County Kerry - Heating strategy

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Project Information

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The Hotmaps project

The EU-funded project **Hotmaps** aims at designing a toolbox to support public authorities, energy agencies and urban planners in strategic heat planning on local, regional and national levels, and in line with EU policies.

In addition to guidelines and handbooks on how to carry out strategic heat planning, **Hotmaps** will provide the first heat planning software that is

- **User-driven**: developed in close collaboration with 7 European pilot areas
- **Open source**: the developed tool and all related modules will run without requiring any other commercial tool or software. Use of and access to Source Code is subject to Open Source License.
- **EU-28 compatible**: the tool will be applicable for cities in all 28 EU Member States

The consortium behind

Scientific partners

Pilot areas for developing and testing the tool

List of terms and abbreviations

AIEA	Association of Irish Energy Agencies
CM	Calculation Module (in the **Hotmaps** toolbox[1])
County Kerry	The geographical area of County Kerry
Dept Agric.	Department of Agriculture
Dept CCAE	Department of Communication, Climate Action and Environment
Dept HPLG	Department of Housing, Planning and Local Government
Dept PER	Department of Public Expenditure and Reform
DH	District heating
DHC	District heating and cooling
Heat demand	Useful heat demand (if not stated differently)
Kerry Co Co	Kerry County Council (KCC, administrative and political entity, County Kerry)
NEEAP	National Energy Efficiency Action Plan
RE	Renewable Energy
RES	Renewable Energy Share
SEAI	Sustainable Energy Authority of Ireland
SEAP	Sustainable Energy Action Plan
SEC	Sustainable Energy Community
SECAP	Sustainable Energy and Climate Action Plan

[1] https://www.Hotmaps.hevs.ch/map

Executive Summary

This heating strategy was developed in the course of the **Hotmaps** project. An overall aim with this study was to exemplify how a city council can use the **Hotmaps** tool with only very limited supporting data and tools at hand, in developing a comprehensive heating strategy.

The analyses in this strategy focus on two areas: Dingle and Killarney (please refer to the introduction of Chapter 4 for the presentation of these areas). The overall approach to the calculations is presented in the toolchain, described in Section 2.3. It can here be noted that the heat demand in the Hotmaps tool was calibrated to match the bottom-up heat demand model, prepared by XDC Consult. The calculation modules in the Hotmaps tool were then used in the subsequent calculation steps to identify possible potentials for district heating and the resulting cost, carbon emission effects and distribution of energy supply via DH and centralised heat supply.

For Dingle, it can be concluded that there certainly are ways to reach significant carbon reductions at cost neutrality or minor cost reductions. However, these are only obtained in small parts of the total heat demand.

For Killarney, it can be concluded that significant reductions of heat-related CO_2 emissions (up to 5,000 tonnes/year) can be reached by establishing a district heating grid, primarily supplied by a waste-to-energy plant. These reductions would result in a minor increase in heating costs for those affected and are hence unlikely to be feasible to carry out, without economic incentives, e.g. funding.

Given the economic potential for district heating is only addressing a smaller fraction of the total final energy demand in Cthe analysed areas in County Kerry, the key actions towards transformation of the heating sector in County Kerry should be concentrated on conventional, carbon-intensive individual heating technologies. These should be replaced with the energy-efficient and sustainable alternatives such as heat pumps. This approach could help in transforming the heating sector in County Kerry, as the potential of district heating to do so is limited.

Unfortunately, the planned involvement of stakeholders had to be adapted several times, resulting in the decision, not to actively involve the stakeholders in the development of the analysis and strategy. This was due to the Covid19-outbreak in 2020 and the travel and meeting restrictions in relation to it. This decision is further elaborated in Section 2.2.2.

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1 Introduction to County Kerry

Location: Northwest Europe	Population (inhabitants): 147,554
Size: 4,807 km^2	Households: 53,300

Kerry is a rural peripheral county in the southwest of Ireland which is located in the westernmost point of Europe. The majority of the population lives in rural areas (66%). Agriculture, manufacturing (in particular food processing) and tourism are key economic sectors for the county. Kerry County Council is the local authority for the county.

The main towns in the county are:

- Tralee (23,693 pop.)
- Killarney (14,219 pop.)
- Listowel (4,832 pop.)
- Dingle (2,000 pop.)
- Rural areas and smaller townships (102,810 pop.)

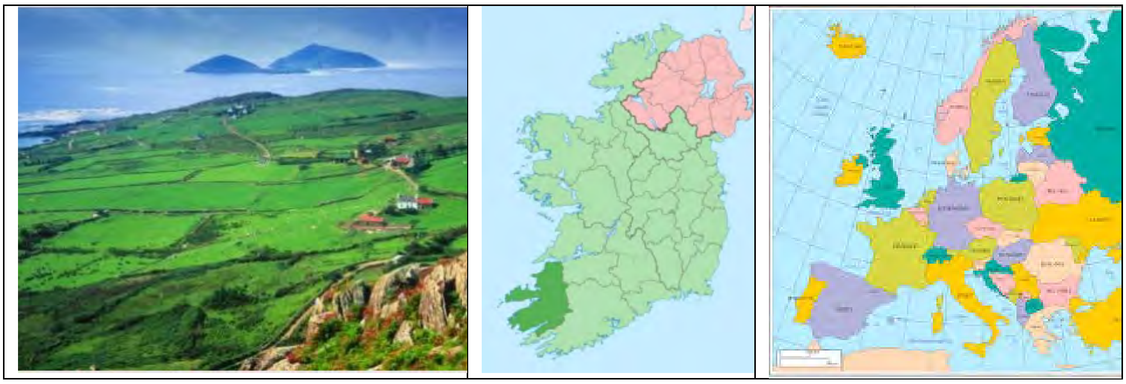

Figure 1: County Kerry

2 Strategy objectives and approach

2.1 Objectives and point of departure

Kerry County has for several years focused on the decarbonization of the energy sector and securing environmentally friendly and economically feasible energy supply in the region. This strategic aim has led to the following studies and project participation throughout the past years:

- District Heating Pre-Feasibility Report for Killarney, Sep 2013
- SmartReFlex, 2014-17.
- Study for SEAI (Sustainable Energy Authority of Ireland), XD Consult, 2018

There is currently a 1 MW district heating system in Tralee town. As part of the SmartReflex EU project Kerry has analysed the possibilities to expand the district heating grid in Tralee. Hence, no further investigations of this case will be carried out at this point and the previous work with Tralee will only be used to validate results and input data for this study. The results from the pre-feasibility report for Killarney are used for the comparison of results as well as for validation.

The **Hotmaps** project will be used to carry out an analysis for the towns of Killarney (14,219 pop + 28,000 hotel beds that are typically occupied from May to September during the summer season) and Dingle (2,000 pop, which also increases in summer due to the tourism industry) similar to the analysis carried out for the town of Tralee. This analysis should conclude on areas relevant to analyse for future district energy development. An additional objective is to analyse relevant future individual supply options outside the towns of Tralee, Killarney and Dingle.

In parallel to the **Hotmaps** strategy development, local stakeholders are working on several projects regarding future energy planning in the region. On the Dingle peninsula, a local interest group is investigating the possibilities of an anaerobic digestion plant, for potential biogas production. Please refer to the Stakeholder Analysis in Section 3.2 for further information.

Topics that are expected to be addressed within the framework of **Hotmaps** for the region of County Kerry:

- Assessment of the possible future role of district heating in decarbonisation and CO_2-reduction policies, based on specific local projects in scenario calculations
- Develop greater insight and knowledge about the status quo and development of heat demand
- Comparison of lifetime costs of energy (LCOE) for selected potential district heating supply areas, compared to individual alternatives
- Road map for alternatives (economic and environmental aspects) for the heating supply outside possible district heating areas.

Expected outcome:

- The strategic document, analysing the potentials for renewable energy share in heat consumption as well as CO_2-emission reduction
- Action plan on how to achieve the local political targets, cf. Section 3.1.

Timeline / Schedule of the Process:

- Before the project start:
    - Discussions following up on the outcomes of the SmartReFlex project
- 2016-18:
    - Initial stakeholder meetings, kick-off, initiated through existing planning processes.
- 2019:
    - The interest group for the Dingle Peninsula works, together with the local partner (XD Consultancy) and the local authority (Kerry County Council – KCC), on 1) a feasibility study regarding an anaerobic digestion plant and 2) an overall energy and sustainability plan for the peninsula.
- 2020:
    - Presentation of heating strategy draft and discussion of approaches, results and limitations. Divided into one meeting in Dingle and one in Killarney.
    - A final draft of the action plan by Fall 2020 (final period of the **Hotmaps**-project)

In conclusion, the outcome of the **Hotmaps** study is a heating strategy, evaluating two key areas for potential district heating grids in Kerry County, which can be used as a techno-economic sector-analysis and be used as input in a trans-sectoral energy planning initiative for County Kerry, alongside with corresponding sector-analyses e.g. the sectors electricity, agriculture, tourism and transportation, not to mention other key sectors in County Kerry.

2.2 Approach

2.2.1 Data Collection and Calculation Methods

The data analyses in the framework of the **Hotmaps** project are limited to the use and adjustment of data that is available in the **Hotmaps** database, as no detailed local data on the buildings in the area has been available for the study. This data is continuously cross-checked with data from the mentioned SmartReFlex-project, as well as with input from local stakeholders.

By using only data and calculation modules from the **Hotmaps** toolbox, this study illustrates how the **Hotmaps** toolbox[2], can be used for the development of comprehensive heating strategies for geographical regions in the EU-28 area, with only limited local data at hand in the beginning of the process.

2.2.2 Process and Stakeholder Involvement

Involving stakeholders in relevant parts and phases of a strategy development process can be key to the success of the strategy process. However, especially for stakeholders with only little interest or power in a given planning process, it is also important to have a certain level of data and (preliminary) results available for discussion, when addressing these stakeholders in order to avoid the frustration regarding lack of progress, data availability etc. amongst the stakeholders.

In the context of this strategy, it is chosen to involve stakeholders after preliminary results are available, i.e. to use stakeholder meetings primarily as a forum for the discussion of the produced outputs and only secondary for the development of scenarios, discussion of calculation assumptions and available data. These initiating decisions and discussions are hence dealt with within the project group, consisting of the planning authority and their consultant. A high grade of inclusion of external, local stakeholders is however still ensured, by inviting stakeholders to a first stakeholder meeting, where preliminary results are discussed and hence the development of the heating strategy can still be affected and changed.

The choice of this process is partly due to the timing of the strategy development phase in the **Hotmaps** Project, and partly due to delays and struggles in identifying available data to produce bottom-up heat density and consumption data. Hence, to proceed in the strategy development process, decisions regarding the use of data and assumptions had to be made, without involving further stakeholders in order to secure progression in the strategy development.

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[2] together with affiliated documents, produced and published in the **Hotmaps** Project e.g. *Djørup, S. R., Bertelsen, N., Mathiesen, B. V., & Schneider, N. C. A. (2019). Definition & Experiences of Strategic Heat Planning.* *https://vbn.aau.dk/ws/portalfiles/portal/302317030/Handbook_1_Hotmaps_definition_experiences_of_strategic_heat_planning.pdf*

Tralee: Due to the focus on the two other areas, no stakeholders will be involved for a strategy development regarding Tralee. Existing results from the SmartReflex-Project will be used to validate **Hotmaps** Data for Killarney and Dingle.

Killarney: Stakeholder meeting with building owners, utility company and other stakeholders

Prior to this stakeholder meeting, a draft of this heating strategy with preliminary results will be published and discussed at the stakeholder meeting.

The agenda for this stakeholder meeting consists of discussions of the overall district heating potentials, as well as the individual heat supply alternatives.

Dingle: Stakeholder meeting with the local energy group and tourism industry

Prior to this stakeholder meeting, a draft of this heating strategy with preliminary results will be published and discussed at the stakeholder meeting.

Due to substantial work and interest of the local energy group, the stakeholder meeting will focus on the possibilities in Dingle solely.

Stakeholder meetings had been scheduled for mid-March 2020 but had to be postponed due to travel restrictions in the very beginning of the Covid19-outbreak. Based on the then uncertainty regarding the development of the Covid19-related travel restrictions, it was decided to postpone the stakeholder meetings to the beginning of September 2020, as having stakeholder meetings on-site was assessed to be key for successful stakeholder involvement. However, due to the by September ongoing mandatory self-isolation rules upon arrival in Ireland and restrictions on the maximum number of participants in personal meetings, it was deemed impossible to carry out the stakeholder meetings as planned.

As district heating is a rather new technology to Ireland it was considered key to perform the stakeholder meetings in person, in order to be able to react to discussions, "read the situation" etc. Performing stakeholder meetings online was hence not deemed a feasible possibility, as it was assumed critical to the stakeholder involvement after project duration not to "scare them off" with a stakeholder meeting that was not as good well carried out as it could have been.

2.3 The Applied Hotmaps Toolchain

The overall approach for the calculations in this strategy is to limit the applied data to the use of data and tools within the open-source, publicly available, browser-based version of the **Hotmaps** toolbox[3]. No standalone tools were used, only the validation of the heat demand data using previous studies (elaborated in the following chapters). The toolchain shown in Figure 2 illustrates the calculation steps in developing a heating strategy using the calculation modules (CMs) integrated into the **Hotmaps** toolbox. Please note that some of the calculation steps yield intermediate results which are used as input parameters in subsequent calculation modules. The order (number 1 to 10) of the calculation steps in the toolchain is structured in order of succession.

The parameters chosen in the calculations are described and discussed in later chapters. The purpose of this description is solely to present the approach behind the chosen calculation modules[4] and creating a toolchain for the development of the County Kerry Heating Strategy. For a more detailed description of the different CMs, e.g. description of calculation methods, adjustment of parameters and limitations regarding the use of data, please refer to the **Hotmaps** Wiki[5]. Direct links to the descriptions of the used CMs are provided in the header for each toolchain step (if applicable).

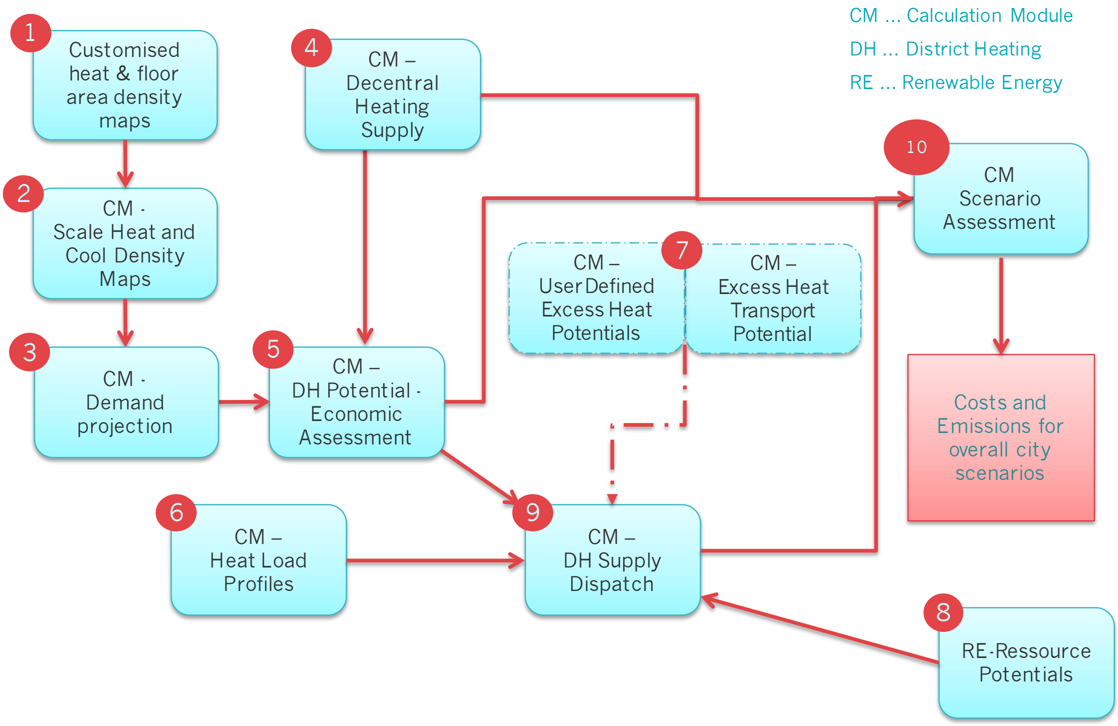

*Figure 2 **Hotmaps** toolchain, applied in the development of the Kerry County Heating Strategy*

[3] https://www.Hotmaps.hevs.ch/map
[4] For further instructions in the usability and functions of the different CM's, please refer to https://wiki.Hotmaps.eu/en/Welcome#how-to-apply-Hotmaps-toolbox.
[5] https://wiki.Hotmaps.hevs.ch/en/Welcome#calculation-modules-cm

2.3.1 Customised Heat & Floor Area Density Maps

This step of the toolchain is to produce relevant heat and floor area density data, to be used in the following calculations. For this, default data in the toolbox can be used (and possibly adapted using the scaling module), or alternating data can be uploaded by the user. The produced heat density data can be illustrated in the toolbox and used to produce heat and floor area density maps for the use in a strategy process.

For County Kerry, heat density maps do exist on an aggregated level (250x250m). These were produced in previous projects, cf. Section 2.1. Cf. the following descriptions, the existing maps are used to calibrate the default data from the **Hotmaps** Toolbox.

2.3.2 CM Scale Heat and Cool Density Maps

If a validated total heat demand for the geographical area of investigation does exist, the CM scaling can be applied on the default dataset to calibrate the default dataset of heat demand densities on hectare level in the region to match the known total heat demand of that specific area. If the default dataset matches the known data by the user or differs only minor/to an acceptable level, this step is not necessary.

For County Kerry, heat demand density data only exists on a more aggregated level (250x250 m resolution) and hence the scaling module can be used to calibrate the default dataset to match the total of the geographic area of investigation.

2.3.3 CM – Demand Projection

The default data set in the **Hotmaps** database only covers the current heat demand estimate, based on building stock data from 2014. The CM Demand Projection can be used to create future projections of heat demand and gross floor area density maps, based on the 2014-data. For the precalculated scenarios in this CM, scenarios of the development of the national building stocks under different boundary conditions were calculated with the Invert/EE-Lab model[6] to the selected region. The projection based on the precalculated scenarios can be adjusted by the user regarding the development of basic parameters like the floor area and the specific energy needs (kWh/m^2).

For County Kerry the default developments, cf. the June 2020 release, given in this calculation module, are applied. Based on this, a projection for the heat demand density and heated gross floor area map for 2030/40/50 is created for further calculations.

2.3.4 CM – Decentral Heating Supply

The reference prices for the individual heating supply are identified in the CM Decentral Heating Costs. These costs are used to assess the economically competitive heating price the possible district heating system would have to compete against. Prices for individual heating can be found for a large array of building types, energy efficiency standards/heat demands

[6] https://invert.at/

etc., and the local specific needs can thus be addressed in the presentation of individual heating supply costs.

For the calculations for County Kerry, the pre-defined costs in this CM were included in the first draft of calculations and discussed at the stakeholder meetings.

2.3.5 CM – District Heating Potential – Economic Assessment

With 1) heat demand and gross floor area density maps of the current status, 2) a projection of these for a future scenario and 3) the reference heating prices at hand, this CM District Heating Potential – Economic Assessment can be used to analyse the economic potential for district heating, taking into account the input parameters and thresholds, defined in previous calculation steps, i.e. which heat density to expect and which costs for decentral heating supply to compete with.

The results of this CM are used to evaluate the span of potential district shares, depending on the given choice of parameters. Hence, results from this CM are used in the development of scenarios, cf. Section 4.3.1.

Alternatively, for district heating potential: CM District Heating Potential Areas: User-Defined Thresholds

In the course of the **Hotmaps** project, a similar CM was created (CM District Heating Potential Areas: User-Defined Thresholds[7]). In this CM, similar results (potential/feasible district heating areas) can be analysed as well. The input parameters to this CM are more simplified, as the key purpose of this CM is to create an overview of potential areas of interest (for further analyses) in larger regions.

Hence, this step is not chosen to be included in the study for County Kerry, as the described areas of interest are given beforehand, based on the availability of interested and engaged local stakeholders.

2.3.6 CM – Heat Load Profiles

Different consumer types influence the heat load profiles of a heating grid, which affects the need for installed heat generation capacity. Hence detailed heat load profiles are necessary to make precise calculations for the energy system modelling possible, i.e. to assess needs for installed base and peak load capacity as well as to ensure enough redundant heat generation capacity. The CM Heat Load Profiles develops such heat load profiles, taking into consideration predefined annual load profiles (resolution: hourly) for several consumer groups. The user can affect the developed heat load profile by adapting the weighting of the heating and hot water for residential and tertiary consumers respectively.

As County Kerry is characterised by having a large tourism industry with many hotels, the share of tertiary heating and hot water supply must be rather high. The heat load profiles are thus adapted to a rather flat profile, compared to e.g. those for residential areas. Hence, the

[7] https://wiki.Hotmaps.hevs.ch/en/CM-District-heating-potential-areas-user-defined-thresholds

average power needed is lower, compared with heat load profiles with a less flat duration curve.

2.3.7 CM – User Defined Excess Heat Potentials

The default dataset for the primary sources on excess heat in the **Hotmaps** Toolbox does not include potential sources in the areas of investigation, as there is no heavy industry or major business parks in the area. Hence, possible excess heat sources need to be identified based on knowledge to possible projects in the area.

For the Dingle-area, plans for an anaerobic digestion plant are currently being developed and the possible heat output from an upcoming biogas-fuelled engine is modelled manually by adding this source of excess heat cf. the CM-description for the CM User Defined Excess Heat Potentials[8].

Alternatively, for excess heat: CM – Excess Heat Transport Potential

In the CM Excess Heat Transportation Potential, possible sources of industrial excess heat are identified, primarily larger industrial sites. The CM estimates the transportation costs for transmission lines, based on the distance to possible district heating supply areas, based on thresholds, similar to those identified in the CM District Heating Potential Areas: User-Defined Thresholds, and thus consistency in these calculation steps can be achieved by entering the same input parameters, as used in previous calculation steps.

For the development of a heating strategy for County Kerry, it has been chosen to solely use the upload of own excess-heat data function, as data for potential excess heat does exist, but is a) too small to be captured in the default dataset or b) stems from planned projects, i.e. the data regarding excess heat for County Kerry in the default data is not useful.

2.3.8 RE-Resource Potentials

Before creating and calculating scenarios for possible future district heating systems, the available resources, apart from the above-mentioned industrial excess heat, need to be mapped. The **Hotmaps** Toolbox can be used for this, by evaluating the different potentials in the *Layers* tab and creating selections for the area under investigation. The selection area for these potentials may very well cover the hinterland of an upcoming district heating supply area, i.e. the entire Dingle peninsula may be used in an estimate of available resources in Dingle Town.

For this, please also see the mapping exercises described in the framework of the **Hotmaps** training workshops[9].

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[8] https://wiki.Hotmaps.hevs.ch/en/CM-add-industry-plant
[9] *Link to be inserted to D6.4 once published.*

2.3.9 CM – DH supply dispatch

At this point, the necessary information regarding the two sections of a heating system (supply and demand) are gathered and scenarios for the heating supply can be defined. These scenarios can be investigated in the CM DH Supply Dispatch, creating supply scenarios based on defined capacities of supply units and related costs. Please refer to Section 5.1 for a description of the chosen scenarios and how they were derived, based on the input described in the previous steps.

2.3.10 CM – Scenario Assessment

Finally, after having calculated competing district heating supply scenarios, the results need to be analysed, interpreted and discussed in order to formulate the techno-economic input to a heating strategy. In the final version of the toolbox (Q1/Q2 2020), the scenario assessment is performed by the user in a spreadsheet, for which a template is provided on the platform. The scenario assessment can evaluate the competing scenarios by different parameters, such as the heat supply costs, CO_2-intensity pr. kWh, the share of local renewable energy resources, the share of fuel/combustion-free heating and thus, different scenarios may perform well on some indicators and less optimal on others. The scenario assessment should cover all relevant parameters of the regional context of the heating strategy in order to evaluate the given scenarios in the best way.

3 Target and policy instruments

3.1 Local, regional and national targets and policy instruments

On an international level, two key political agreements must be noted that form the background for much of the national and local policymaking in this field:

The Kyoto Protocol (1997) is an international treaty to achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The Paris Agreement (2016) is an international agreement relating to national level commitments to reducing greenhouse gas emissions. Each country that has signed up to the agreement set nationally determined contributions which specify how much they will reduce their emissions by.

National targets

In line with the EU's Renewable Energy Directive, Ireland has committed to a renewable energy target of 16% of its final energy consumption by 2020[10]. This will include:

- 40% of electricity will be generated from renewable sources.
- The heating sector is the largest user of energy in Ireland and, 12% will come from renewable sources by 2020
- 10% of transport demand will be met by renewable sources.

It proposes to achieve a 40% reduction in greenhouse gas (GHG) emissions by 2030 relative to 1990, and a binding EU-wide target for renewable energy of at least 27% by 2030.

At the meeting of the European Council in October 2014, a political agreement was reached on the headline targets for the 2030 Climate & Energy Framework, namely:

(i) a reduction in greenhouse gas emissions of 40%;
(ii) an increase in EU energy from renewable sources to 27%; and
(iii) an indicative target of 27% energy efficiency.

This equates to emission reductions of 43 % and 30 % respectively for the Emissions Trading Scheme (ETS) and non-ETS sectors on 2005 levels.

The National Energy Efficiency Action Plan (NEEAP)[11], published by the Department of Communications, Energy & Natural Resources, set an overall national goal of 20 %

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[10] https://www.dccae.gov.ie/en-ie/energy/topics/Renewable-Energy/irelands-national-renewable-energy-action-plan-(nreap)/Pages/Action-Plan.aspx
[11] https://www.dccae.gov.ie/documents/NEEAP%204.pdf

improvement in energy efficiency by 2020, within which the public sector was set a more demanding improvement target of 33 %.

The Government's NEEAP and the European Communities (Energy End-Use Efficiency and Energy Services) Regulations 2009 place several obligations on public bodies regarding their 'exemplary role' concerning energy efficiency. These include obligations on energy-efficient procurement, energy management practices, use of energy-efficient buildings and annual reporting of the actions being taken to improve energy efficiency.

In addition to the NEEAP, the Department of Communications, Climate Action and Environment published the Climate Action Plan 2019[12] in July which sets out an ambitious course of action for the coming years to address the issue of climate change which is already having diverse and wide-ranging impacts on Ireland's environment, society, economic and natural resources. Some of the key measures outlined in the Climate Action Plan 2019 include:

(i) Targets of 50 % Energy Efficiency and 30 % greenhouse gas emissions reduction.
(ii) Delivery of two new district heating systems, and implementation of a roadmap for delivering District Heating potential,
(iii) Design policy to get circa 500,000 existing homes to upgrade to B2 BER[13] and 400,000 to install heat pumps.
(iv) Increase reliance on renewables from 30 % to 70 %

The key initiatives with regards to district heating which will be developed under the plan are:

(i) Develop a national framework for district heating, which covers the key areas of regulation, planning, financing and research.
(ii) Use the two district heating pilot schemes to develop experience and knowledge that can promote and inform further schemes nationwide to facilitate greater uptake of district heating through self-financed heat networks.
(iii) Ensure the potential of district heating is considered in all new developments and in particular in Strategic Development Zones (SDZ's)[14].
(iv) Identify a set of potential early mover projects beyond the first two pilot schemes.

Further details on the two district heating pilot schemes referenced in the Climate Action Plan 2019 are shown below:

Dublin City Council: Dublin District Heating System – Up to €20 million is being invested to capture waste heat generated at industrial facilities, in particular, the Dublin Waste to Energy Plant in Ringsend and piping it into homes and businesses in Poolbeg, Ringsend and Docklands areas.

[12] https://www.dccae.gov.ie/documents/Climate%20Action%20Plan%202019.pdf
[13] https://www.seai.ie/home-energy/building-energy-rating-ber/
[14] SDZ's are designated by the government on foot of a proposal by the Minister for Housing, Planning and Local Government. SDZ's can include industrial, residential or commercial development.

South Dublin County Council: The South Dublin County Council Tallaght District Heating Scheme – Up to €4.5 million is being provided to establish a sustainable district heating solution in the Tallaght area to provide low carbon heat to the public sector, residential and commercial customers.

Local targets

2020 targets of a 33% reduction in primary Energy Consumption by Kerry County Council based on a baseline of consumption in 2006. The Energy Section collate and submit annual energy consumption data for all Council operations to the Sustainable Energy Authority of Ireland (SEAI)in line with the energy Monitoring and Reporting requirements of SI 426 of 2014.

- Kerry County Council have implemented an ISO 50001 certified Energy Management System across the organisation. The ISO 50001 standard specifies the requirements for establishing, implementing, maintaining and improving an energy management system, whose purpose is to enable an organisation to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy security, energy use and consumption. The standard will help Kerry County Council to continuously reduce energy use, and therefore reduce energy costs and greenhouse gas emissions.

- Kerry County Council is a partner in the Sustainable Energy Community Network run by SEAI. As part of this Kerry County Council will work closely with the appointed Sustainable Energy Community Network mentor in establishing the organisation's competency level in terms of establishing a successful Sustainable Energy Community (SEC), establishing a network of SEC's in the area and a committee of same to work together in knowledge sharing and supporting locally established SEC's.

- Kerry County Council are committed to continuing to work with and support the Kerry Sustainable Energy Co-op, North East West Kerry Development Partnership, South Kerry Development Partnership, IRD Duhallow and Dingle Sustainable Energy Community in the areas of energy efficiency and sustainability.

- Kerry County Council is a member of the Covenant of Mayors and completed a Sustainable Energy Action Plan 2012 to 2020, which was published in January 2013.

- Kerry County Council adopted a Climate Change Adaptation Strategy 2019 – 2024 in September 2019 which enables the council to address the impacts of climate change and help build climate-resilient communities, protect people, ecosystems, businesses, infrastructure and buildings from the negative impacts of climate change. This adaptation strategy is set within a policy framework at International, European and National Level.
- Objective EP-10 of the Kerry County Development Plan 2015-2021 states that Kerry County Council will support the sustainable development of District Heating Schemes and associated infrastructure at appropriate locations.

- Objective NR7-52 of the Kerry County Council Renewable Energy Strategy 2012 states that Kerry County Council will seek to promote the installation of district heating schemes powered by renewable fuel sources that are produced sustainably. Community groups will also be facilitated in any efforts to develop bioenergy schemes.

Local action plans

- A Sustainable Energy Action Plan 2012 to 2020 was published in January 2013. The overarching objectives of the plan are;
    - To reduce the economic expenditure on energy for citizens, businesses and the local authority
    - To reduce the per capita CO_2-emissions
    - To reduce the dependence on imported fuel and highlight opportunities for locally-based renewable energy sources
    - To increase the level of renewable energy produced in the county
    - To enhance the competitive and attractive nature of Kerry as a destination for business through modern and efficient energy infrastructure and pricing
    - To increase the knowledge and understanding of the objectives of the Sustainable Energy Action Plan

- Transition Kerry's Sustainable Energy Community Roadmap is an Action Plan for County Kerry's Transition to 100% Renewable Energy Supply. The overall objective of this study is to assist communities in Kerry to develop a strong, positive vision of its sustainable energy future and plan the journey for the transition of the county towards 100% renewable energy supply by 2030. The study is intended to complement existing initiatives in the area of sustainable energy development in Kerry, and it is hoped that the study will stimulate wider discussion and community participation in the area.

- Kerry County Council Climate Adaptation Strategy 2019 – 2024. The Climate Adaptation Strategy sets out a framework of actions and measures that Kerry County Council proposes to undertake to further embed climate adaptation into all of the local authority's areas of responsibility and to assist communities in adapting to climate change. The Climate Adaptation Strategy takes on the role as the primary instrument at the local level in Kerry to:
    - Ensure a proper comprehension of the key risks and vulnerabilities of climate change
    - Bring forward the implementation of climate-resilient actions in a planned and proactive manner
    - Ensure that climate adaptation considerations are mainstreamed into all plans and policies and integrated into all operations and functions of the local authority

3.2 Stakeholder Analysis

A stakeholder analysis is carried out in order to identify and classify the stakeholders with an interest and/or influence in the development of a heating strategy in County Kerry. Amongst other ways to have an interest and/or influence is to have/not have a role in the execution of upcoming heating projects. The methodology for the stakeholder analysis has been developed within the **Hotmaps** strategy development process. For each stakeholder, the following parameters are evaluated:

- Stakeholder name
- Category, e.g.:
    - Authorities
    - Consumers
    - Developers
    - Energy supplying companies
    - NGO's
    - Media
- Interest/impact of the stakeholder
  How much does the strategy/heating planning impact them? (qualitative rating in High/Medium/Low and description)
- Power/influence of the stakeholder
  How much influence do they have over the strategy/heating planning? (qualitative rating in High/Medium/Low and description)
  What is important to the stakeholder?
- Contributions
  How could the stakeholder contribute to the strategy/heating planning?
- Blocking risk
  How could the stakeholder block the strategy/heating planning (and what is the likeliness of the stakeholder doing so)?
- Strategy for engaging the stakeholder in the strategy/heating planning?
  Is anything particular done to engage this stakeholder, which does differ from the general engagement strategy (e.g. invitations to stakeholder meetings and information about progress in the strategy development)?

3.2.1 Key stakeholders

Kerry County Council (KCC)

The key stakeholder in the strategy phase is the local planning authority, in this case, Kerry County Council (KCC). As the public authority on heating, a large heat consumer due to the ownership of public buildings and housing, KCC has multiple interests in the development of heat planning in the region. With these multiple interests, potential conflicts of interest may arise. These need to be addressed early in the strategy development, in order to avoid a conflict that may block the process towards the development of new approaches to heat planning later on.

As with all Local Authorities in Ireland, Kerry County Council is a major economic driver within the county, supporting all aspects of the local economy including, in particular, the construction, tourism and retail sectors and all aspects of urban and rural development. Kerry County Council as an organisation is divided into a number of separate directorates which provide an extensive range of services which focus on the needs of the public and the improvement of the quality of life of the people of Kerry. The role of these directorates is explained further below.

<u>Directorate of Housing Services</u>

This directorate is responsible for providing a range of services to those in need of housing support.

<u>Directorate of Roads, Transportation and Marine</u>

This directorate is responsible for the delivery of roads and marine services, supporting local communities and the management of major capital infrastructure to support economic development.

<u>Directorate of Economic and Community Development</u>

This directorate is responsible for leading, coordinating and collaborating with various other directorates within the Council and outside agencies, both public and private, and the wider community to achieve the best impact in economic, social and community development within the county.

<u>Directorate of Water, Environment, Fire and Library Services</u>

This wide-ranging directorate acts as an agent for Irish Water who are responsible for the provision of clean water for Kerry, the safe treatment and disposal of wastewater through treatment plants. This directorate is also responsible for waste management, recycling, litter control, the Kerry Fire Service and the Kerry Library Service.

<u>Directorate of Finance</u>

This directorate is responsible for developing and implementing effective financial policies, procedures and structures across the whole organisation.

Directorate of Corporate Services

This directorate is responsible for the provision of the following business units:

- Council Services
- Media and Communications
- Franchise
- Facilities Management and Development
- Information Technology and Systems Services
- Internal Audit
- Organisation Development and Performance

Dingle Hub

The Dingle Hub is a community enterprise initiative with a vision to build a sustainable community fostering an ecosystem to facilitate the creation of diverse companies with all-year, well-paid jobs on the Dingle Peninsula. The enterprise consists of a broad variety of different local stakeholders from e.g. tourism, industry, energy supply and other interested and engaged citizens. They aim to identify opportunities through collaborative projects to improve core skills, to facilitate learning new skills, to help entrepreneurship and business and to improve people's lives.

The Dingle Hub is also involved in the Dingle 2030 Project which is a multi-partner initiative based on the Dingle Peninsula. Other Partners involved in this Project include ESB Networks, North East West Kerry Development (NEWKD), and Marine and Renewable Energy Ireland (MaREI). This diverse group is actively working with the local community, schools, business and farming sector to explore, support and enable the broader societal changes required for the low carbon transition.

Sustainable Energy Authority of Ireland (SEAI)

SEAI is Ireland's national sustainable energy authority. SEAI's mission is to play a leading role in transforming Ireland into a society based on sustainable energy structures, technologies, and practices. In order to achieve this SEAI actively works with householders, businesses, communities, government and local authorities.

The Association of Irish Energy Agencies (AIEA)

The AIEA is an all-island body engaging with Local Authorities and the communities they serve to meet their energy performance targets through professional development and implementation of good and best practices.

The overall common aim of the AIEA is to support its members in achieving sustainable energy actions in member regions. This includes both sustainable energy and climate change actions. The AIEA also provides a network for all members to share their experience and knowledge.

Electricity Supply Board (ESB)

ESB is a semi state corporate body which controls and develops Ireland's electricity network. ESB is involved in the generation and supply of electricity to both domestic and commercial users. ESB is the largest electricity utility in the state.

Department of Communications, Climate Action and Environment (Dept CCAE)

The Department of Communications, Climate Action and the Environment is responsible for the delivery of policies and programmes in a number of areas and must ensure that all of its policies are in line with EU and global obligations. The department oversees 17 commercial, non-commercial and regulatory bodies which are each responsible for a specific division within the department. Examples of these bodies include both SEAI and ESB.

Department of Housing, Planning and Local Government (Dept HPLG)

The Department of Housing, Planning and Local Government is responsible for:

- Ensuring that planning and building in our regions and communities contribute to sustainable and balanced development
- Providing for a stable, sustainable supply of good quality housing
- Providing a framework for the sustainable management of water resources from source to sea
- Supporting and enabling democratic, responsive and effective local government, effective electoral management and high-quality fire services and emergency management
- Serving society by producing and communicating reliable weather and climate information to protect life and property and to improve Met Eireann's role as the authoritative voice for high impact weather in Ireland

Department of Public Expenditure and Reform (Dept PER)

The Department of Public Expenditure and Reform is responsible for supporting the delivery of well-managed, well-targeted and sustainable public spending through modernised, effective and accountable public services.

Department of Agriculture

The Department of Agriculture is responsible for:

- Policy advice and development in all areas of Departmental responsibility.
- Development and implementation of national and EU schemes in support of Agriculture, Food, Fisheries, Forestry and Rural Environment.
- Regulation of the agriculture, fisheries and food industries through national and EU legislation.
- Monitoring and controlling animal and plant health and animal welfare.

KCC Utility Provider – Kerry County Council District Heating Scheme Tralee

In Tralee, a 1 MW district heating grid is operated by Kerry Council. The plant supplies social housing, private homes and public buildings. Since the project started in 2007, capacity regarding the technical and non-technical aspects as well as regarding the design and operation of a district heating scheme has been built up locally. The District Heating distribution pipelines are 2km long, the plant is made up of 2 no. 500kW wood chip boilers with an auger feed system and these are linked to 2 no. 5,000 litre thermal store buffer tanks. The District Heating system is backed up by 3 no. 115kW gas boilers.

3.2.2 Stakeholders – overview

The stakeholders are presented in a more schematic way in Table 1 and Table 2.

Table 1: Overview of stakeholders

Name[15]	Category	Interest / Impact	Power / Influence	Needs	Contributions	Blocking risk	Engaging strategy
Dept CCAE	National authority	Medium	High	Achieve national target	National policy and financial incentives (RHI) Incentivise the migration from fossil fuel dependence to more carbon friendly energy consumption.	To date there is no financial incentive offered however this may change in the near future following on from the Climate Action Plan 2019.	Inform
Dept HPLG	National authority	Low	Medium	Achieve national target	Building regulation for domestic	Treatment of DH by Building regulations	Inform
Dept PER	National authority	Medium	High	Achieve national target	Energy Efficiency Fund & NTMA – investor	No financial incentive offered	Inform
Dept Agriculture	National authority	Medium	Medium	Achieve national target	Forestry and supply chain for Biomass, energy from agricultural waste	Lack of knowledge of District Heating and a reluctance to move away from traditional systems of farming	Inform
SEAI	National energy authority	High	High	Achieve national target	Manage and administer incentive schemes, provide training and support	No support in terms of finance and training	Inform
Kerry Co Co	Local Authority	High	High	Achieve local and national targets	Support and guidance, development of heat strategy for the county	A lack of knowledge among Elected Members who are the policy makers at the local level	Actively involved
AIEA	Other - Energy experts and advisors	High	Medium	Aide in achieving national target	Support local and national energy initiatives, expertise in energy mapping, knowledge in	Lack of interest and support	Inform and invite to partake in stakeholder meetings

[15] Acronyms cf. The list of terms and abbreviations.

Name[15]	Category	Interest / Impact	Power / Influence	Needs	Contributions	Blocking risk	Engaging strategy
					renewable technologies		
ESB, Gas Networks Ireland, SSE, Energia	Other - Utility providers (gas and electricity) Possible ESCO's	Medium	Medium	Financial Interest to maximise profit	Network knowledge, connectivity to every building, recording and payment system	May be reluctant to consider District Heating as it may be perceived as reducing their profit margins	Inform and invite to partake in stakeholder meetings
Buildings Owners	Final Energy Consumers – residential and small business	High	High	Low cost reliable heat supply	Customer for the network	Lack of interest and uptake, lack of knowledge	Inform and monitor
Local Industry	Final Energy Consumers – Business – Large Heat user	High	High	Low cost reliable heat supply	Customer for network and possible provider of waste for heat production depending on industry	Lack of knowledge – (Note this is growing)	Actively involved
Farmers and land owners	Final Energy Consumers – Business – Heat users Energy Supplier – possible providers of waste for heat	High	High	Low cost reliable heat supply	Customer for network and possible provider of waste for heat production depending on system	Lack of knowledge of District Heating and a reluctance to move away from traditional systems of farming	Actively involved
Local Media	Media	Low – Medium	High	Inform public of local events	Assist in awareness building of stakeholder meetings	Negative press on DH, lack of knowledge or interest	Inform and monitor
Utility Providers	Energy Supplier	High	High	Ensuring profitability and efficiency of the service provided.	Responsible for meeting demand, contingency planning and supplying reliable energy.	Limited involvement in the planning / strategy development phase	Inform and invite to partake in stakeholder meetings
Local IT and University	Other	High	Medium	Research, analyse and educate	Analysis of heat demand, development of mapping and investigation of suitable technologies	Lack of interest	Actively involved

Table 2: Visual map of stakeholders

	Low Interest / Impact	**Medium Interest/ Impact**	**High Interest / Impact**
High Power / Influence		• Dept CCAE • Dept PER	• SEAI • Kerry Co Co • Local Industry • Local Farmers & Land Owners
Medium Power/ Influence	• Dept HPLG	• Utility Providers • AIEA	
Low Power / Influence	• Local Media	Local IT & University	• Building Owners

3.2.3 Discussion of Stakeholders

The change from individual heating systems to a district heating system involves a paradigm shift for people, who are used to behaving in a particular way during their daily life. Structural changes to these routines can generate social resistance. Therefore, it is important to carefully inform and involve local stakeholders to explain the procedures and benefits of District Heating Schemes. Stakeholder engagement when completed successfully can make the difference between requests for resources being refused or accepted, customers signing up or walking away, and investors backing the project of looking elsewhere. Poor stakeholder engagement is likely to lead to unnecessary project risk, increased cost, the narrowing of options and can ultimately lead to project failure.

4 Description of Heat Demand and Supply Options

In this chapter the basic calculations and preparations of the calculations described in the toolchain approach, Section 2.3, are presented. First, the heat demand is derived (steps 1-3 in the toolchain description). Secondly, the existing heat supply (individual heating) is analysed (step 4 in the toolchain description). In the third key part, the competitiveness of district heating systems in the local environment is analysed, i.e. supply costs for district heating systems as well as the heat load profiles to be supplied, are analysed (steps 5-6). Finally, the potential energy sources for district heating (local renewable potentials, incl. excess heat) are identified and analysed (steps 7 and 8 in the toolchain).

All these steps comprise the input for the scenario analysis, where supply options for the district heating grid are investigated (step 9 of the toolchain) and the whole heating supply system in the region of investigation (individual and district heating) is analysed in the scenario analysis tool (Step 10 in the toolchain). These last two steps of the toolchain are described in Chapter 5.

In this study, two geographical areas are investigated. Both areas are presented and described in more details throughout this report. The areas are:

1. The town of Killarney
2. The township of Dingle, with the surrounding townland of Glin

*Figure 3: The location of Dingle and Killarney in County Kerry. Please refer to Chapter 1 for a presentation of County Kerry. Source: **Hotmaps**-Toolbox*

The technical analysis for this report is done based on manual selections of areas. However, electoral divisions (LAU2-regions) have been used for some scoping analyses. The different geographical divisions used in the analyses are presented in the below figures.

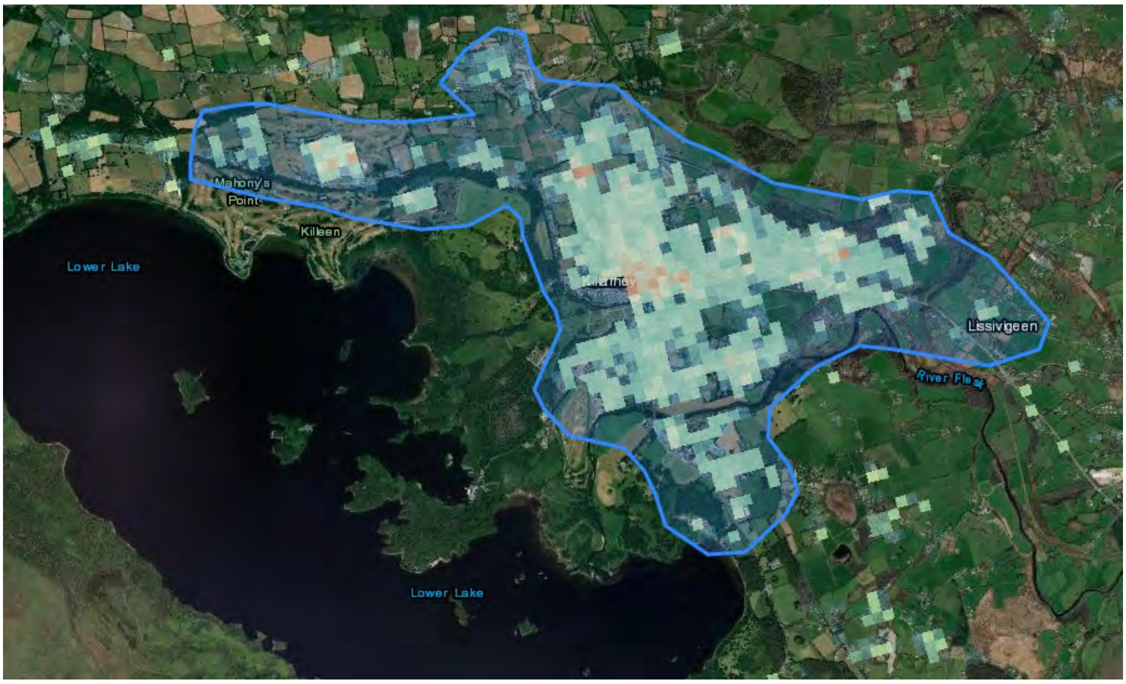


*Figure 4: Killarney area (manual ha-selection). Source: **Hotmaps**-Toolbox.*

*Figure 5: Dingle Townland (manual ha-selection). Source: **Hotmaps**-Toolbox.*

*Figure 6: Electoral division of Glin with the electoral divison of Dingle in the center. Source: **Hotmaps**-Toolbox.*

4.1 Heat Demand

4.1.1 Validation of toolbox-data against bottom-up data

The existing data on heat demand and hence heat demand density for County Kerry has been analysed in a previous EU-Horizon 2020-Project (SmartReFlex). Since then it has been further developed in a study for the Sustainable Energy Authority of Ireland (SEAI), conducted by XD Sustainable Energy Consulting Ltd (XDC). The outputs from this study have been used in the testing phase of the **Hotmaps** project to validate the default data from the toolbox, and possibly adjust them by applying a given multiplication factor for a given region.

The output data from previous work was made available in form of total heat demand (250x250m resolution), divided into residential, non-residential and total heat demand. The figures have been used to validate the heat demand data generated using the Hotmaps toolbox, released in December 2019.

The ratio between the aggregated residential and non-residential heat consumption in 2014 from the validated data source and the **Hotmaps** results were used as a multiplication factor (scaling factor). This was further used to calibrate the heat mapping results from the toolbox so that techno-economic assessment performed in this strategy will reflect the energy needs of the County Kerry region, cf. the heat demand mapped in the validation source.

The comparison of the final heat demand figures from both data sources, along with the correction factors used for calibrating future demand projection for Dingle and Killarney city are presented in Table 3 and Table 4:

*Table 3: Heat demand protocol, comparing **Hotmaps**-Toolbox data with the local bottom-up data and heat demand estimation at 2050 for Dingle (*T: Toolbox, V: Validation source)*

Heat demand type	Unit	Residential	Commercial	Total
Final Heat demand 2014 (T)	MWh/yr	11,240	8,770	20,010
Final Heat demand 2014 (V)	MWh/yr	17,456	11,872	29,328
Deviation from validated data	%	-35.6%	-26.1%	-31.8%
Multiplication factor applied to toolbox data	-			1.47
Final Heat demand 2050 (T)	MWh/yr			17,480
Revised Final Heat demand 2050	MWh/yr			25,690

*Table 4: Heat demand protocol, comparing **Hotmaps**-Toolbox data with the local bottom-up data and heat demand estimation at 2050 for Killarney town (*T: Toolbox, V: Validation source)*

Heat demand (HD) type	Cat.	Residential	Commercial	Total
Final Heat demand 2014 (T)	MWh/yr	88,320	54,900	143,230
Final Heat demand 2014 (V)	MWh/yr	93,451	57,382	150,834
Deviation from validated data	%	-5.5%	-4.3%	-5.0%
Multiplication factor applied to toolbox data	-			1.05
Final Heat demand 2050 (T)	MWh/yr			116,600
Revised Final Heat demand 2050	MWh/yr			122,430

As can be seen in the tables, there is a very varying deviation in the data. Both, for the Dingle and Killarney areas, **Hotmaps** default data deviate extensively from the bottom-up data prepared by XDC, particularly for the residential houses.

Furthermore, data deviation (especially for residential heat demand) decrease with an increase in region/town size, with the relative deviation being biggest in Dingle and smallest in Killarney. This deviation in the default data set is well known and based on the chosen data processing approach and is elaborated by Müller et. Al.

The area boundaries of the investigated regions in Dingle and Killarney are presented in Figure 7 and Figure 8.

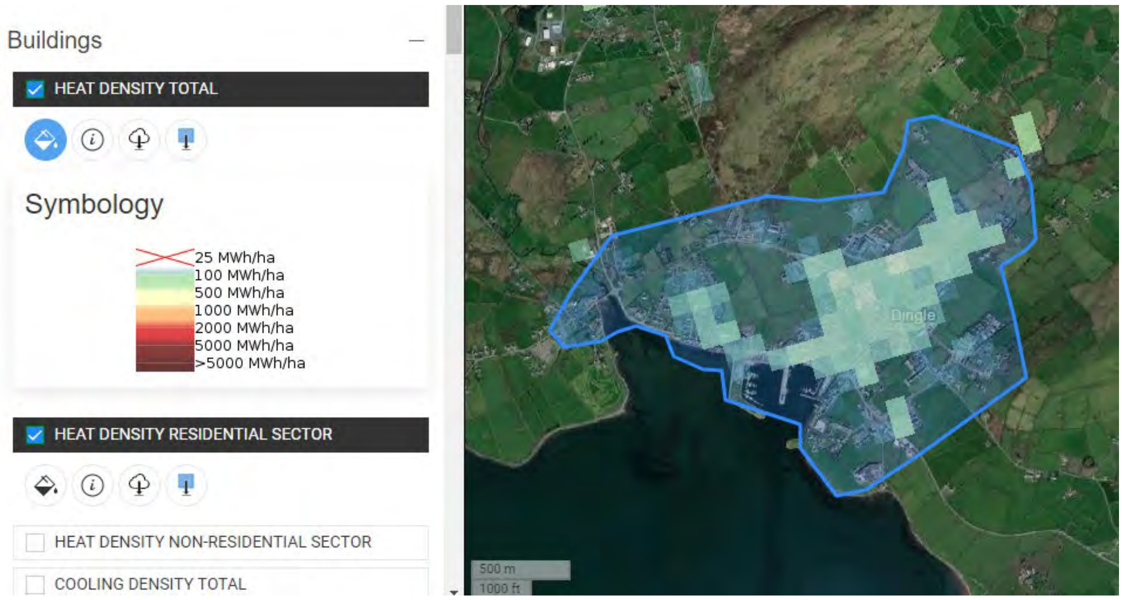


Figure 7: Heat demand map and region boundaries for Dingle.

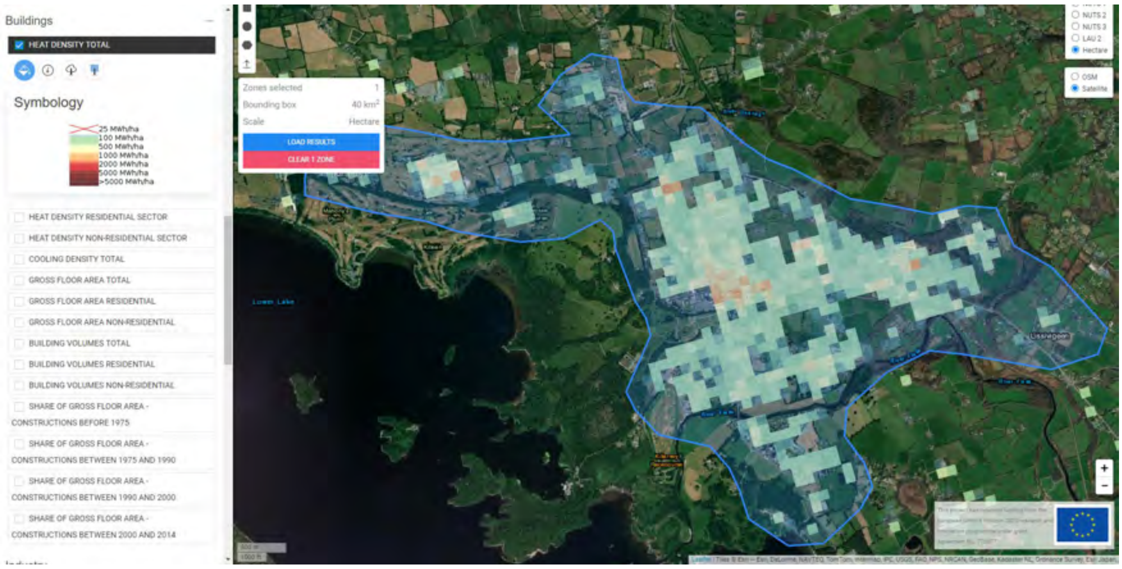


Figure 8 Heat demand map and region boundaries for Dingle.

4.1.2 Heat demand development

As stated by XDC, 2018, Frederiksen and Werner 2013 and others, thermal energy demand and the development of it throughout the years, can be key for the feasibility of a grid-based energy system. Hence, estimations of the future development of a given heat demand must be taken into consideration upon the design and planning of a plant. The development of the heat demand in Killarney and Dingle is estimated by using the **Hotmaps** Calculation Module Demand Projection, using the adapted heat demand and gross floor area density maps, cf. above sections, as maps for the current situation.

The development of the useful heat demand in the building stock is assessed based on the predefined scenarios available in the CM. In sensitivity analyses, a correction factor of the following parameters has been assessed, cf. Table 5.

Table 5: Input parameters for CM Demand Projection. Three scenarios are investigated: 1) Reference (the base scenario for calculations), 2) Low (lower specific energy need) and 3) High (higher specific energy need).

Parameter		Sensitivity: "Low"	Reference	Sensitivity: "High"
Renovation rate	*%*	*2*	*1.016*	*0.5*
Target year		*2050*	*2050*	*2050*
Reduction of floor area (all construction periods)	*%*	*100*	*100*	*100*
Reduction of specific energy needs (all ages)	%	150	100	50
New constructed building		Replace only demolished	Replace only demolished	Replace only demolished

[16] Based on the refurbishment rates stated by Irish Government, 2019, corresponding a deep refurbishment rate for approx. 1.5 % of current building stock pr. year until 2030 (assumed to stay the same 2030-50).

Whilst the parameters for the reference-scenario are based on the available scenarios in the default settings in the CM, supplemented by input from e.g. The Irish Climate Action Plan, the other two scenarios are chosen, to create a certain variation in the figures.

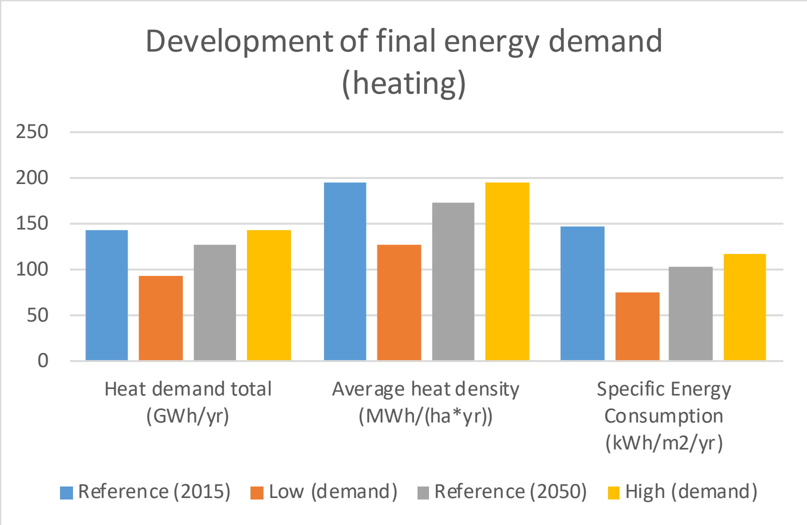


Figure 9: Development of final energy consumption for heating. Three parameters. For all scenarios, the heated floor area develops from 0.96 million m^2 in 2014 to 1.22 million m^2 in 2050.

The reference scenario results in a reduction of the specific final energy consumption for heating of 30 % in the reference scenario (48/21 % for the low/high scenarios) and a reduction of the average heat density in the area of 11 % for the reference scenario (35/0 % for the low/high scenarios). Regarding this, it must be noted, that no deviation in the heated floor area is assumed.

4.1.3 Heat Demand to be used in calculations

For the reference situation in 2050 projection, the heat demand density and heated floor area maps, as derived from the CM Scale Heat and Cool Density Maps cf. the description in Section 2.3.2 are used. Given the discrepancy between the default data from the toolbox and the figures obtained from XDC study, the heat density map for Killarney and Dingle was then recalibrated using scaling factor of 1.05 and 1.47, respectively (see section 4.1.1).

4.2 Decentral (Individual) Heat Supply

The energy consumption and emissions baseline inventory for 2008 determined that the total final energy consumption for the county was 4 TWh/yr and energy-related CO_2-emissions were 1.22 million t/yr. Heat represents a significant proportion of the final energy demand at 1.81 TWh/yr, 67% of which is used in the residential sector. Close to 60% of the heat demand is supplied by individual oil or LPG boilers, with the remainder heated by solid fuel and electricity. There is a very limited natural gas supply in the county with only Listowel and the surrounding area in the north of the county currently connected to the natural gas network. The network was extended to Listowel predominantly to supply the anchor load of “Kerry Ingredients” which made the extension of the network to Listowel commercially viable.

District Heating is relatively new in Ireland and not widely used. Kerry was the first county in Ireland to have a fully operational biomass district heating system, which was commissioned in 2008. The plant in Tralee is a 1 MW biomass (woodchip) system, which serves both new houses and existing houses in the area, a library, old peoples daycare centre (Retrofitted 1850's former Convent), a school and a new mix use community/office building. The DH plant is owned and operated by Kerry County Council. As the only operating district heat plant in County Kerry is placed in Tralee, individual heating is the reference heat supply form in all scenarios.

The final energy consumption for heating has been estimated to match the shares derived by XDC for County Kerry as a total (for 2015 51 % oil, 26 % electricity and 23 % solid fuels/biomass).

The Dingle area is assumed to have a building mix comprised of Multifamily houses (55%), Hotels and Restaurants (30%) and Single houses (15%) which in larger proportion are buildings from 1970-1979, and the remaining estates were constructed after 2000. The TABULA WebTool[17] is used to find the characteristics (average gross floor area of a building) of buildings originated from those periods and building category. The toolbox provides a database with main characteristics for buildings in different European countries, including Ireland. There was a slight discrepancy between the age category of buildings in TABULA and **Hotmaps**, therefore the periods 1965 - 1980 and 2004 – 2009 available in TABULA have been used to match the construction periods 1970 - 1979 and 2000 – 2010 respectively used in **Hotmaps** (TABULA).

The building individual heating needs, both for Dingle and Killarney have been estimated based on the fuel mix by 2030 from (Curtin K. et al., 2019) study produced for Dingle. This indicates the dominance of oil-based heating which is likely to correspond to half (51%) of the total fuel consumption with the remaining half distributed nearly evenly between biomass or other biofuels (23%) and electricity (26%).

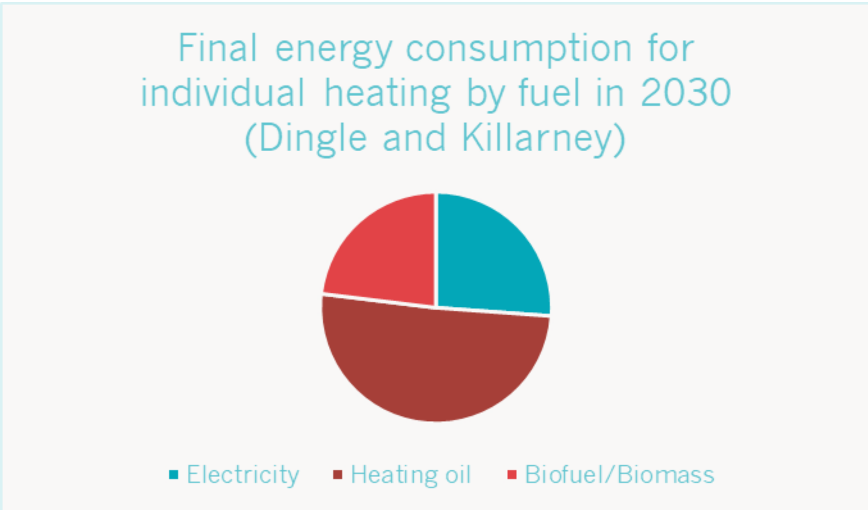


Figure 10: Assumed Final energy consumption for individual heating by fuel in 2030 (Dingle and Killarney) based on the fuel mix in 2050 for Dingle.

[17] http://webtool.building-typology.eu/

The individual heating is to be supplied with the following technologies which are correlated with the fuel consumption mix as indicated in the graph.

Electricity	Oil	Biomass/Biofuel
•Air to air HP	•Oil boiler	•Biomass automatic

These individual heating technologies were allocated to buildings with different proportion, depending on the building character and age which was substantiated using good practice. For example, the new multi-family houses and hotels are likely to invest into more heat pumps, while old single houses would rather rely on biomass boilers. The older properties will remain more oil-based heating installations, while the newer buildings replace the oil boilers with modern biomass ord wood boilers or air to water or brine to water heat pumps.

The cost, emission and energy allocation by the technological unit in the decentral heating supply to the regions Dingle and Killarney is presented in Figure 11 and Figure 12.

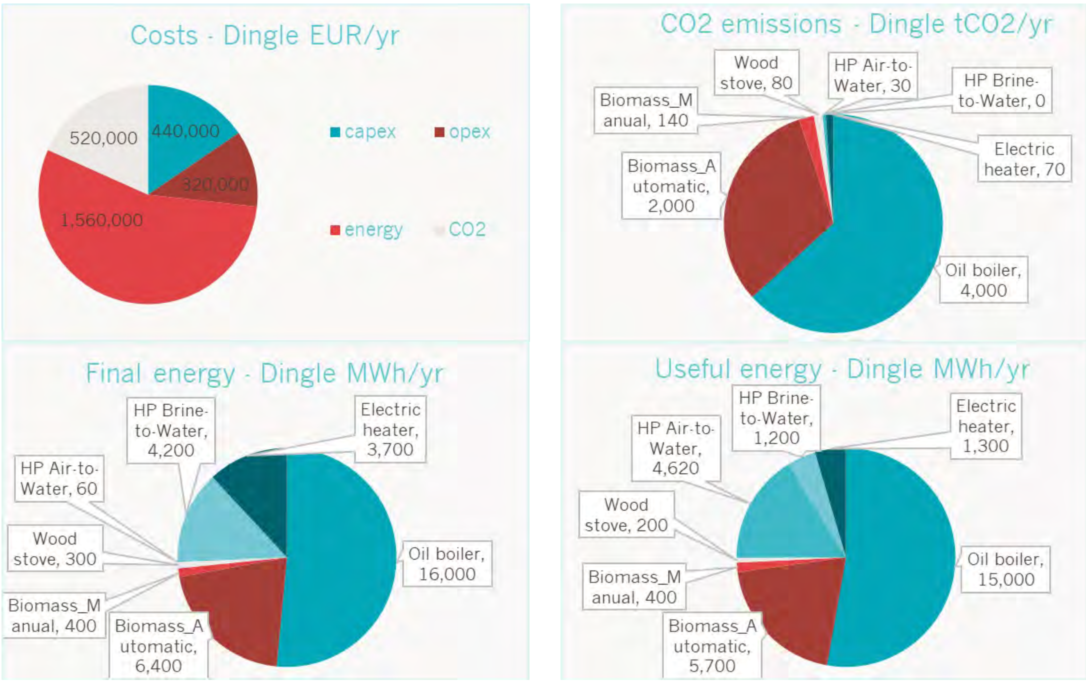


Figure 11: The cost, emission and energy breakdown of final and useful energy consumption, carbon emissions and annualized cost for individual heating technologies in Dingle.

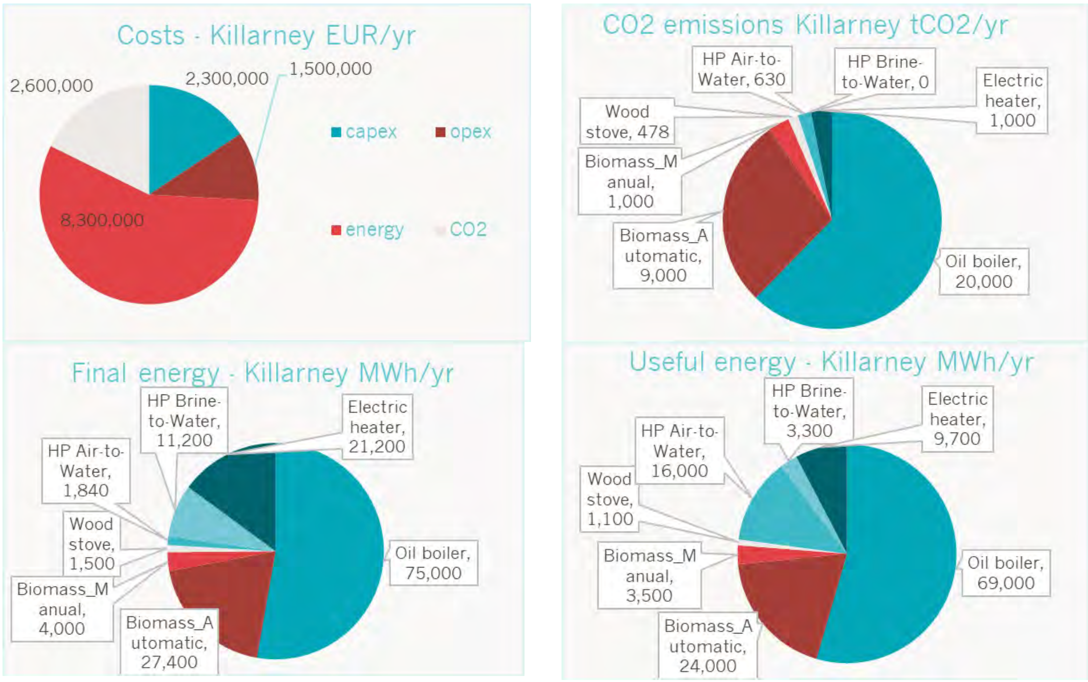


Figure 12: The cost, emission and energy breakdown of final and useful energy consumption, carbon emissions and annualized cost for individual heating technologies in Killarney.

4.3 Calculations for Business Cases for District Heating

4.3.1 Economic Assessment of District Heating Potentials

The economic assessment of possible district heating schemes in Dingle and Killarney are assessed in two steps, starting with a rather indicative assessment to identify expectable shares of district heating in the given areas. This is calculated using the **Hotmaps** CM DH user-defined threshold which identifies the maximum district heating coverage in the area, based on two boundary conditions: Minimum heat demand in hectare and minimum heat demand in a DH area. The first factor determines the scattering of the consumers considered for connection to DH, while the other condition decides on the size of the network. In other words, the higher the minimum heat demand per hectare, the network would be concentrated only on the most dense areas. This entails a cheaper DH infrastructure, however, since fewer houses get supplied via the efficient decentralised network, the overall heat tariff per MWh may be high.

On the other hand, the higher minimum heat demand in a DH area, the lower DH potential is likely to be achieved, as this would disqualify smaller networks from the range.

The simulated scenarios in the initial assessment and the resulting DH potentials for Dingle and Killarney are summarised in Table 6 and Table 7.

Table 6: Input and output for the calculation module User Defined Thresholds for Dingle.

	Parameter	Unit	Default data	Run 1.4 A	Run 1.4 B	Run 1.4 C	Run 1.4 D	Run 1.4 E	Run 1.4 F	Run 1.4 G
INPUTS	Min. heat demand in hectare	MWh/ha	333	200	300	500	200	300	500	400
	Min. heat demand in a DH area	GWh/year	30	5	5	5	10	10	10	8
OUTPUTS	Total heat demand in GWh within the selected zone	GWh		26	26	26	26	26	26	26
	Total district heating potential in GWh within the selected zone	GWh		16	13	8	16	13	0	10
	Potential share of district heating from total demand in selected zone	%		62	51	32	62	51	0	40

Table 7: Input and output for the calculation module User Defined Thresholds for Killarney.

	Parameter	Unit	Default data	Run 1.4 A	Run 1.4 B	Run 1.4 C	Run 1.4 D	Run 1.4 E	Run 1.4 F	Run 1.4 G
INPUTS	Min. heat demand in hectare	MWh/ha	333	200	300	500	200	300	500	400
	Min. heat demand in a DH area	GWh/year	30	5	5	5	10	10	10	8
OUTPUTS	Total heat demand in GWh within the selected zone	GWh		122	122	122	122	122	122	0
	Total district heating potential in GWh within the selected zone	GWh		80	45	0	80	45	19	0
	Potential share of district heating from total demand in selected zone	%		65	37	0	65	37	16	0

The potential for district heating in Killarney and Dingle varies significantly, depending on the chosen input parameters for the analyses. With rather moderate parameters, the potential in Dingle reaches approximately half of the final energy consumption. In Killarney, the same parameters only lead to a district heating potential of roughly 1/3 of the final heat energy consumption (≈37%), which indicates a lower heat density in the total area of Killarney, compared to Dingle.

A low minimum heat demand density in the area (MWh/ha) indicates more spread DH network. Lower thresholds for heat demand density results in more final consumers can be supplied, which increases the cost of the DH infrastructure. However, the more houses are supplied by decentralised heat, the lower should be the overall cost of heat per MWh. Even with rather low heat energy density (200 MWh/ha), the maximum of the final energy consumption to be converted to district heating is found at 62% (Dingle) and 65% for Killarney.

Based on this, it is unlikely to identify a business case for district heating with DH penetration of much more than 60% of the total heat demand in the areas of Killarney and Dingle.

To estimate the cost associated with the DH development based on the targeted potential for district heating in County Kerry, the above results are used as input in the Economic Assessment CM. In a series of CM-runs, a variety of parameters are assessed including the grid cost ceiling and the investment depreciation time. Based on the findings from Table 6 and Table 7, the targeted maximum market shares for district heating during the project period (2020-50) are assumed at 30%, 50% and 60%. The achieved DH penetration level according to the CM is presented in Figure 13 and Figure 14.

The result of the simulation that was selected for the further energy strategy assessment was determined based on the highest DH potential it can bring, before changing the boundary parameters does not impact the resulting DH potential significantly (or at all). In the case of Dingle, the highest DH penetration (6%, 27% and 34%) was achieved for 45 EUR/MWh of DH ceiling costa and 35 depreciation period (red dotted graph in Figure 13). In the base case scenario of energy dispatch, only the highest DH share is taken into consideration as this needs to be compared with a wide range of technology portfolio. The lower DH penetration is analysed in the sensitivity analysis.

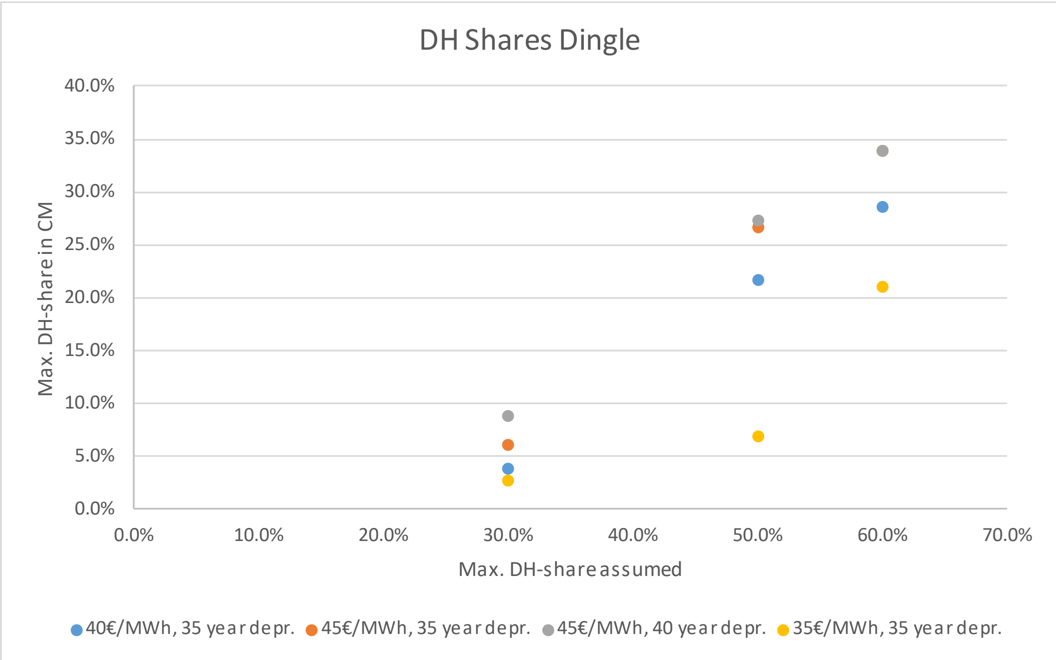


Figure 13: District Heating Shares Dingle

In Killarney case, the highest DH penetration (6%, 30% and 38%) was achieved for 40 EUR/MWh of DH ceiling costa and 35 depreciation period (blue dotted graph in Figure 14). All three levels of DH share are compared later with the technology portfolio in the base case scenario of energy dispatch.

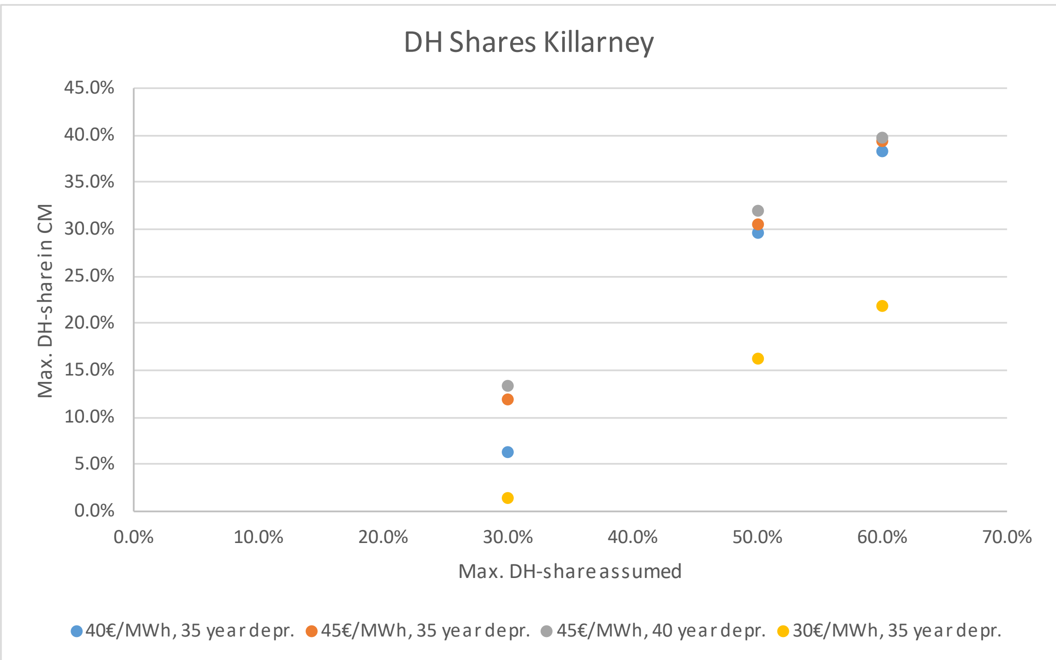


Figure 14: District Heating Shares Killarney.

4.4 Resource potentials

The resource potentials in County Kerry are primarily estimated based on the **Hotmaps** database and toolbox and are, when possible, validated with alternative references.

Dingle, due to its location in the rural part of Ireland and highly forested, has the highest potential in biomass sources. It is estimated that circa 500,000 tonnes of biomass per year can be collected from the neighbouring region to produce up to 16 MW of heat. In the same time, circa 150,000 tonnes/year out of the total biomass feedstock can be converted into the biogas (150 TJ/year) giving the heating and electricity production potential up to 3.5 MWth and 2.5 MWe, respectively. Proximity to sea-water and high spatial availability allows considering ground and water heat source recovery through a heat pump. This also creates an opportunity for solar thermal energy production from the ground solar panel installations.

Killarney, as a larger agglomeration than Dingle, surrounded by other towns and located in a more concentrated and populated area, gives the highest energy potential from the waste. It is assumed that the waste source can be collected from all neighbouring municipalities and utilised in the energy to waste facility. The alternative energy source for main or peak heat generation similarly to Dingle is biomass.

5 Scenario Analysis

5.1 District Heating Supply Scenarios

Scenarios on the supply side to be investigated in Dingle:

1. Biogas (from a possibly coming anaerobic digestion plant) sized according to the available biogas production potential and a backup boiler (wood pellets)
2. Wood pellet boiler
3. Electric Heat Pump
    a. Air-to-Water
    b. Brine-to-water, close to the surface
4. Woodchip boiler
5. Solar thermal + woodchip boiler (same as 3)

Scenarios on the supply side to be investigated in Killarney:

1. Large Energy-from-Waste CHP supplying the most of the energy demand and a backup wood pellet boiler
2. Medium Energy-from-Waste CHP and a backup wood pellet boiler
3. Small Energy-from-Waste CHP supplying baseload and a large wood pellet boiler

The technologies have been sized according to the highest DH potential estimated for Dingle and Killarney in the earlier section 4.3 which was circa 60 % of the total heat demand. This corresponds to nearly 3 MW peak and 8,730 MWh/year of thermal heat demand to be supplied in Dingle and 16 MW peak and 46,500 MWh/year in Killarney.

For each of the scenarios for heat supply of a given district heating scheme, sensitivity analyses will be carried out taking into consideration the district heating share, development in useful heat demand (energy efficiency measures on building level and development of technology shares for decentral heating options).

The key assumptions for the evaluated district heating energy supply options for Dingle and Killarney are included in Appendix 9.1. The overview of the heat supply cost, the annualised total investment and operation cost, emissions and final energy consumption for the centralized heat supply through DH in Dingle by the investigated technology is summarised in the graphs Figure 15 and Figure 16.

Figure 15: The levelized cost of heat, the annualised total investment and operation cost, emissions and final energy consumption for the centralized heat supply through DH in Dingle by the investigated technology.

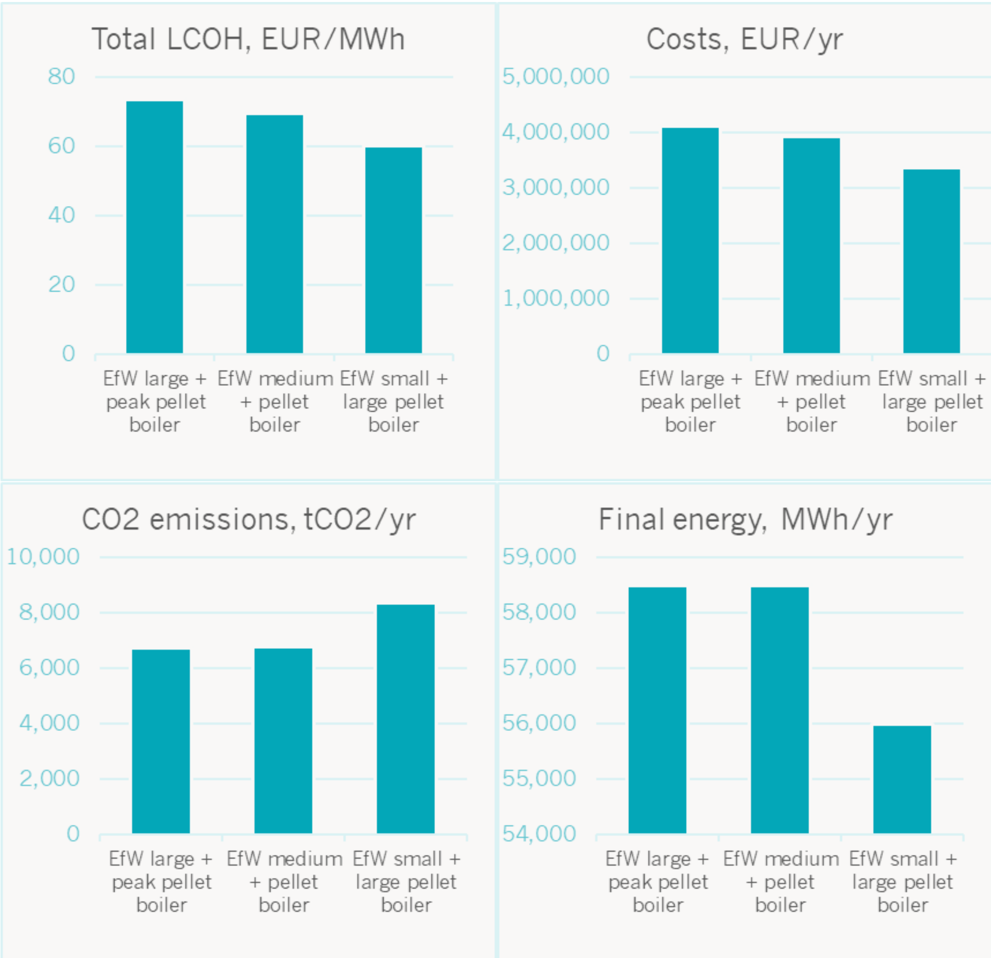


Figure 16: The levelized cost of heat, the annualised total investment and operation cost, emissions and final energy consumption for the centralized heat supply through DH in Killarney by the investigated technology.

5.2 Assessment of scenarios

In the scenario analysis, outputs from three calculation modules are brought together to model the entire building stock in the areas of investigation and the heat supply for these:

1. CM Decentral Heating Supply: The results from this CM are used to evaluate the energy carriers and costs and emissions related to these, in individual heating systems.
2. CM DH Economic Assessment: The results from this CM are used to evaluate a variety of different district heating shares.
3. CM DH Supply Dispatch: The results from this CM are used to evaluate the energy carriers and costs and emissions related to these, in individual heating systems.

The focus of the analysis in this paragraph is on the central estimate, i.e. a scenario where parameters are chosen to represent most likely development of key parameters.

The scenarios to be analysed in the development of the heating strategy for County Kerry differ between the two areas of interest, due to differences in available resources. On the demand side, only one business-as-usual (BAU) scenario is being investigated. This assumes that all heat demand in the area is supplied using decentralised individual heating technologies as described in section 4.2

The alternative energy supply scenarios are built with the aim that the heat demand is covered in up to 60% via district heating (see sections 4.3 and 5.1), while the remaining energy consumption is supplied locally using individual technologies (refer to section 4.2).

5.3 Scenario Calculations and Results - Dingle

The heating scenarios for Dingle combine one main production technology in the centralised solution each, responsible for 34% DH supply (the resulting highest DH penetration level achieved based on the targeted 60% goal, see section 4.3) and the mix of local heaters, mostly: oil boilers, biomass boilers and electric heating (heat pumps and electric heater) supplementing the remaining heating needs. Given a large number of DH technologies (six), the base analysis concentrates only evaluating them for one DH share. The smaller DH coverage in total head demand will be additionally assessed on the sensitivity analysis chapter.

The overview of the scenario characteristic highlighting the individual heating option, DH penetration level and centralised heating technology is presented in Table 8.

Table 8: Scenarios for coverage of heating demands (DH shares of final energy consumption), Dingle

scenario0	scenario1	scenario2	scenario3	scenario4	scenario5	scenario6
S0 Reference 2050 + No DH expansion + Only decentral supply	S1 Reference 2050 + High DH expansion 34% high DH budget + Biogas CHP (available potential) + wood pellet boiler	S2 Reference 2050 + High DH expansion 34% high DH budget + Wood pellet boiler	S3 Reference 2050 + High DH expansion 34% high DH budget + ASHP (air to water)	S4 Reference 2050 + High DH expansion 34% high DH budget + GSHP (brine to water)	S5 Reference 2050 + High DH expansion 34% high DH budget + Wood chip boiler	S6 Reference 2050 + High DH expansion 34% high DH budget + Solar thermal + Wood chip boiler

5.3.1 Costs

Connecting circa 1/3 of all heat consumers to the DH is expensive, and as indicated by dark blue marking on the diagram (Figure 17) which is nearly as high as the investment into all individual heating units in the reference scenario (light blue blocks). This investment still proves to bring cost savings due to operating more effective and less carbon-intensive technologies, such as air-source heat pumps (ASHP). A slightly more expensive alternative for individual heating is the solar thermal plant supplemented with the wood chip boiler.

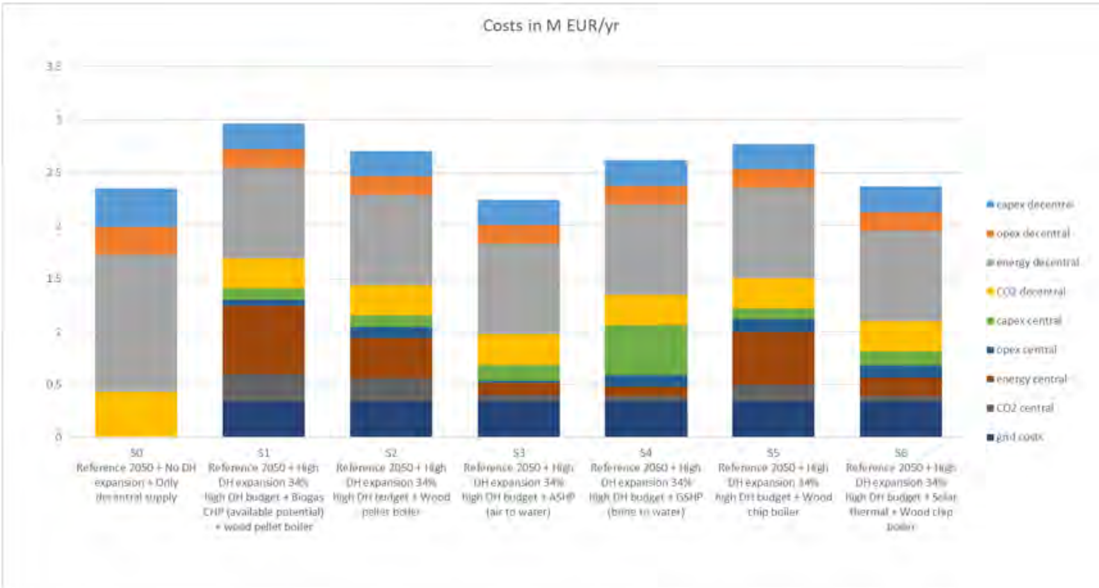


Figure 17: Costs of scenarios in Dingle.

The other cost parameter that can be compared between the energy supply scenarios is Levelized Cost Of Heat supply expressed in EUR/MWh (LCOH). The levelized cost of heat for each heating system is calculated as the net present value of the cash flow divided by the heat generation over the lifetime. As a result, this indicates the heat tariff (the unit heat price) that will incur on the final user to compensate for the investment cost, variable and fixed operation cost and emissions expenses of the DH operator. The indicators in Figure 18 distinguish the heat cost produced locally centrally and the weighted average price, given that 34 % of heat demand is supplied via DH, while the rest rely on the individual heating systems.

Scenario 3 with the DH system utilising ASHP as the main energy production technology reaches the heat price lower than the cost of heat in the reference case.

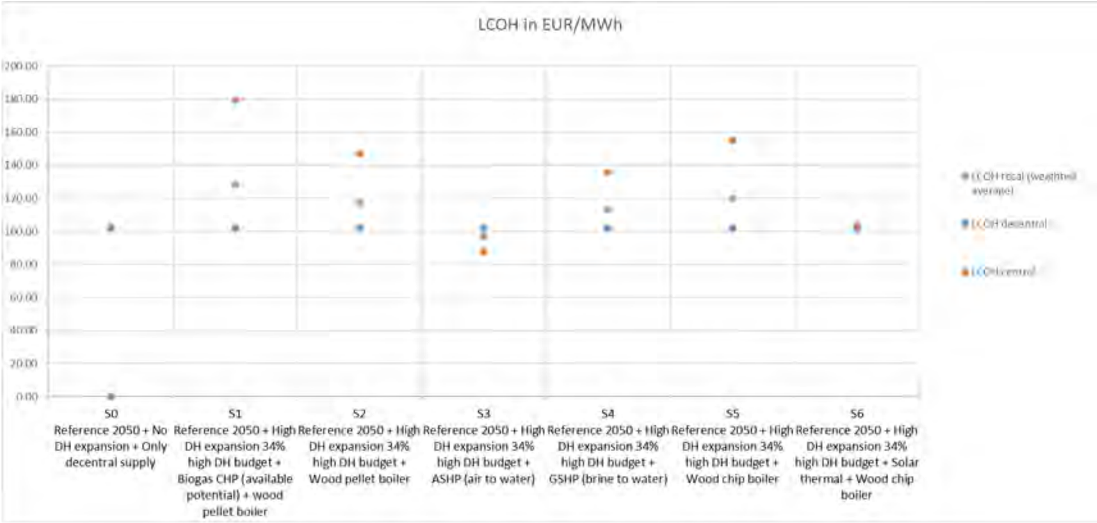


Figure 18: LCOH by a scenario in Dingle.

5.3.2 Emissions

The only more carbon-intensive options than the reference case are the DH energy production based on biogas CHP[18] and a wood pellet boiler (scenario 1 and 2). The heat pump options, solar and wood chip boiler systems would contribute to Dingle with carbon abatement[19]. The highest carbon emission reduction is anticipated in the system with the GSHP which acts at the most efficient among the heat pumps based on the thermal reservoir (lower heat source) temperature level.

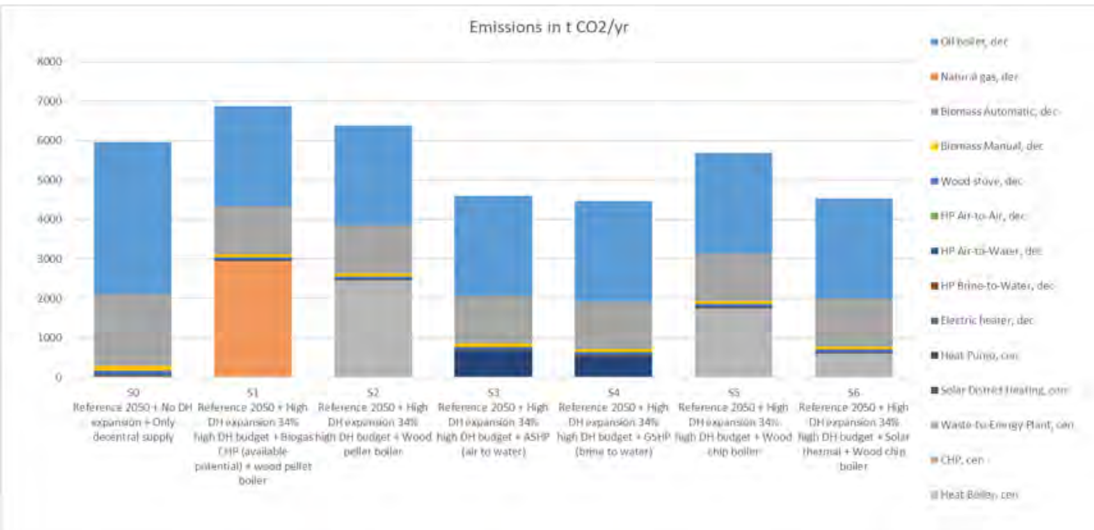


Figure 19: Emissions, Dingle.

[18] Considering the combustion of biomass and biogas CO_2-neutral, but not emission-free processes.
[19] Please note that emission factors for the electricity mix that has been assumed in the calculations are sourced from the energy statistics SEAI (Sustainable Energy Authority of Ireland), Electricity - Provisional 2019, https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/.

5.3.3 Final Energy Consumption

The most efficient in terms of final energy (fuel/energy carrier) consumption are the heat pump solutions (scenario 3 and 4). The solar thermal scenario that uses also wood chip boiler as a back-up and for time with no solar radiation, comes as the second most efficient DH system (scenario 6), especially that solar energy is available at no cost. The fuel consumption from individual heating remains the same for all scenarios, where it is responsible for covering the remaining 66% of total heat demand.

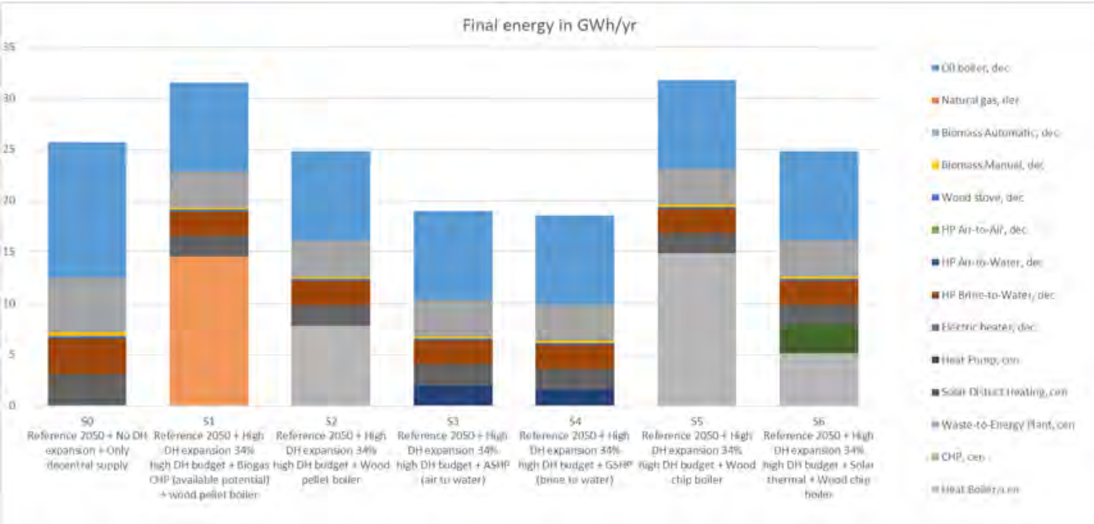


Figure 20: Final energy consumption, Dingle.

5.4 Scenario Calculations and Results - Killarney

In the Killarney case, three alternative energy from waste systems are assessed in a combination of high, medium and low DH penetration (6%, 30% and 38%). The remaining heat demand of the region, similarly to Dingle, is provided by the means of oil heating supplemented with biomass boilers and heat pumps.

The scenario analysis for Killarney follows the same structure as the one for Dingle. The overview of the scenario characteristic highlighting the individual heating option, DH penetration level and centralised heating technology is presented in Table 9.

Table 9: Scenarios for coverage of heating demands (DH shares of final energy consumption), Killarney

scenario0	scenario1	scenario2	scenario3	scenario4
S0 Reference 2050 + No DH expansion + Only decentral supply	S1 Reference 2050 + Limited DH 6% DH expansion medium budget + EfW large + peak pellet boiler	S2 Reference 2050 + Limited DH 6% DH expansion medium budget + EfW medium + pellet boiler	S3 Reference 2050 + Limited DH 6% DH expansion medium budget + EfW small + large pellet boiler	S4 Reference 2050 + Semi-Ambitious 30% DH expansion medium budget + EfW large + peak pellet boiler

scenario5	scenario6	scenario7	scenario8	scenario9
S5 Reference 2050 + Semi-Ambitious 30% DH expansion medium budget + EfW medium + pellet boiler	S6 Reference 2050 + Semi-Ambitious 30% DH expansion medium budget + EfW small + large pellet boiler	S7 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW large + peak pellet boiler	S8 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW medium + pellet boiler	S9 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW small + large pellet boiler

The nine scenarios start with the reference, i.e. individual heating in the entire building stock of Killarney. In the eight other scenarios, three different district heating shares are assessed, (6 % in scenarios 1-3, 30 % in scenarios 4-6 and 38 % in scenarios 7-9). For each of these three district heating shares, three different supply portfolios have been evaluated, all utilizing a waste CHP-unit, combined with a wood pellet boiler. They vary by the selected capacity of the waste combustion unit and the pellet boiler.

5.4.1 Costs

The larger the DH coverage, the higher the investment of the grid infrastructure (see the difference between the size of a dark blue block in scenarios 1-3, 4-6 and 7-9 in Figure 21). Installation of the larger CHP waste incinerator also incurs the higher upfront cost (capex central marked with light blue block), so it slightly increases running costs of the plant (opex central highlighted with medium blue blocks).

The same tendency is noticed with the heat price for the final user (LCOH) which is the most attractive with the smallest waste incinerator supplemented with larger wood pellet boiler (scenarios 3, 6 and 9). Overall, there is no much difference between the total cost of the combined DH and decentralised systems and neither vary the heat price, compared to the reference scenario. This indicates that the high investment cost of DH solution is compensated with lower consumption of relatively cheap fuel which is very costly for the local heating options.

Hence, the rationale for selecting the most advantageous energy development scenario should be drawn from the carbon emission abatement results or fuel consumption effectiveness.

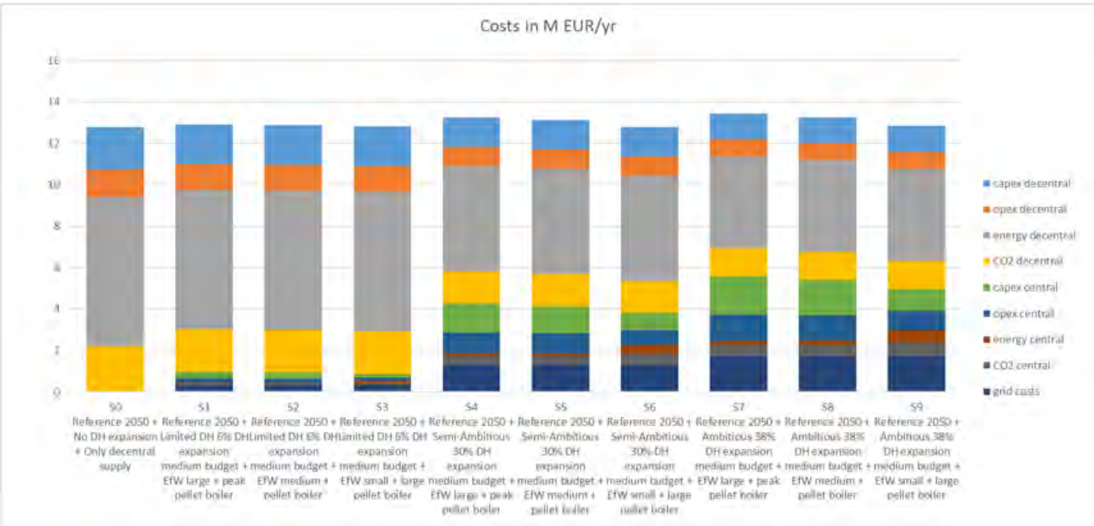


Figure 21: Costs of scenarios in Killarney.

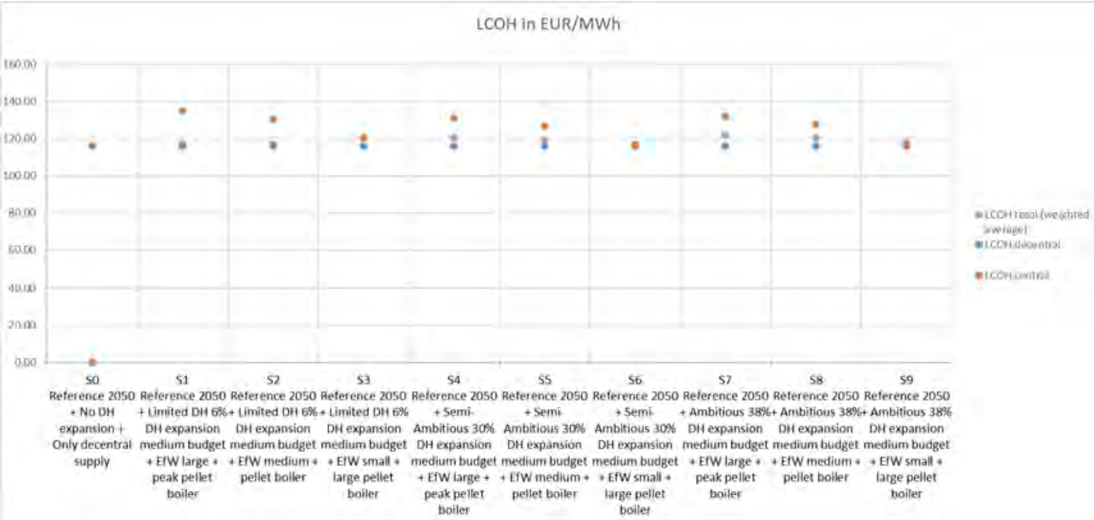


Figure 22: LCOH by scenario in Killarney.

5.4.2 Emissions

The highest CO_2 reduction is achieved with larger waste incinerators (scenario 1, 4 and 7). The highest improvement, though, is noticed with the development of DH from the limited DH development up to 6% share (scenario 1)to semi-ambitious 30% DH coverage (scenario 4). Although the highest level of DH penetration at the ambitious level of 38% (scenario 7) boost the CO_2 savings even further, this may not be the most optimal solution given, the increased cost of investment into more remote DH transmission infrastructure (Figure 21).

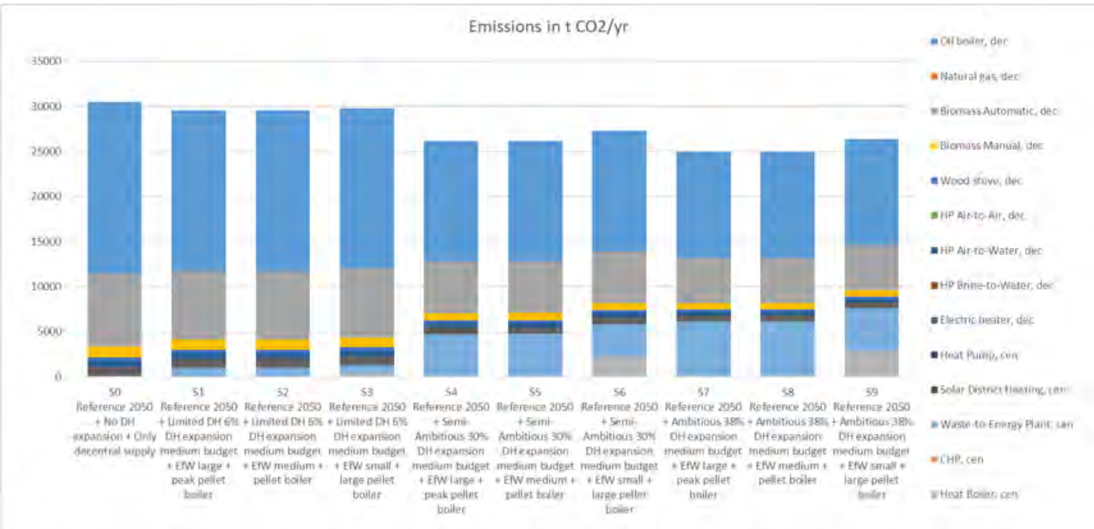


Figure 23: Emissions, Killarney

5.4.3 Final Energy Consumption

The fuel consumption as indicated by the final energy graph Figure 24, does not deviate in a significant way from the reference case based on individual heating only. Waste sources consumed in the central heat supply solution replace the high utilisation of the oil fuel in the individual heating.

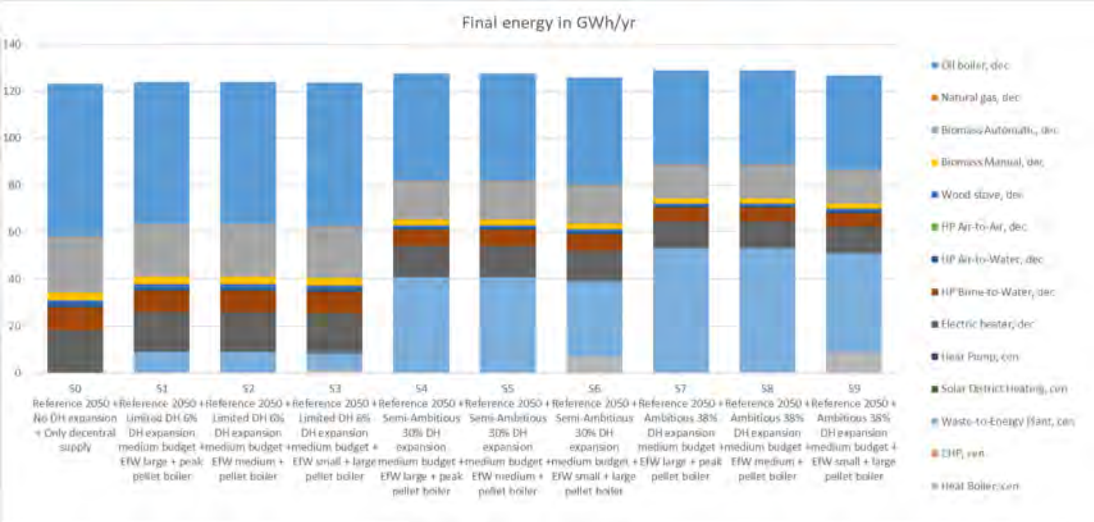


Figure 24: Final energy consumption, Killarney

5.5 Sensitivity Analyses

In order to validate the findings in the above section, sensitivity analyses have been carried out to investigate how the internal hierarchy of scenarios in given parameters (total investment and operation costs, heat supply cost (LCOH), CO_2-emissions and final energy consumption) remains constant, even though key factors are changed. In this sensitivity analysis, the parameters that are changed are divided into three groups:

1. Cost factors
2. Heat demand development
3. Decentral heating supply

5.5.1 Cost Factors

In the key set of sensitivity analyses, cost factors are adjusted. The following are investigated:

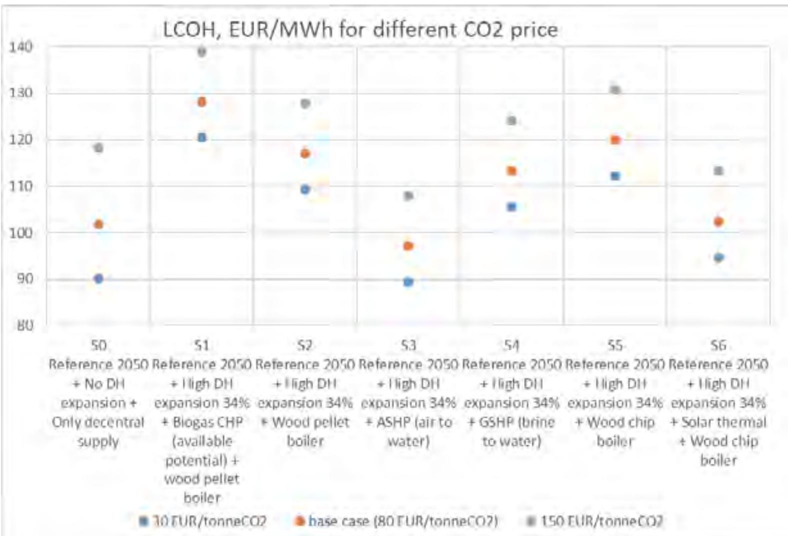
1. CO_2-prices: low (30 €/tonneCO_2) and high (150 €/tonneCO_2)
2. Investment costs district heating (capacity and grid): +/- 20%, including:
    a. Construction costs of DH network
    b. Investment cost of the centralised energy plant
    c. Fixed and variable maintenance cost of the centralised energy plant
3. Investment costs decentral heating (capacity and O&M): +/- 20%, including:
    a. Investment cost of individual production units

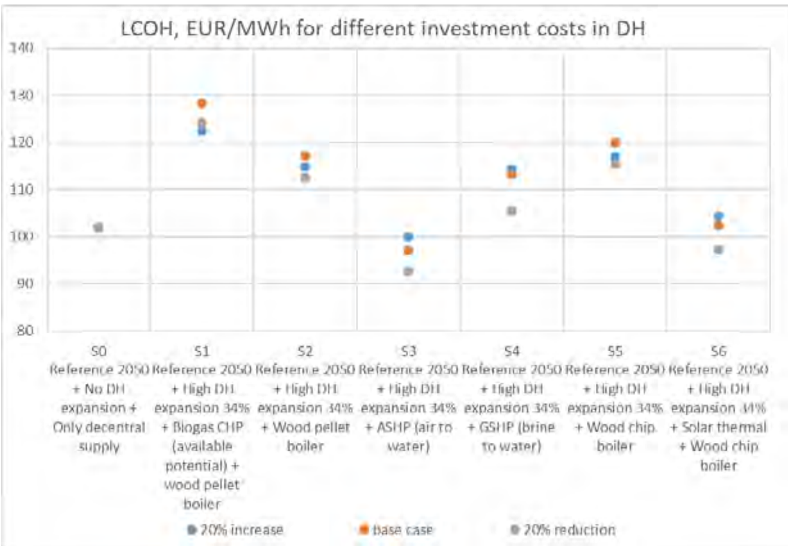
        b. Fixed and variable maintenance cost of individual production units
4. Energy carrier costs district heating: +/- 20%, including:
    a. Cost of fuel for the centralised energy plant (waste, wood pellet, wood chip, biogas and electricity for heat pumps)
5. Energy carrier costs decentral heating: +/- 20%, including:
    a. Cost of fuel for individual production units (oil fuel, biomass and electricity for heat pumps and electric boilers)

In this study, all four output parameter, as total investment and operation costs, heat supply cost (LCOH), CO_2-emissions and final energy consumption have undergone sensitivity tests.

In Dingle, the highest influence on the total costs and the final cost of heat supply have the parameters such as the price of carbon emissions and the cost of energy carrier (fuel and electricity) consumed by the decentral heating technologies. The deviation of the LCOH in these cases reaches up to 16 % in both direction from the heat cost in the base case scenario. The range of the achieved LCOH in all sensitivity scenarios can be seen in Figure 25. The correlation of total costs with the heat price (LCOH) is analogical, with the maximum deviation not higher than 16%.

The key finding of the sensitivity simulation is noticed for the very high CO_2 price (150 EUR/tonneCO_2) in the scenario with the ASHP based DH supply (scenario 3) which can achieve almost 10% lower LCOH compared with the heating supply entirely based on individual heating. A similar heat cost reduction can be found for the scenario with the ASHP if the energy carrier prices for individual heating increase by 20%.




LCOH, EUR/MWh for different investment costs in DH
140
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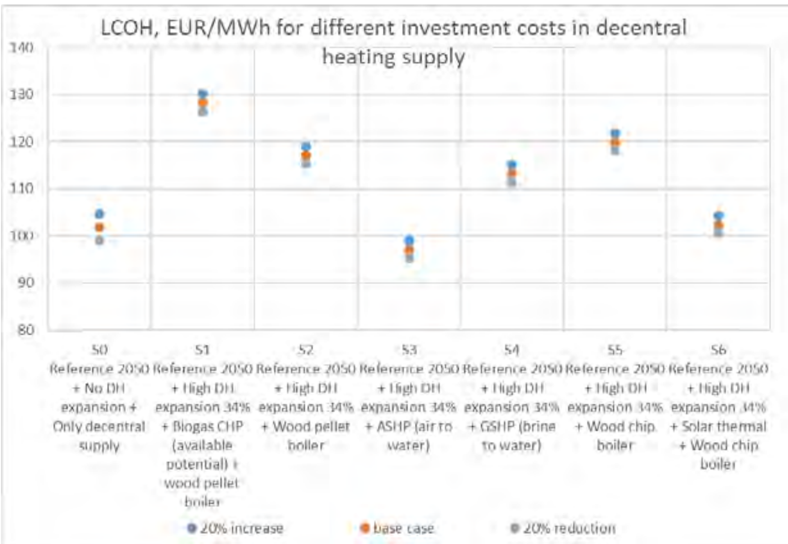
80
S0 Reference 2050 + No DH expansion + Only decentral supply
S1 Reference 2050 + High DH expansion 34% + Biogas CHP (available potential) + wood pellet boiler
S2 Reference 2050 + High DH expansion 34% + Wood pellet boiler
S3 Reference 2050 + High DH expansion 34% + ASHP (air to water)
S4 Reference 2050 + High DH expansion 34% + GSHP (brine to water)
S5 Reference 2050 + High DH expansion 34% + Wood chip boiler
S6 Reference 2050 + High DH expansion 34% + Solar thermal + Wood chip boiler
20% increase
base case
20% reduction


LCOH, EUR/MWh for different investment costs in decentral heating supply
140
130
120
110
100
90
80
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S1 Reference 2050 + High DH expansion 34% + Biogas CHP (available potential) + wood pellet boiler
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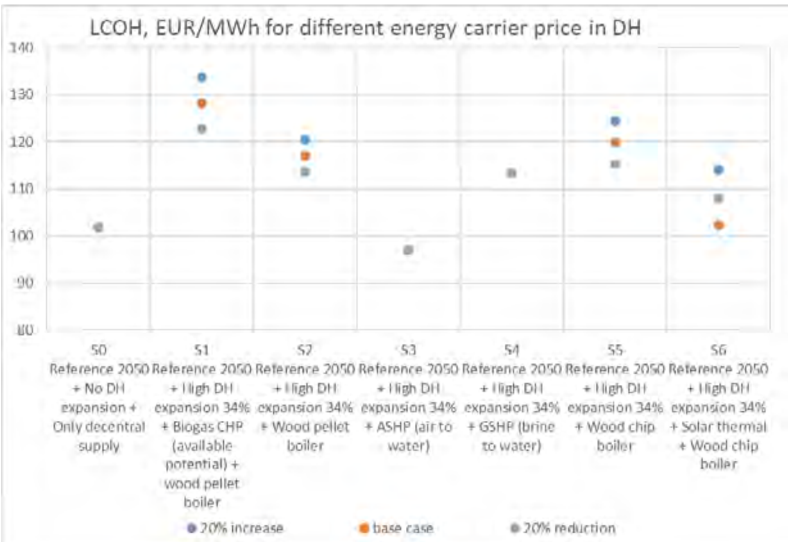
20% increase
base case
20% reduction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20% increase
base case
20% reduction

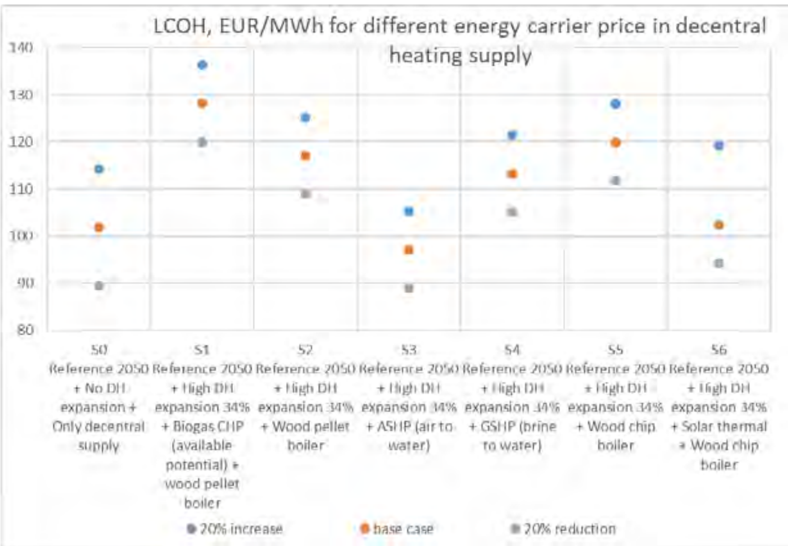


Figure 25 The variation of levelized cost of heat for the energy development scenarios in Dingle depending on carbon emission price, investment cost and cost of fuel.

Only one sensitivity scenario impacts the cost of the carbon emissions in which the investment cost of DH has been changed. This is the only parameter that can decide on the feasibility of developing a larger or smaller DH network, and as an effect, impact the overall CO_2-emissions from the system. This is because of the changing proportion of DH heat supply and individual heating technologies with a different carbon footprint. 20% reduction in the DH investment cost, led to the similar DH development ratio, at circa 35% as it was achieved in the base case scenario which also indirectly confirms the earlier conclusion, that further development of DH would not improve the carbon emission savings over the level achieved in the base case (irrespective of the DH construction would be cheaper, the target for DH development itself would be more ambitious or we would allow for more favourable investment conditions as depreciation time).

Since the more costly DH can contribute with up to 25% DH heat supply proportion, which entails higher CO_2-emissions, the base case once more was confirmed to be an optimal solution for DH penetration level at Dingle.

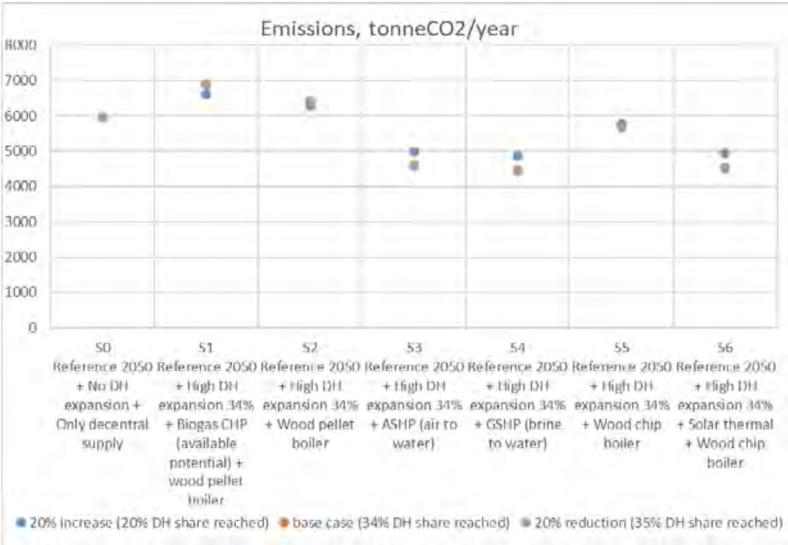
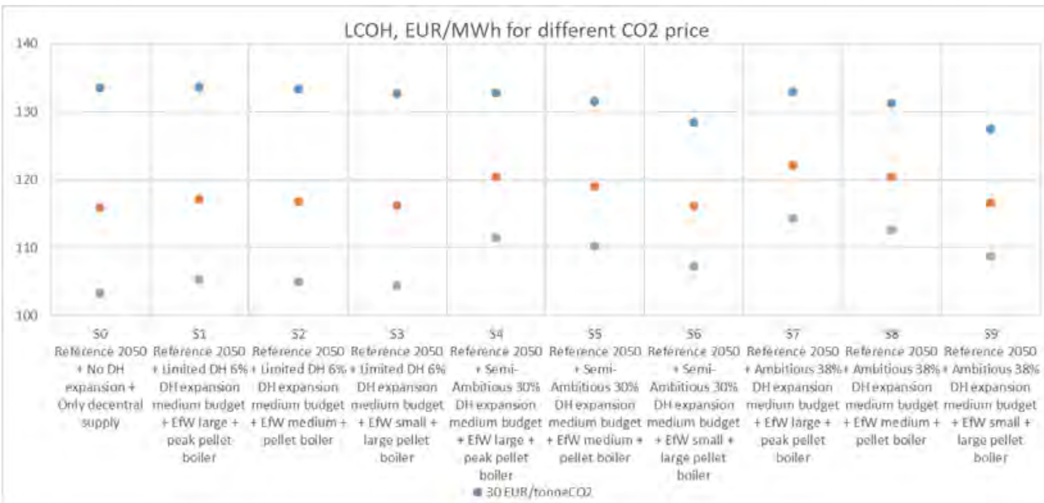
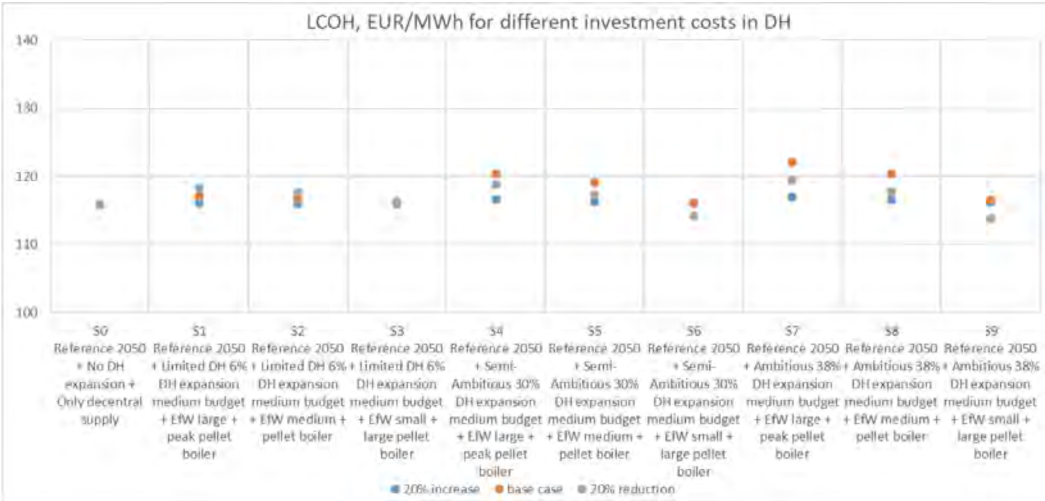


Figure 26 The variation of CO_2-emissions in Dingle for the different investment costs assumptions into the DH network.

Similarly for Killarney, the price of carbon emissions and the cost of energy carrier (fuel and electricity) consumed by the decentral heating technologies have the highest influence on the results of the analysis, this in particular on the total costs and the final cost of heat supply. The deviation of the LCOH in these cases reaches up to 15% in both direction from the heat cost in the base case scenario. The range of the achieved LCOH in all sensitivity scenarios can be seen in Figure 27. The correlation of total costs with the heat price (LCOH) is analogical, with the maximum deviation not higher than 15%.

None of the +20%/-20% fluctuations in the prices evaluated in the sensitivity analysis, concluded on a more cost-effective DH solution for Killarney compared with the individual heating supply from the base case.

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S7 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW large + peak pellet boiler
S8 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW medium + pellet boiler
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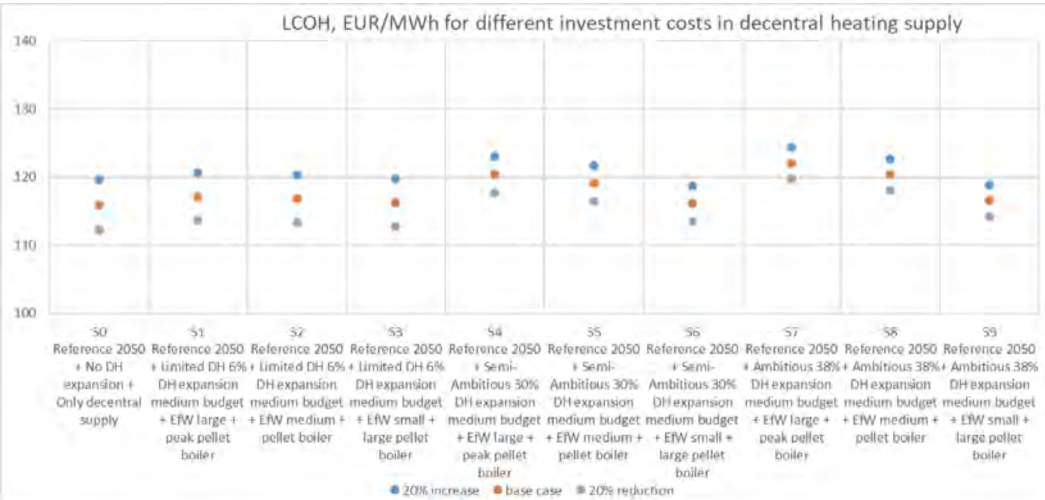
20% reduction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S8 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW medium + pellet boiler
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20% increase
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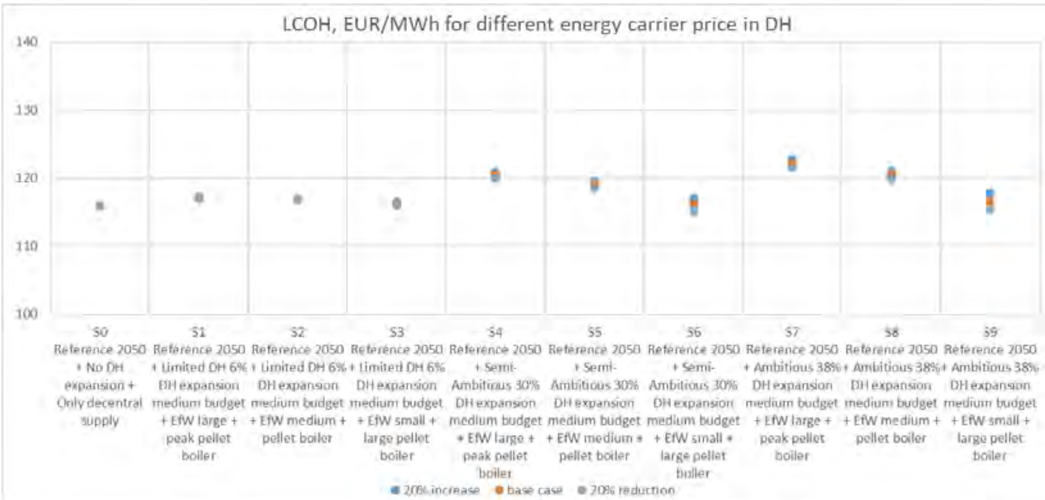
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S7 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW large + peak pellet boiler
S8 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW medium + pellet boiler
S9 Reference 2050 + Ambitious 38% DH expansion medium budget + EfW small + large pellet boiler
20% increase
base case
20% reduction

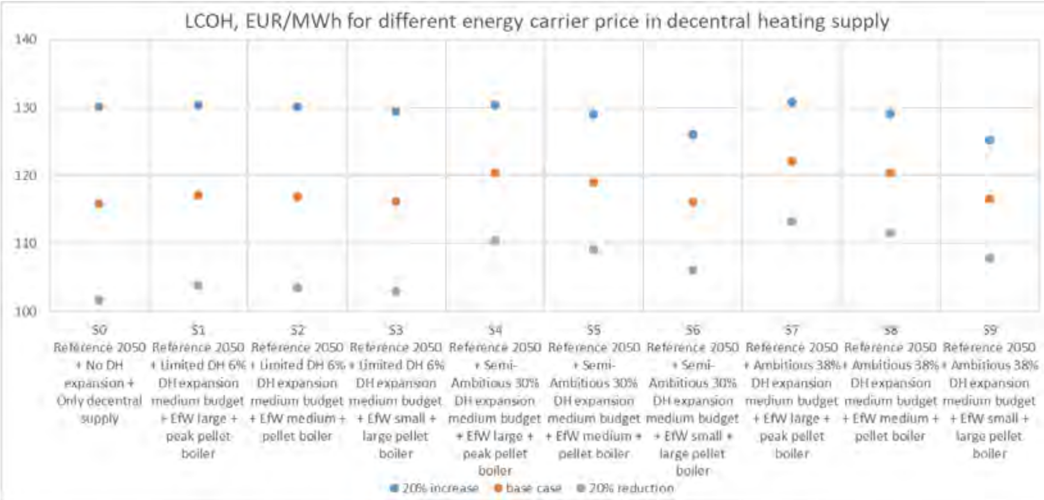
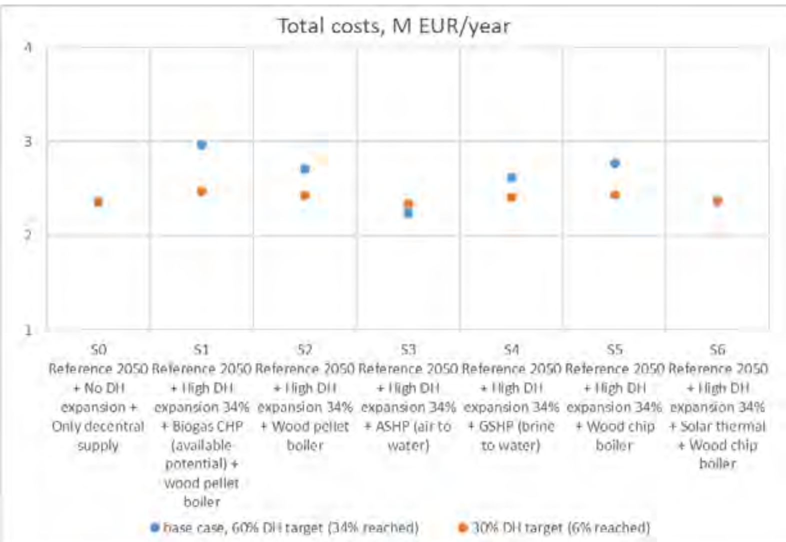


Figure 27 The variation of levelized cost of heat for the energy development scenarios in Killarney depending on carbon emission price, investment cost and cost of fuel.

5.5.2 Decentral Heating Supply Options

This sensitivity analysis only investigates the main set of scenarios, described in Sections 5.2 and 5.3 by changing the distribution of decentral heating alternatives. Since the analysis for Killarney already assessed the impact of the development of the DH network at different levels, this simulation was performed only for Dingle.

The lower penetration of DH-based heat supply in Dingle brings cost savings between 8,000 EUR and 0.5 million EUR/year, however, in the same time, this entails also lower carbon emission savings between 300 tonnes CO_2/year and 1,200 tonnes CO_2/year, which implies that the low-carbon network will also incur a cost of implementing the green transition.



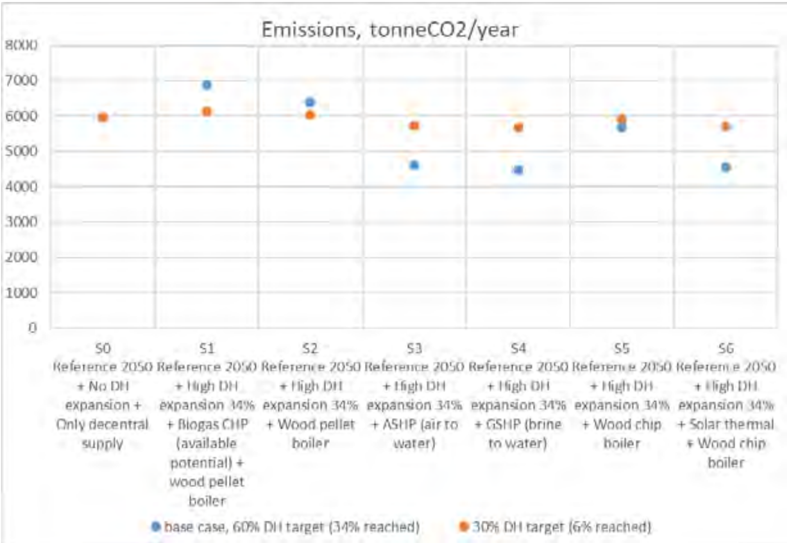


Figure 28 The variation of levelized cost of heat and CO_2-emissions for the energy development scenarios in Dingle in two variants of DH development level.

5.6 Conclusions

5.6.1 Dingle

The **Hotmaps** analysis of a possible district heating supply in Dingle shows that district heating is unlikely to result in significant cost reductions of the total costs for heat supply in the Dingle area. Only scenario 3 (high district heating penetration, supplied with ASHP) would result in a decrease of costs (45,000 €/year, 4 % reduction). The corresponding reductions in heating costs are approximately 14 €/MWh, i.e. in the range of 200-300 €/household/year. Scenario 6 (high district heating penetration, supplied with solar thermal and woodchips boiler) would result in practically the same costs. In all other scenarios, costs could increase by approximately 250-600,000 € for the entire urban area of Dingle, corresponding to an increase of approximately 11-25 %.

Notably, the possible increase in costs comes with a shift in price structures and cost components. Whilst in the decentral heat supply, the costs for energy carriers (fuels) comprise the largest price element, the largest share of the total costs in a district heating system is related to the fixed costs. Thus, heating costs will be more stable, if only a smaller (compared to individual heating) part of the price is subject to the price variations on energy markets etc. It must be noticed that this effect is most noticeable for those scenarios using the highly efficient heat technologies such as solar thermal and heat pumps.

At the same time, three scenarios (3, 4 and 6) result in significant reductions of CO_2-emissions. It is notable that scenarios three and six simultaneously result in a reduction or stable costs of heat supply, i.e. these emission reductions could be achieved whilst being cost neutral at worst. It is however also necessary to emphasise that the suggested district heating shares will be hard to reach with "only" cost neutrality or rather small cost reductions.

The significant cost improvement (at circa 10%) for Dingle over the base case energy supply relying entirely on individual heating, was found through the sensitivity analysis. It was noticed in case of a very high CO_2 price (150 EUR/tonne CO_2) in the scenario with the ASHP based DH supply. A similar heat cost reduction can be concluded if the energy carrier prices for individual heating increase by 20%.

For Dingle, it can be concluded that there certainly are ways to reach significant carbon reductions at cost neutrality or minor cost reductions. However, these are only obtained in small parts of the total heat demand.

5.6.2 Killarney

The **Hotmaps** analysis of a possible district heating supply in Kilarney shows that district heating of varying penetration rates may be obtained at near cost neutrality. In total, for the Killarney area, costs are estimated to increase by 30-70,000 €/year, corresponding to an increase of max. 5 % in total costs for heat supply. The specific heating costs for district heating lie approximately 0.7-16 €/MWh higher than those for individual heating. The smallest increase in heating costs is found in Scenarios 3, 6 and 9 (low/medium/high district heating shares, all supplied with a smaller waste-to-energy unit with wood pellet-backup).

Similarly to Dingle, it is notable that the possible increase in costs comes with a shift in price structures and cost components. Whilst in the decentral heat supply, the costs for energy carriers (fuels) comprise the largest price element, the largest share of the total costs in a district heating system is related to the fixed costs. Thus, heating costs will be more stable, if only a smaller (compared to individual heating) part of the price is subject to the price variations on energy markets etc. It must be noticed that this effect is most noticeable for those scenarios using the highly efficient heat technologies such as solar thermal and heat pumps.

All scenarios result in reductions of CO_2-emissions. It is, however, necessary to stress that the scenarios with the highest CO_2 abatement are also the most expensive, increasing the total cost of the investment and the price of heat supply. In other words, the economic incentive is not for those scenarios of least CO_2-emissions.

For Killarney, it can be concluded that significant reductions of heat-related CO_2-emissions (up to 5,000 tons/year) can be reached by establishing a district heating grid, primarily supplied by a waste-to-energy plant. These reductions would result in a minor increase in heating costs for the final user and are hence unlikely to be feasible to carry out, without economic incentives, e.g. funding.

5.6.3 County Kerry

Given the economic potential for district heating is only addressing a smaller fraction of the total final energy demand, the key actions towards the transformation of the heating sector in County Kerry should be concentrated on conventional, carbon-intensive individual heating technologies. These should be replaced with energy-efficient and sustainable alternatives such as heat pumps. This approach could help in transforming the heating sector in County Kerry, as the potential of district heating to do so is limited.

6 Drivers and barriers

6.1 Drivers

Supply-Side Drivers	**Demand-Side Drivers**
Financial – economic	*Financial – economic*
• Renewable Heat Incentive • Local sustainable jobs	• Increase local employment • Reduced cost of heating • Better cost security for heat
Institutional	*Institutional*
• Greener Ireland • Clear plan as to how targets can be achieved	
Regulative	*Regulative*
• More efficient (primary energy factor) than current heating systems • Current building regulations require a minimum level of renewable in new builds • NZEB requirements coming in 2020	• Current building regulations require a minimum level of renewable in new builds • NZEB requirements coming in 2020
Normative	*Normative*
Technical	*Technical*
• Greater use of renewables • Greater integration of energy storage	• Locally sources renewable energy

6.2 Barriers

Supply-Side Barriers	**Demand-Side Barriers**
Financial – economic	*Financial – economic*
• Development cost • Initial cost • Long term financial structure required • Operating cost	• Initial cost • Operating cost • Relative cheap fossil fuels (oil & gas)
Institutional	*Institutional*

• Lack of any national or local organisation with a mandate and authority to develop heat planning • Lack of experience in managing large-scale renewable heating projects	
Regulative	*Regulative*
• No regulation to directly support heat planning • Lack of any heat plan or strategy	
Normative	*Normative*
• Lack of awareness of the benefit of heat planning among decision-makers • Low housing density in Irish towns compared to continental Europe	• Little or no understanding of what DH is and the benefits of DH for the individual heat consumers • Uncertainties • Low housing density in Irish towns compared to continental Europe
Technical	*Technical*
• Lack of technical knowledge and experience in large scale heat project development in Ireland (e.g. DH is a new technology in Ireland) • Lack of technical knowledge and experience in local energy and heat planning among national and local planning authorities • Kerry is a rural county which may raise questions on its suitability for large scale renewable heating development	• Lack of knowledge of the options available in terms of renewable heat • Lack of trained workforce • Lack of maintenance support

6.3 Discussion of Drivers and Barriers

6.3.1 Drivers

Ireland has one of the highest import dependencies for fuel in Europe and leaves Ireland at great risk if there was a crisis in the gas or oil markets. This issue is of particular relevance to Kerry as much of the county is not on the gas grid, which means that heating is currently supplied mostly by deliveries of oil or Liquified Petroleum Gas (LPG). Creating a DH network that can utilise more local resources, such as waste heat, CHP heat and renewable heat including biomass means there is increased security of supply and less money is used to pay for imported fossil fuels. The following drivers are related to developing medium-to-large scale systems and the DH market as a whole in Ireland.

Technical

Ireland has a large percentage of renewable electricity supplied by wind power, which is a fluctuating source and needs to be balanced or stored at certain times by other units connected to the grid. DH grids allow greater integration of renewables on the electricity grid by helping to balance energy input from renewables, and therefore reduce the need for curtailment and negative pricing. DH can achieve this by using large scale heat pumps or electric boilers when there is a surplus of RE on the grid and utilising thermal storage to store this energy in the form of heat for later use on the DH network. The DH system can also turn CHP units on/off when balancing of renewables is required and again makes use of thermal storage.

Economic

With the higher efficiencies related to sizing and maintaining one large energy plant to cover multiple building heat demands as opposed to multiple individual boilers, coupled with cheaper sources of heat production, and negotiating cheap prices for industrial waste heat (if available), the overall customer price for heat can be reduced.

Regulatory

International Policy

EU Energy Performance of Buildings Directive (EPBD, 2002) is European legislation which requires all EU countries to improve their Building Regulations and introduce energy certification schemes. The 2010 recast EPBD requires countries to move towards new and retrofitted 'nearly zero energy buildings' standards by 2020 (2018 for public buildings). The directive was updated in 2016 to cover additional efficiency and technology in buildings.

EU 2030 Energy Strategy (2014) sets out a framework for the development of climate and energy policies across EU member states. This framework helps the EU address issues such as the EU's dependence on energy imports, the need to replace and upgrade energy infrastructure and to reach an agreement of a greenhouse gas reduction target for 2030.

National Policy

The Climate Action Plan 2019 states some of the following actions regarding DH:

- Implementing a roadmap for delivering DH potential
- An additional increase of 120 GWh (*ed. assumed to be gross production*) growing linearly from 2023 to 2028
- Develop a national policy framework (including; regulation, planning, financing and research)
- Ensuring the potential of DH is considered in all new developments and in particular, strategic development zones
- Identifying a set of early mover projects beyond the initial two schemes in Dublin

There is currently no heat strategy in Ireland. However, the Project Ireland 2040 National Planning framework does state "District heating networks will be developed, where technically feasible and cost-effective, to assist in meeting renewable heat targets and reduce Ireland's GHG emissions". A Support Scheme for Renewable Heat (SSRH) has been introduced which will help support renewable heat production for DH schemes with a capital contribution for heat pumps and a support tariff for biomass and biogas heat production.

Social

Fossil fuel heating systems based on coal, oil, gas and peat produce GHG's and other particle emissions, vented through chimneys and flues, and released into the local environment. These emissions can affect local air quality and health, depending on the technology used. Replacing these sources of heat production with 'clean' sources reduces the direct health impacts of poor local air quality, and importantly, lessens the impact on global temperatures. Reducing CO_2-emissions will also contribute to mandatory emissions targets and lessen the impact of financial penalties associated with not meeting these targets.

There will be increased local employment during the construction of DH networks, energy centres and customer interfaces, as well as long term local employment in the operation and maintenance of all system components.

The lower costs of heat that are possible with DH systems which can be supplied to residential areas that have low building energy efficiencies and high levels of unemployment can reduce the risk of energy poverty. Fossil fuel is usually burned onsite within the consumers' own boiler unit, which can create a risk of carbon monoxide poisoning in all buildings, particularly in homes where the boiler is located inside the house. DH supply negates the need to burn or store any fossil fuels onsite, thus reducing health and safety risks. The heat exchanger has very low maintenance costs, as there are very few mechanical moving parts. With a DH connection, customers do not need to time heating to fill hot water tanks or to turn on electric immersions, as hot water is available on demand with no run-up times required. The customer does not require any fuel storage tanks or fuel deliveries.

6.3.2 Barriers

District Heating in Ireland faces organisational, technical, regulatory and economic barriers to growth. The barriers differ depending on the type of DH system; communal and localised systems face fewer barriers than when implementing medium to large scale DH projects. This is due to the added complexities of such systems, such as large transmission pipes requiring way leaves and planning permissions, multiple and varied customer connection agreements, and long-term planning for extensions. The following barriers are related to developing medium-to-large scale systems and the DH market as a whole in Ireland.

Organisational

There is a general lack of knowledge and awareness of DH technologies and their benefits in Ireland, and many myths surrounding the use of DH still exist and are prohibitive to its consideration. Many local authorities do not have the in-house skills and do not have any national framework or guidance to develop DH. DH is also often not on the curriculum of energy-related college course in Ireland, and therefore there is a lack of local skills and knowledge of DH.

Technical

There are far fewer technical barriers to DH because the technologies used are themselves not new or innovative and are all well-established throughout Europe. The technical barriers in Ireland are on the demand side rather than the heat supply. For DH to be economically feasible, there needs to be a sufficient heat demand within a given area. This is because the denser the heat demand, the shorter the pipelines required, which means lower investment costs, and lower operational costs through lower losses and lower pumping requirements. DH is, therefore, more suited to dense urban areas, which means DH will be most suited to large cities and towns in Ireland.

Certain building types, known as anchor loads, such as hospitals, nursing homes and hotels are ideal for optimal DH operation as they have long hours of space heating demand and large hot water demands. Additionally, if the anchor load is a public sector tenant, it can offer security in terms of connection and payment reliability. DH is also most successful if there is a cheap waste heat source which can be utilised, such as a large electricity producer operating as CHP generator, or a large industrial facility with a waste heat source.

Regulatory

Although, the Climate Action Plan 2019 contains actions to implement a roadmap for delivering DH potential and develop a national policy framework there are currently no guidelines, regulations, policies, frameworks or standards for DH in Ireland. This creates high risk and uncertainty when planning medium-to-large scale systems.

To assist in the viability of potential DH systems DH pipes should be considered and treated the same as any other underground pipe or cable and be exempt from planning permission in most circumstances under the Planning and Development Act.

Economic

Any investments made in DH infrastructure by local authorities are taken account of on the government balance sheet and require approval by the Department of Finance. It can therefore be difficult to secure public funding to cover the large capital costs of the network. Privately owned networks do not have the same considerations but do require a high return on capital. Public-private partnerships, long-term bonds or other financial options must be considered to address the particular funding requirements of DH.

Installing DH transmission pipelines, like any large infrastructure project, will disrupt traffic and business for a period of time. However, with effective planning, the installation of sections of DH pipelines can be scheduled to overlap with other planned infrastructure projects such as roadworks and installations of other underground services to lessen the disruption caused and also decrease overall installation costs.

7 Local Heating Strategy Roadmap

This Heating Strategy Document will be considered in the making of the next County Development Plan which will cover the period from 2022 – 2028. Kerry County Council as the Planning Authority for the county has a duty to make a Development Plan for its functional area and to review it every six years. The County Development Plan sets out the overall strategy of the proper planning and sustainable development of the County over a six-year period, within the context of the national, regional framework of strategies and guidelines. Kerry County Council is currently in the process of preparing the new Development Plan 2022 -2028 which sets out the policy framework and a Core Strategy within which development throughout the county is promoted and regulated over the six-year period of the plan. Therefore, it is an opportune time for this "**Hotmaps** – County Kerry Heating Strategy Document" to be completed as it will allow sufficient time for the outcomes of the strategy to influence the new County Development Plan 2022 - 2028.

Local Authorities are widely regarded as being a key stakeholder and enabler in District Heating development. To overcome the barriers to District Heating outlined in Section 6.3.2, it is imperative that Local Authorities, such as Kerry County Council play a key role in driving the development of District Heating. Local Authorities can also play a key role in ensuring the viability of potential District Heating Schemes as Local Authority buildings can be used as anchor tenants which will decrease the risks involved in ensuring a viable heat demand is connected to the system. The Local Authority would also be a reliable customer in terms of payment to any potential private developer of a District Heating Scheme.

8 References

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TABULA, WebTool: http://webtool.building-typology.eu/.

9 Annexes

9.1 Appendix 1

Run			A K2050 *Biogas CHP (available potential) + wood pellet boiler*	B K2050 *Wood pellet boiler*	C K2050 *ASHP (air to water)*	D MK2050 *GSHP (brine to water)*	E MK2050 *Wood chip boiler*	F MK2050 *Solar thermal + Wood chip boiler*
CM | 3.2 DH supply dispatch								
INPUT DATA		MW peak	2.99	2.99	2.99	2.99	2.99	2.99
		Installed	2.99	2.99	2.99	2.99	2.99	5.98
			0	0	0	0	0	3
	Parameter	Unit	**Run 1.7 A K2050** Biogas CHP (available potential) + wood pellet boiler	**Run 1.7 B K2050** Wood pellet boiler	**Run 1.7 C K2050** ASHP (air to water)	**Run 1.7 D MK2050** GSHP (brine to water)	**Run 1.7 E MK2050** Wood chip boiler	**Run 1.7 F MK2050** Solar thermal + Wood chip boiler
INPUTS	Thermal Output Capacity -Back Pressure CHP	MW	3	0	0	0	0	0
	Thermal Output Capacity -Waste Incineration Plant	MW	0	0	0	0	0	0
	Thermal Output Capacity -Heat Boiler	MW	0	3	0	0	3	3
	Thermal Output Capacity -Heat Pump	MW	0	0	2.99	2.99	0	0
	Thermal Output Capacity -Solar Thermal	MW	0	0	0	0	0	2.99
	CO2 Price	EUR/tCO2	80	80	80	80	80	80
	interest rate	1	0.03	0.03	0.03	0.03	0.03	0.03
	invest mode		dispatch	dispatch	dispatch	dispatch	dispatch	dispatch

Figure 29 Energy production unit capacity in the DH Supply dispatch CM for Dingle.

Run			A K2050 *EfW large + peak pellet boiler*	B K2050 *EfW medium + pellet boiler*	C K2050 *EfW small + large pellet boiler*
CM | 3.2 DH supply dispatch					
INPUT DATA			15.9	15.9	15.9
			16	17	17
			0	1	1
	Parameter	Unit	**Run 1.7 A K2050** EfW large + peak pellet boiler	**Run 1.7 B K2050** EfW medium + pellet boiler	**Run 1.7 C K2050** EfW small + large pellet boiler
INPUTS	Thermal Output Capacity -Back Pressure CHP	MW	0	0	0
	Thermal Output Capacity -Waste Incineration Plant	MW	14	12	5
	Thermal Output Capacity -Heat Boiler	MW	2	5	12
	Thermal Output Capacity -Heat Pump	MW	0	0	0
	Thermal Output Capacity -Solar Thermal	MW	0	0	0
	CO2 Price	EUR/tCO2	80	80	80
	interest rate	1	0.03	0.03	0.03
	invest mode		dispatch	dispatch	dispatch

Figure 30 Energy production unit capacity in the DH Supply dispatch CM for Killarney.

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