capital cost (at today's rates) of carrying out a medium-depth energy retrofit of 75% of all dwellings is €3,820.43M approx, without grant support (€23,928 per dwelling (City) & €24,432 per dwelling (County))

Whereas the CAP envisages a retrofit of 500,000 (25% approx) of the national dwellings stock to B2 BER grade (with heat pumps installed in 400,000 existing dwellings), this EMP proposes energy retrofit of 75% of dwellings within Cork County, with typical BER impacts as follows:

Age Band	City: medium retrofit	County: medium retrofit
0 - 1970	B3	C2
1971 - 1990	B2	C1
1991 - 2000	B2	B3
2001 - 2010	B1	B2
2011 - 2017	A3	B1

By way of comparison, the projected deep retrofit of 100% of City Council housing stock (Action 2 Cork City SECAP 2018) projected a 60% CO_2 saving, whereas the measures above project a 43% CO_2 reduction if carried out on all City dwellings.

6.2 Non-Residential

Energy Demand Reduction Action 1 – deployment of large-scale energy retrofit measures to deliver 40% energy demand reduction in the non-residential stock.

This sector is less conducive than the residential sector to the modelling of the impacts of energy retrofit measures on energy usage. However, there is an availability of financial drivers to incentivize roll-out of the required measures such Accelerated Capital Allowances, Energy Efficiency Fund and SEAI Community Grants. Furthermore, the significant energy savings potential from this sector can induce additional financial incentives from energy suppliers through the Energy Efficiency Obligation Scheme. In addition, the upcoming implementation of NZEB Building Regulations for new-build and major renovations will act as a further strong driver towards increased mobilization of energy efficiency measures.

In particular, potential energy retrofit measures include the following:

- ~ Wall and roof insulation upgrades
- ~ Window, external door replacement
- ~ Solar thermal domestic hot-water heating
- ~ Air tightness measures
- ~ Replacement of inefficient, end-of-life heat sources
- ~ Low heat loss DHW storage cylinders
- ~ Time and temperature heating controls
- ~ LED lighting, with presence detectors where possible

The total projected retrofit capital cost for the non-residential sector is €3,421M approx. (€790.3M (City), €2,630.7M (County))

6.3 Municipal and Local Authority

Energy Demand Reduction Action 1 – Public Lighting: This action is based on the replacement of 17,044 no. non-LED public lights, with LED public lighting, to facilitate 30% energy demand reduction in this area. The projected energy savings and capex is deduced from TII/ARUP Report "Road Lighting – A New Era" Sept 2018. (It should be noted that the efficacy of LED lighting is an currently evolving discussion, with issues of concern being raised).

Energy Demand Reduction Action 2 - Transport: Proposed 20% energy demand reductions, per Transport opportunity actions – see below.

Energy Demand Reduction Action 3 – Non-Residential Buildings: Proposed 30% energy demand reductions, per Non-Residential opportunity actions – see above.

Energy Demand Reduction Action 4 – Water Services: Proposed 30% energy demand reductions, per the following possible actions:

- ~ Significant reduction in Unaccounted For Water (UFW, networks and private-side)
- ~ Significant reduction in consumer-driven service demand
- ~ Water/Wastewater treatment: enhanced scheduling measures, appropriately designed plant capacities, upgrading of pumps and blowers with variable speed drives (VSD's), preventative maintenance schedules, review of plant power factors and control strategies, etc

The foregoing measures have the potential to reduce 2016 energy demand in this sector by 30%.

The total projected retrofit capital cost in the municipal and local authority sector is €70.81M approx.
(€23.93M (City), €46.88M (County))

6.4 Fisheries and Agriculture

Energy Demand Reduction Action 1: Proposed 30% energy demand reductions across the agriculture sub-sector, per the following possible actions:

- Design and procurement of energy efficient equipment
- Optimizing field operations, using task-appropriate machinery, discard unnecessary ballast, scheduling of equipment preventative maintenance, monitoring tyre pressures
- Good grassland management practices
- Milk cooling: Use of pre-cooling using mains or well water
- Water heating systems: Insulation of storage tanks and pipework; time/temperature controls; elimination of leaks and limescale coating; use of heat recovery from milk pre-cooling and cooling systems
- Use of energy efficient lighting and controls
- Use of high efficiency motors and variable speed drives, especially with vacuum pumps
- Other measures specific to pig and poultry production farms

The total projected retrofit capital cost in the Agriculture Sub-Sector is €106.80M approx.

6.5 Transport

Energy Demand Reduction Action 1: This action is based on:

(i) The prediction that there will be 500,000 electric passenger cars in Ireland by 2030, per "SEAI National Energy Projections: 2030", scaled to project usage of electric and PHEV's in the study area, with EV efficiencies taken from SEAI published data. The CAP has been prepared on the basis of an upwardly revised stock projection of 840,000 passenger EV's by 2030, our projections are based on the more conservative estimate contained within the above recently published SEAI report.

(ii) The prediction that there will be 23,000 electric goods vehicles, 4,650 CNG freight vehicles, 450 electric buses and 1,500 CNG busses in Ireland by 2030, per "Alternative Fuels Infrastructure for Transport in Ireland: 2017 – 2030"", scaled to the study area. The calculations are based on assumptions that biofuels will be 11% of the diesel mix by 2030 and that CNG will be 20% renewable by 2030.

(iii) This action is based on the commitment contained within the NTA Rail Review Report 2016 in respect of the electrification of rail transport on the Dublin – Cork/Belfast/Galway routes, scaled based on the length of Cork-Dublin route contained within County Cork.

Energy Demand Reduction Action 2: This action is based on a 15% modal shift to both public transport and non-motorised transport respectively, in the City area based on discussions with Cork City Council during development of SECAP for Cork City in 2018. No energy demand reductions are included for modal shift outside of the City area.

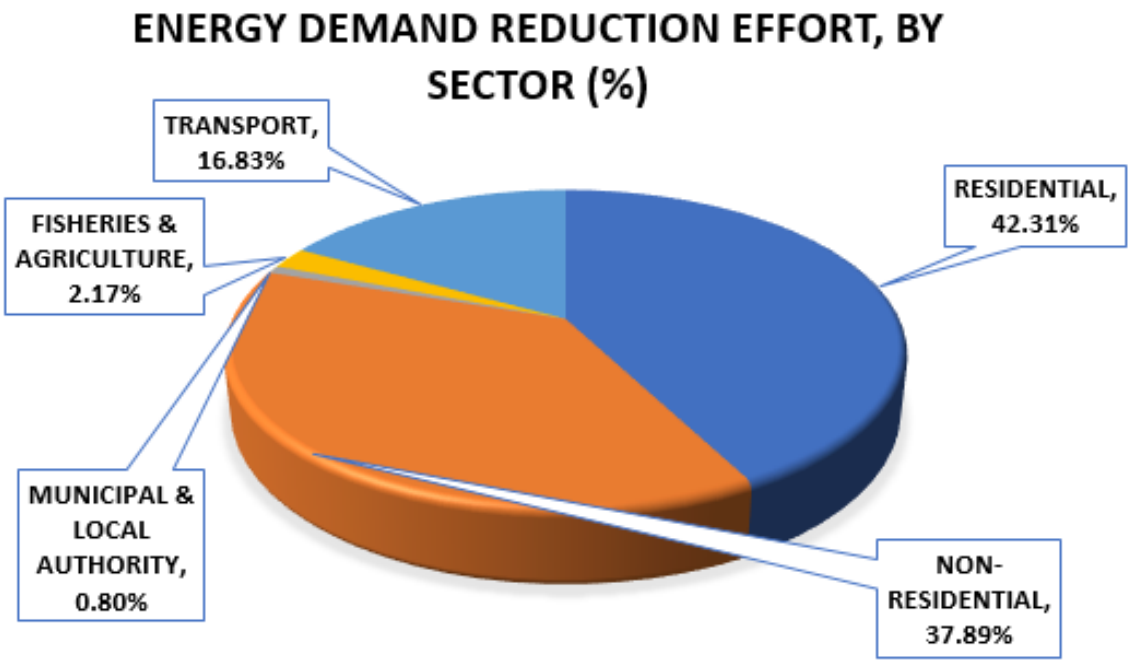
Energy Demand Reduction Action 3: This action is based on the prediction contained within the National Mitigation Plan, that eco-driving can reduce fuel usage by 5 – 10%. An average 10% reduction figure out to 2030 is assumed.

All the foregoing measures apply to both City and County, with the exceptions of modal shift (City only) and electrification of the Dublin-Cork rail line (County only). The foregoing measures have the potential to reduce 2016 energy demand in this sector by 20%.

The total projected capital cost in the Transport Sector is €806.28M approx.

Summary – Energy Demand Reduction Measures

The aggregated post-works energy demand across all sectors from the above measures amount to 4,765.53GWh, which represents a reduction of 34.6% on the 2016 energy demand of 13,766.9GWh.
The total projected capital cost = €8,225.32M



7 Commentary on Register of Renewable Energy Contribution Opportunities

7.1 Residential

Renewable Energy Contribution Action 1: This action is an intrinsic part of residential energy demand action no. 1 above (i.e.) deployment of heat pumps. To maximise impacts, early prioritisation should be given to replacing out oil and solid fuel heating systems with heat pumps in the least efficient dwelling stock, as part of the medium retrofit (ref Section 6.1 above).

Renewable Energy Contribution Action 2: This action is based on the proposal that 4.14 kW_p roof-top PV panels and battery storage is deployed on 30% of all residences. This measure would provide 184.48GWh renewable contribution towards residential electricity demand (based on E/W orientation with modest over-shading).

The total projected capital cost for renewable energy installations in the Residential Sector is €756.79M approx. (Action 2 only)

7.2 Non-Residential

Renewable Energy Contribution Action 1: This action is based on the proposal that roof-top PV panels and battery storage be deployed to meet 30% of electricity demand across this sector. This measure would provide 314.76GWh renewable contribution towards residential electricity demand.

Renewable Energy Contribution Action 2: This action is based on the proposal that existing fossil fuel heat sources be changed out and replaced by biomass-fueled boilers to meet 10% of heating demand across this sector. This measure would provide 164.92GWh renewable contribution towards renewable heat. (This measure has the potential to realise tariff payments, under the proposed Support Scheme for Renewable Heat (SSRH).

The total projected capital cost for renewable energy installations in the Non-Residential Sector is €804.31M approx.

7.3 Municipal and Local Authority

Renewable Energy Contribution Action 1: This action is based on the proposal that the respective Local Authorities and Irish Water meet 40% of their reduced electricity demand from deployment of photovoltaic panels and battery storage, a renewable contribution of 29.93GWh pa.

The total projected capital cost for renewable energy installations in the Municipal and Local Authority Sector is €71.78M approx.

7.4 Fisheries and Agriculture

Renewable Energy Contribution Action 1: This action is based on the proposal that the agriculture sub-sector deploys roof-top photovoltaic panels and battery storage to meet 20% of their reduced electricity demand, a renewable contribution of 11.19GWh pa.

The total projected capital cost for renewable energy installations in the Agriculture Sub-Sector is €31.84M approx.

7.5 Transport

Renewable Energy Contribution Action 1: This action is based on predictions, contained within "SEAI National Energy Projections: 2030", that biofuel share will increase to 11% by 2030. This is considered to be a cost-neutral measure, per Task T21 of the National Mitigation Plan. In addition to this, there will be a renewable contribution to transport given that CNG will be 20% renewable by 2030 (as referenced in Section 7.6 below).
Accordingly, the predicted % renewable energy contribution to the reduced transport energy demand is 11%.

7.6 Large-Scale Deployment

Renewable Energy Contribution Action 1: Deployment of 160MW PV farms (40 no. 4MW). This measure is predicted to provide 163.36GWh renewable contribution towards overall electricity demand in the study area - this projected renewable contribution is calculated on the basis of optimal orientation/inclination, no over-shading and annual solar radiation of 1074kWh/m^2. Projected capital cost of these measures will be dependent on site-specific civil and connectivity-related costs – estimation of these project costs is outside the scope of this survey.

Renewable Energy Contribution Action 2: 20% renewable gas on the natural gas grid by 2030 (GNI commitment). This measure could potentially provide 502.03GWh renewable heat and electricity towards energy demand in the study area by 2030. The feasibility of this action very much depends on the availability of suitable feedstocks such as energy crops/grass silage, food wastes, animal slurries, etc. For the purposes of this study, this measure is considered to be cost-neutral.

Renewable Energy Contribution Action 1: Deployment of 285.36MW currently TSO- and DSO-contracted contracted onshore wind-farms. This measure is predicted to provide 689.93GWh renewable contribution towards overall electricity demand in the study area, based on assumed national capacity factor of 27.6%.
Projected capital cost of this measure will be dependent on site-specific civil and connectivity-related costs – estimation of these project costs is outside the scope of this survey.

Renewable Energy Contribution: Continued deployment of existing renewable technology installations, predicted to provide 1,441.42GWh renewable contribution towards overall electricity demand in the study area (see Section 4 above).

Summary – Renewable Contribution

The aggregated contribution from the above measures amount to 4,816.71GWh, which represents a contribution of 53.51% towards the reduced energy demand of 9,009.9 GWh.

The total projected capital cost = €1,664.7M (excl GNI and grid-scale initiatives)

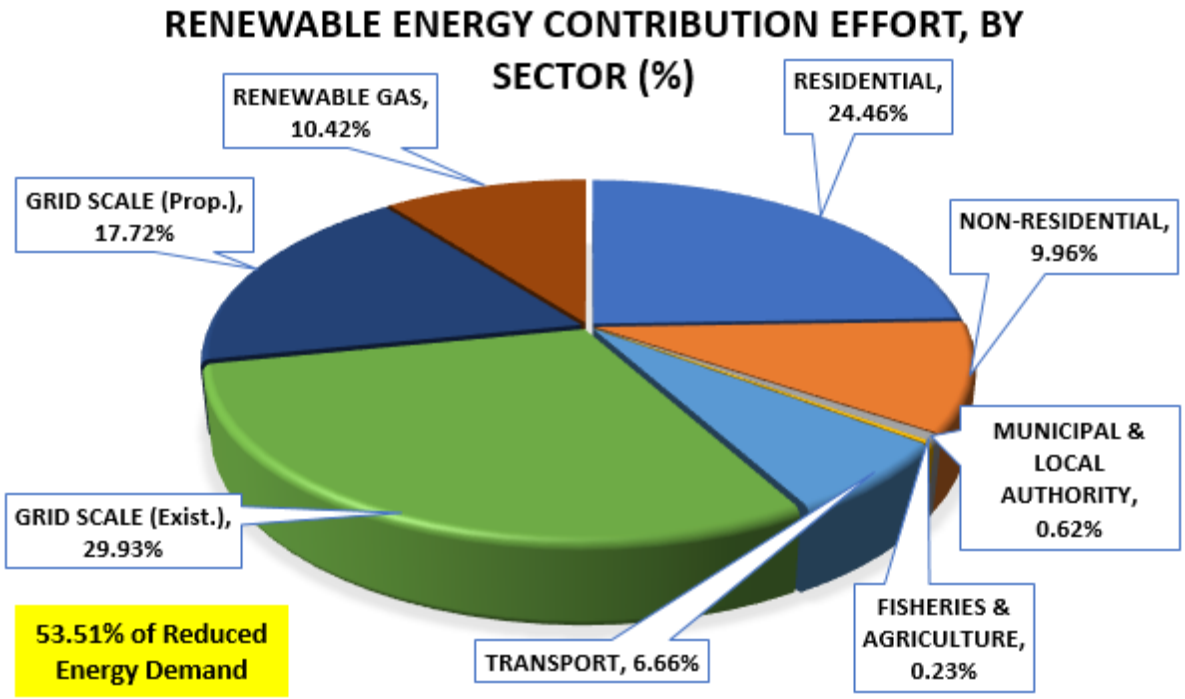
It should be noted that the total renewable electricity contribution of 2,804.9GWh projected above for 2030, represents 56.5% of the estimated 2030 electricity demand of 4,964.4GWh. The relevant total renewable electricity projected in CAP is 70%.

While the amount of proposed PV deployment outlined above is very significant in scale, the potential to realise a virtual power plant (VPP) in the study area should be given serious consideration in due course. This technology is currently being trialed in an IERC STORENET project in the Dingle Peninsula; the technology is also currently being rolled out in neighboring jurisdictions.

This option should become technically feasible on completion of the roll-out of smart meters (it is projected that the national smart meter roll-out will be completed by end of 2024). VPP technologies will have the capability of opening up a number of positive tradable services to the network operator, as well as significantly reducing electricity costs for property-owners with no up-front costs for battery installation.

Summary – Energy Demand Reduction and Renewable Contribution Measures – Costs

The measures detailed above have the potential to reduce energy costs by 32.32%, based on 2016 prices (i.e.) an annual saving of €476.04M on a current (2016) energy spend of €1,472.91M.


RENEWABLE ENERGY CONTRIBUTION EFFORT, BY SECTOR (%)
RENEWABLE GAS, 10.42%
RESIDENTIAL, 24.46%
GRID SCALE (Prop.), 17.72%
NON-RESIDENTIAL, 9.96%
MUNICIPAL & LOCAL AUTHORITY, 0.62%
GRID SCALE (Exist.), 29.93%
FISHERIES & AGRICULTURE, 0.23%
TRANSPORT, 6.66%
53.51% of Reduced Energy Demand

8 NEXT STEPS

While the precise strategies to be followed by ENERGY CHAMPION are matters for the Steering group, it is felt that the notional timeline sequencing hereunder may be of some assistance in the preparation of an action plan for the initial 3-year period - the action plan for the subsequent 2023-2025 period needs to be prepared based on the learnings and achievements of the initial 2020-2022 start-up period.

STEP 1: 2019 (Q3, Q4)

- ~ Decide on necessary human, financial & other resources required for ENERGY CHAMPION to drive the level of ambition contained within this EMP Report, over 2020-2023 period.
- ~ Deployment of necessary human, financial & other resources required for ENERGY CHAMPION to drive the level of ambition contained within this EMP Report, over 2020-2023 period.

STEP 2: 2020

- ~ Engage with existing SEC's within Cork County to inform them of the outcomes of this EMP Report and to take on board the objectives of their respective groups.
- ~ Engage with existing SEC's within Cork County to mobilise necessary actions with a view to implementing completed EMP Reports or procurement/completion of EMP Reports, as applicable.
- ~ Engage with Local Authorities and Irish Water with a view to getting agreement in principle on short to medium-term action plans that create pathway towards 2030 targets contained within this EMP Report for this sector
- ~ Engage with financial institutions with a view to rolling out fit-for-purpose financial products for residential and non-residential energy efficiency retrofit projects
- ~ Engage with technology suppliers with a view to rolling out fit-for-purpose performance-based solutions for residential and non-residential energy efficiency retrofit projects
- ~ Engage with obligated energy suppliers with a view to providing seed funding and technical expertise to project-owners, where appropriate, towards delivery of the mutually beneficial objectives contained within this EMP Report.
- ~ Engage with industry stakeholders and academic institutions to a view to scoping a study designed to assess qualitative and quantitative supply chain constraints that have potential to negatively impact delivery of objectives contained within this EMP report.
- ~ Engage with relevant stakeholders with a view to designing Smart Driving Program for HGV's & LGV's
- ~ Set up an online one-stop-shop advisory platform, under the auspices of ENERGY CHAMPION, to assist & guide potential project owners.

- ~ Facilitate recruitment of an initial €0.5M cross-sectoral project for application under 2020/2021 SEAI Community Grant funding (Project 1).

STEP 3: 2021

- ~ Consolidate engagement with existing SEC's within Cork County with a view to delivering on identified, high-priority, near-term EMP actions.
- ~ Consolidate engagement with Local Authorities and Irish Water with a view to delivering on agreed short to medium-term actions.
- ~ Engage with financial institutions with a view to creating awareness on newly developed fit-for-purpose financial products for residential and non-residential energy efficiency retrofit projects
- ~ Engage with technology suppliers with a view to creating awareness of newly-developed fit-for-purpose performance-based solutions for residential and non-residential energy efficiency retrofit projects
- ~ Continue engagement with obligated energy suppliers with a view to providing seed funding and technical expertise to project-owners, where appropriate, towards delivery of the mutually beneficial objectives contained within this EMP Report.
- ~ Procure a high-level study designed assess qualitative and quantitative supply chain constraints that have potential to negatively impact delivery of objectives contained within this EMP report.
- ~ Engage with relevant stakeholders with a view to rolling out Smart Driving Program for HGV's & LGV's
- ~ Engage with relevant stakeholders with a view to designing Smart Driving Program for Private Cars
- ~ Oversee operation of an online one-stop-shop advisory platform, under the auspices of ENERGY CHAMPION, to assist & guide potential project owners.
- ~ Oversee delivery of an initial €0.5M cross-sectoral project (Project 1) funded under 2020/2021 SEAI Community Grant funding.
- ~ Facilitate recruitment of further 3 no. €0.5M cross-sectoral projects in conjunction with SEC's within Cork County for application under SEAI Community Grant funding (Projects 2-4).

STEP 4: 2022

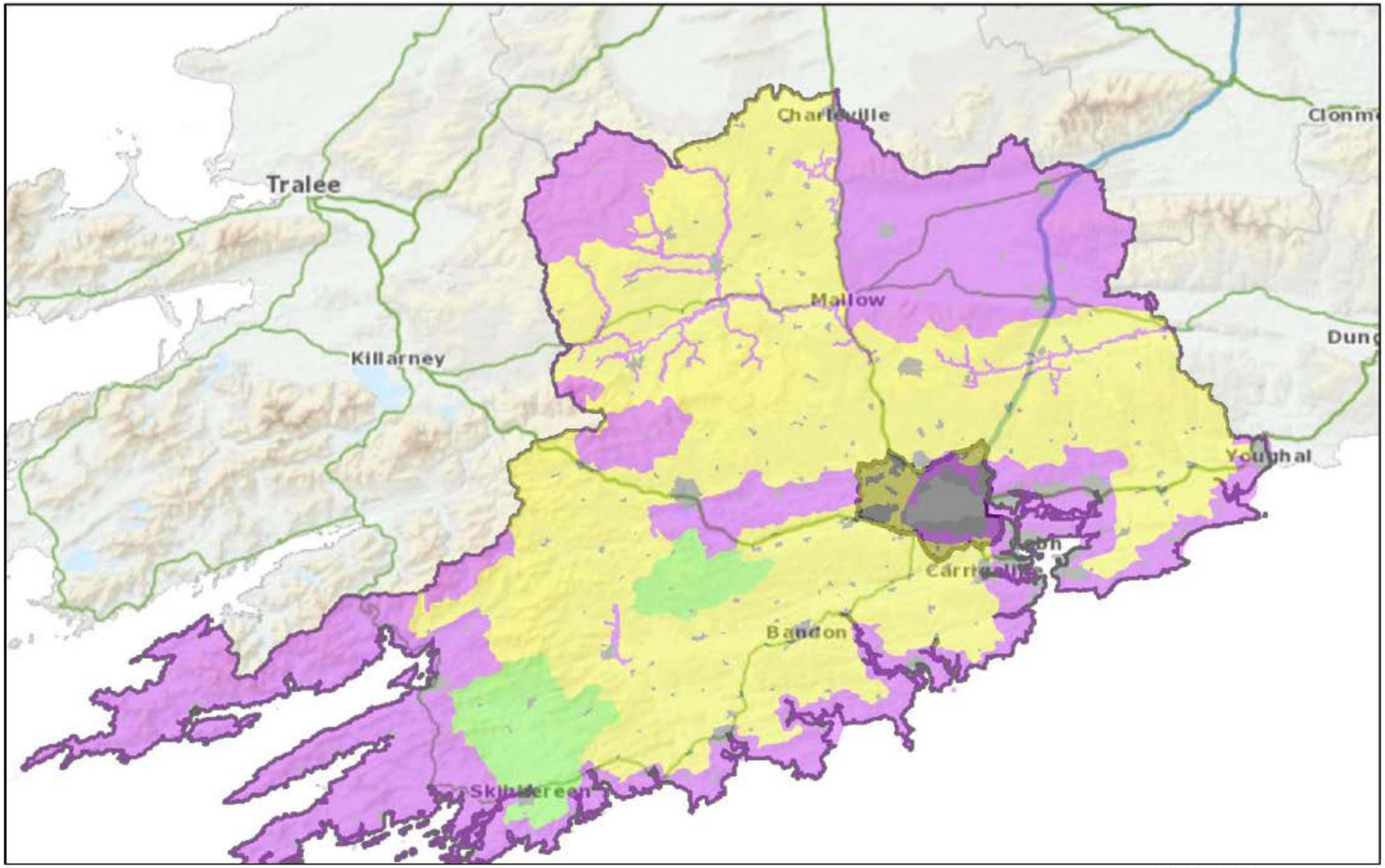
- ~ Develop a Draft 3-year Action Plan for Years 2023-2025 based on achievements to date and also based on learnings from supply chain assessment study.
- ~ Continue engagement with existing SEC's within Cork County with a view to delivering on identified, high-priority, near-term EMP actions.
- ~ Continue engagement with Local Authorities and Irish Water with a view to delivering on agreed short to medium-term actions.
- ~ Continue engagement with financial institutions with a view to creating awareness and increasing take-up of fit-for-purpose financial products for residential and non-residential energy efficiency retrofit projects

- ~ Continue engagement with technology suppliers with a view to increasing take-up of fit-for-purpose performance-based solutions for residential and non-residential energy efficiency retrofit projects
- ~ Continue engagement with obligated energy suppliers with a view to providing seed funding and technical expertise to project-owners, where appropriate, towards delivery of the mutually beneficial objectives contained within this EMP Report.
- ~ Continue engagement with relevant stakeholders with a view to rolling out Smart Driving Program for HGV's & LGV's
- ~ Engage with relevant stakeholders with a view to rolling out Smart Driving Program for Private Cars
- ~ Oversee operation of an online one-stop-shop advisory platform, under the auspices of ENERGY CHAMPION, to assist & guide potential project owners.
- ~ Oversee delivery of 3 no. €0.5M cross-sectoral projects (Project 2-4) funded under SEAI Community Grant funding.
- ~ Facilitate recruitment of further 6 no. €0.5M cross-sectoral projects in conjunction with SEC's within Cork County for application under SEAI Community Grant funding (Projects 5-10).
- ~ Agree 3-year Action Plan and establish funding for Years 2023-2025.

9 APPENDICES

9.1 APPENDIX 1: RESOURCE MAPS

Wind Energy Strategy Map



Acronyms

COM: Covenant of Mayors
SECAP: Sustainable Energy and Climate Action Plan
EU: European Union
SME: Small and Medium-Sized Business
GHG: Greenhouse Gas
NEEAP4: 4th National Energy Efficiency Action Plan
SEAI: Sustainable Energy Authority of Ireland
BEI: Baseline Emissions Inventory
CSO: Central Statistics Office
BER: Building Energy Rating
DBER: Domestic Building Energy Rating
NBER: Non-Domestic Building Energy Rating
EPPSU: Energy Policy Statistical Support Unit (of SEAI)
ICT: Information and Communication Technology
ETS: Emission Trading Scheme
CIBSE: Chartered Institute of Building Services Engineers
nZEB: Nearly Zero Energy Buildings
PPP: Public Private Partnership
EV: Electric Vehicles
CNG: Compressed Natural Gas
DTTAS: Department of Transport Tourism and Sport
DCCAE: Department of Communications Climate Action and Environment
ED: Electoral District
SA: Small Area
SAP MAP: CSO Small Area Population Map
PHEV: Plug-in hybrid electric vehicle
NMP: National Mitigation Plan, Department of Communications, Climate Action & Environment (July 2017)
M&R: Monitoring and Reporting
CAP: Climate Action Plan