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Dún Laoghaire–Rathdown Spatial Energy Demand Analysis

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Report prepared by Codema on behalf of Dún Laoghaire-Rathdown County Council

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Glossary of Terms

SEDA – Spatial Energy Demand Analysis
SEAP – Sustainable Energy Action Plan
BER – Building Energy Rating
CSO – Central Statistics Office
SEAP – Sustainable Energy Action Plan
DLR – Dún Laoghaire-Rathdown
DLRCC – Dún Laoghaire-Rathdown County Council
DH – District Heating
SEAI – Sustainable Energy Authority of Ireland
kWh – Kilowatt-hour
MWh – Megawatt-hour (1kWh $*10^3$)
GWh – Gigawatt-hour (1kWh $*10^6$)
TWh – Terawatt-hour (1kWh $*10^9$)
TJ – Terajoule
CHP – Combined Heat and Power
km – Kilometre
PV – Photovoltaic
RE – Renewable Energy
HH – Household

Executive Summary

This is the first Spatial Energy Demand Analysis (SEDA) produced by Codema for Dún Laoghaire-Rathdown County Council (DLRCC). The analysis was carried out by Codema as part of a Sustainable Energy Authority Ireland (SEAI) funded Sustainable Energy Research, Development and Demonstration (RD&D) 2016 project to further develop the SEDA methodology, which has already been applied to the South Dublin and Dublin City areas. A SEDA involves analysing the energy demand within a given area, and creates a spatial visualisation of this information, resulting in evidence-based energy maps which can be used as a tool by town and city planners to create effective policies and actions to influence future energy use. The SEDA seeks to bridge the current gap between spatial and energy planning methodologies at a local level in Ireland, and builds on the experience of other leading European countries. The mapping is particularly important for locating areas of high heat demand density, which is a crucial element in planning for District Heating (DH) schemes.

The sustainable use of energy and natural resources and the negative impacts of CO_2 on our environment have led to energy and climate change becoming a major topic in both the public and private sector discourse. DLRCC has clearly identified the importance of climate change adaptation and mitigation in the 'Climate Change, Energy Efficiency and Flooding' chapter of the Dún Laoghaire-Rathdown County Development Plan 2016-2022. The energy information gathered through this SEDA will inform the energy and CO_2 emissions baseline calculations for the planned Dún Laoghaire-Rathdown (DLR) Sustainable Energy and Climate Action Plan (SECAP), as outlined in the County Development Plan policy CC4. The DLR SEDA also creates increased awareness of energy demand and local resources among other stakeholders and allows for effective development of future scenarios for sustainable energy.

The results of the DLR SEDA show exactly where and what type of energy is being used, and the costs of this energy consumption throughout the DLR region, in each of the residential, commercial and local authority sectors. Over 73,000 dwellings, 5,000 commercial properties and over 150 local authority building-based energy accounts have been analysed in terms of annual energy use and the results have been mapped in this report.

The residential sector analysis allowed the identification of the areas most at risk of energy poverty, based on the three most influential factors affecting energy poverty; the energy efficiency of the home, affordability (in terms of unemployment), and the cost of energy per household. These areas have been highlighted (p.26), and can be prioritised in terms of strategies to combat energy poverty within the county. The results of mapping the average Building Energy Rating (BER) in each of the 761 small areas in DLR has shown that while better building regulations for new dwellings are effectively reducing the energy demand in new developments, the rest of the county's dwellings are becoming older and less efficient, particularly in the areas of Dún Laoghaire and Monkstown. Nearly a third of the dwellings in DLR have BERs of E or lower, and the vast majority of these dwellings were built pre 1970.

While DLR possesses a significant amount of commercial activity, it is relatively small scale, (the majority being retail and office space), and accounts for just 25% of the total building energy demand for the region. The residential sector accounts for roughly 74%, with municipal buildings representing less than 1%. Heat demand represents 80% of total building energy demand in DLR. Thus, the energy used for heating in the residential sector should be of first priority in developing sustainability strategies.

One solution to this issue is to utilise sustainably fuelled District Heating (DH) systems. In terms of DH analysis, there are a number of areas, including Dún Laoghaire, Blackrock, Stillorgan and Dundrum, which would be highly suitable for DH systems. The distance between these areas means that future expansion and inter-connection is also possible, as has been the case in other European cities such as Copenhagen. The SEDA has also identified locations of potential anchor loads and waste heat resources which can be major contributors to a successful DH network.

Overall, DLR spends over €238 million a year on energy within buildings, and a large percentage of this money leaves the Irish economy to pay for fossil fuel imports. Therefore, increasing indigenous energy sources is crucial, and this report has identified solar energy resources as one of the most accessible renewable energy resources in the urban landscape of DLR.

Introduction

The following report has been produced by Codema on behalf of DLRCC and outlines the process and results of the DLR SEDA. This analysis has been conducted by Codema as part of an energy mapping project funded under the SEAI's RD&D 2016 call. The project aims to advance spatial energy demand analysis methods in Ireland so that they are more applicable to the semi-rural and rural areas found in DLR and Fingal county areas.

This SEDA aims to provide the information required for the local authority to increase the uptake of renewable energy through planning, policy and raising awareness. Up to now, the local authority has lacked the evidence-based tools required for planning sustainable energy solutions. This SEDA aims to bridge the gap between energy planning and traditional urban planning within the local authority, and enables planners to build meaningful energy policy and effectively shape the energy-future of the county.

The analysis focuses on the current energy demand and the fuels used to provide such energy within the DLR area, and places this data within a spatial context. Creating these maps helps to identify opportunities, synergies and constraints in different county districts. This detailed mapping process provides a visualisation of many aspects of energy use and its effects, presented in a 500*500m grid format, with some residential aspects presented per small area[1]. The areas examined include:

- Building Energy Ratings (BER)
- Energy use per dwelling
- Energy spends per dwelling
- Fuels used for heating dwellings
- Area of high commercial energy use
- Areas at risk of energy poverty
- Areas of high fossil fuel usage
- Areas with high electrical usage
- Heat demand density

These maps provide the local authority with the information needed to target areas most in need of, and most suitable for, Renewable Energy (RE) solutions. In particular, the areas with high heat demand densities which are deemed most suitable for large scale DH schemes are identified. DH schemes are a proven way to integrate high levels of RE into dense urban areas such as those found in many parts of DLR.

This SEDA is one of only four to be developed in Ireland and is seen as the next coherent step to prepare DLRCC for upcoming climate and energy action plans. The SEDA enhances energy action plans so that they can be more effectively integrated with other action plans and into the planning process. This will bring energy planning in DLR more in line with other European cities that are leading the way in effective local level sustainable energy planning.

Context

Climate Change Challenge

"Climate change is not an abstract phenomenon featuring in arcane science journals and measured only in laboratories. It is present everywhere and perhaps most harshly and adversely in environments where people are least equipped to meet its force and ill effects – and least responsible for its causes."

- Michael D Higgins, President of Ireland

Climate change is widely recognised as the greatest environmental challenge of our time and the evidence of such change is already being felt here in Ireland in terms of rising sea levels, extreme weather events and changes in ecosystems. A recent publication co-authored by the UK's Royal Society and the US National Academy of Sciences, '*Climate Change: Evidence & Causes*', states that the speed of global warming is now 10 times faster than it was at the end of the last ice age, with the last 30 years being the warmest in 800 years (The Royal Society & The US National Academy of Sciences, 2014). The report also concludes that the latest changes in our climate are "almost certainly due to emissions of greenhouse gases caused by human activities" (The Royal Society & The US National Academy of Sciences, 2014, p. B9). This publication is just one of a multitude of evidence and research-based papers which show irrefutable evidence that Greenhouse Gases (GHGs) are responsible for climate change, and it is imperative to act now in order to curtail the irreversible damage caused by these emissions. Fossil fuel use is responsible for over half of all GHG emissions globally, and the majority of these emissions come from energy supply, transport, residential and commercial buildings and industry (IPCC, 2007).

[1] A 'Small Area' is the smallest geographical breakdown used in Ireland for statistical purposes.

The Irish Government has already committed to reducing emissions at a national level, and it is imperative to plan and commit to energy saving and CO_2 reduction at a local level in order to help meet national level targets from a bottom-up approach. It is particularly important for urban regions to look to integrate renewable electricity sources as close to the demand as possible, which leads to reduced losses during transmission. This also has the significant effect of decreasing the burden on rural areas to produce renewable electricity, particularly in the midlands and the west, where large wind farms can in some cases have negative impacts on these communities. There are many significant additional benefits to reducing CO_2 levels and implementing more renewable energy in DLR, including reduced health effects, decreased fossil fuel dependence, higher security of supply, lower energy costs, increased energy price stability, increased economic competitiveness and a sustainable economy.

Local Level Energy Planning

Conventionally, energy planning is implemented at a national level and not effectively addressed within local or regional level planning structures in Ireland. Experience from other countries has shown that national policies on energy which are specifically designed to address energy use from a national level perspective can make it hard for local authorities to fully address energy consumption due to the structure of the national policy framework, and the lack of autonomy and flexibility conferred upon them in the energy sector (Sperling, Hvelplund, & Mathiesen, 2011) (Chittum & Ostergaard, 2014). This leads to local authorities not having the knowledge or experience to make strategic decisions on how energy is or will be provided in their locality.

In contrast, local level energy planning is routine in many other European countries, in particular Denmark, Sweden and recently re-municipalised areas in Germany. Laws were first introduced in Denmark in 1979 requiring municipalities to carry out local level energy plans, and this regulatory framework has been credited with creating the base for the sustainable growth Denmark has seen in the years since. These planning laws required municipalities to conduct analyses of their local heating requirements and the available heat sources, and municipalities were also made responsible for assessing future heating needs and supplies and planning around these. In the 1980s, the government introduced laws to ensure that all energy projects had to be assessed by taking account of the full socio-economic costs and benefits, and based on this, municipalities should only pursue projects which show a high level of socio-economic benefits (Chittum & Ostergaard, 2014).

These laws resulted in high levels of locally produced heat and electricity in the form of Combined Heat and Power (CHP) and DH systems with integrated renewable energy sources. Today, around two thirds of Danish electricity is co-generated with heat, and heat is supplied through DH systems to 60% of Danish households. Studies have shown that this increased use of CHP and DH has reduced overall nationwide emissions by 20%, and reduced CO_2 emissions in the heating sector by 60%. There is currently 386,234m^2 of solar heating being used in municipal DH projects, along with other sustainable sources such as biomass and waste heat. The use of local energy planning in Denmark has reduced energy costs to consumers, enabled higher integration of renewable energy, reduced energy demand and reduced the overall impact on the environment.

The Need for Integrated Energy and Spatial Planning

The increasing need for society to change to more sustainable forms of energy supply to combat climate change and meet growing demands means that space is now a fundamental asset for energy production. This is due to the fact that renewable energy is an area-dependent resource, e.g. space and suitability of land for bio-fuel crops, for wind farms, for solar energy, or for hydro-power (Stoeglehner, Niemetz, & Kettl, 2011). Energy production now enters the competition for space with many other products and services that are reliant on space, such as food production and property development.

Also, the feasibility of DH and CHP systems is dependent on many spatial and urban planning related factors such as heat demand density and zoning of building uses, which reinforces the inseparable nature of spatial planning and energy planning.

In order for planners to evaluate the feasibility of integrating a range of renewable energy resources, they will need to develop a SEDA type tool in order to 'read the energy landscape' (Pasqualetti, 2013). A SEDA allows planners to locate where the large energy demands are, what type of energy is required in these locations, i.e. heat, electricity, gas, etc., the areas susceptible to energy poverty due to high energy costs, and areas of high fossil fuel use.

Economic development in Dublin has been, so far, driven mainly by resources that have no immediate geographic link to the area exposed to planning. The fossil fuels and electricity that will be used during the lifetime of a development have, in most cases, no influence on its location as it can be simply connected by pipe or cable to some far-off location. In this way, spatial planning is not currently linked to energy resource management. The planning system now faces the new challenge of taking account of, and creating balance between designing cities to reduce energy demand, retaining sufficient space for sustainable energy production, and providing energy from local resources, while also evaluating social and environmental considerations.

Spatial Energy Demand Analysis as a tool for Sustainable Spatial Planning

Energy mapping resources are used by energy planners in local authorities throughout Europe and are often referred to as the first step in the energy planning process. It is the foundation for planning for current and future predicted energy consumption at a local level. It allows the planner to define 'energy character areas', based on the estimated energy demand and supply characteristics, and the RE potential of that area.

There are many examples of best-practice energy mapping from European towns and cities, such as the London Energy Map[2], the Amsterdam Energy Atlas[3], and the Scotland Heat Map[4]. An example of the London Energy Map is shown in Figure 1.

The Swedish Energy Agency's guide to sustainable spatial planning outlines how *"integrating energy issues for heating and transport in comprehensive planning"* is one of the four 'leaps' to effective sustainable energy planning, and documenting the current energy effects of heating, cooling, electricity and transport allows the development of future scenarios for energy and transport (Ranhagen, 2011).

These maps are then used by the municipality's energy planners to decide which areas are most suitable for DH or individual heating solutions such as heat pumps or solar thermal, and integrate the findings into future scenario development. This DLR SEDA uses similar methodologies for mapping energy demands to those that are typically used in Swedish and Danish energy planning.

Once this initial step is complete, deeper techno-economic analysis and energy system modelling of an identified energy character area allows the planner to judge if the area is technically and economically feasible to implement the recommended sustainable energy solutions.

Figure 1: Heat Demand Map of London City

[2]https://www.london.gov.uk/what-we-do/environment/energy/scenarios-2050-london-energy-plan
[3] http://maps.amsterdam.nl/
[4] http://heatmap.scotland.gov.uk/

Relating Policy

EU Policy

The European Union (EU) put in place a framework for energy for all member states called the *'2020 Climate and Energy Package'*. This set binding legislation for all member states so that the EU as a whole will achieve 20% GHG emission reductions, 20% energy produced by renewable resources, and 20% increase in energy efficiency by 2020.

From this overarching EU climate and energy package, there are directives which set specific targets for renewable energy for each member state and outline the measures to be put in place for energy efficiency.

The EU Energy Efficiency Directive 2012/27/EU, and Renewable Energy Directive 2009/28/EC have resulted in national level energy action plans in each area respectively. In terms of the Renewable Energy Directive, Ireland has been set a target of 16% of all non-Emission Trading Scheme (ETS) energy consumption to come from Renewable Energy Sources (RES) by 2020, the sectorial split being 40% electricity, 12% heat and 10% transport energy. Latest figures (2013 energy figures) show Ireland's renewable energy in electricity is at 20.9% of gross electricity consumption, renewable heat is at 5.7%, and renewables in transport at 4.9%, therefore Ireland is approximately half-way toward 2020 targets with four years left to improve. This SEDA aims to increase the use of renewables at a local level in order to contribute towards overall national level targets.

Although there are no binding targets for energy efficiency, there are binding obligations on each member state. Of particular relevance to this regional level SEDA, Article 14 of the Energy Efficiency Directive on the 'Promotion of efficiency in heating and cooling' states:

"*Member States shall adopt policies which encourage the due taking into account at local and regional levels of the potential of using efficient heating and cooling systems, in particular those using high-efficiency cogeneration. Account shall be taken of the potential for developing local and regional heat markets.*"

The SEDA will help to identify the most appropriate sustainable energy solutions for heating the current and future building stock in DLR.

In October 2014, due to there being no clear framework post-2020 targets, the EU put in place a new '*2030 Framework for Climate and Energy Policies'* which has set a 40% GHG reduction on 1990 GHG levels, and an EU-wide target of 27% for renewable energy and energy savings by 2030. Under this framework, Ireland has a binding national target of 20.4%[5] reduction compared to 2005 emission levels. The new GHG targets are aimed at the non-Emissions Trading Scheme (ETS) sectors, which cover transport, buildings, agriculture, waste, land-use and forestry.

Of these sectors, transport and buildings are the largest contributors of emissions from fossil fuel consumption, and heating is the largest energy use in buildings. For example, 75% of the average household's final energy consumption is used for space and water heating [2]. There now needs to be a stronger focus on energy efficiency and renewable fuel sources in the heating sector in order to reduce energy related GHG emissions and contribute to meeting Ireland's binding EU 2020 and 2030 targets.

This SEDA will also allow DLRCC to stay on top of energy issues and help to future-proof the region for new energy legislation past 2020.

National and Regional Level Policy

The National Renewable Energy Action Plan (NREAP) and National Energy Efficiency Action Plan (NEEAP) are a direct result of the overarching EU Directives previously discussed. These outline how Ireland intends to implement the energy efficiency and renewable energy targets set by the European Commission. This SEDA aims to help fulfil the goals of the NREAP and NEEAP by developing renewable energy and energy efficiency at a local and regional level within DLR, and developing strategic energy action plans specifically tailored to the energy characteristics of the area.

The Department of Communications, Energy and Natural Resources[6] outlines the pathway to 2030 in the report "*Ireland's Transition to a Low Carbon Energy Future 2015-2030*" and addresses priorities areas relating to energy policy:

[5] The GHG target is 30%, but there have been allowances for land-use and ETS flexibility, which will reduce the overall target to approximately 20.4%.

[6] Now known as the Department of Communications, Climate Action and Environment

- Empowering Energy Citizens
- Delivering Sustainable Energy
- Energy Security
- Regulation, Markets and Infrastructure
- Energy Costs
- Innovation and Enterprise

The SEDA will help to address the priorities surrounding planning essential energy infrastructure and creating a more sustainable energy system within DLR. The SEDA allows DLRCC to take some control and have some influence over the energy used within the region, which can now be used as a bottom-up approach to meeting the new energy policy priorities.

The Regional Planning Guidelines for the Greater Dublin Area (GDA) 2010-2022 provides planning guidance on economic, infrastructure and settlement policies for the GDA which includes DLR. These guidelines specifically support the implementation of local level energy action plans, and also suggest they "*… should be presented in a spatially geographic manner where possible in order to provide an extended evidence base in the decision making process*".

This SEDA will fulfil these suggestions under the Regional Planning Guidelines, and DLRCC will be among the first local authorities to do so, which will pave the way for other local authorities to follow suit.

Analysis of District Heating Potential

DH is a key technology for urban regions to decarbonise their heat supply. '*A Guide to District Heating in Ireland'* (Gartland & Bruton, 2016) is a good source of information on the basics of DH and how DH can be developed in Ireland.

The heat consumption will be shown in terms of 'heat density' and it is important to compare all on an equal parameter, such as terajoules (TJ) per km^2. Mapping heat density is important as it is a key metric for defining the potential for large scale DH.

It is important to analyse DH potential as heating and cooling are fundamentally local and regional matters, and are often not dealt with effectively at a national level. Danish municipalities carry out heat planning studies and judge an area to be suitable for DH based on the measurement of heat density, usually given in TJ/km^2, with any areas measuring above $150TJ/km^2$ deemed technically and economically suitable for developing conventional DH systems. The density is specifically important for DH economic viability as it becomes cheaper to implement when buildings are closer together due to shorter pipelines requiring less investment costs, and therefore the system becomes more cost-effective than individual solutions (Connolly, et al., 2014). Also, shorter pipelines result in fewer losses and less pumping requirements, which can reduce running costs significantly.

There are currently no large scale DH systems in Ireland, and little or no financial or policy supports for DH systems. Due to this lack of experience, and difference in support mechanisms between Denmark and Ireland, it is better to look to first-phase development of large scale DH in areas with the highest heat demand densities available. The Danish 150 TJ/km^2 threshold can then be used once a large scale DH scheme has been initiated and looking to expand. Increasing the minimum density threshold for viability will also allow for potential errors in energy estimations made in this study.

With a DH system, there is opportunity to use heat from one or many sources, which may or may not rely on the location's characteristics. Fuel can be imported in most cases to fuel boilers or CHP units, but will be better placed if close to major road networks for oil or biomass deliveries. Waste heat[7], mainly sourced from industrial processes, is an ideal input into DH systems as it is a potentially low cost source and utilises energy that would otherwise be considered a loss, therefore increasing efficiencies. There are likely to be many industrial process waste heat resources in DLR, such as waste heat from existing power plants, breweries and waste water treatment plants, and the potential to use such resources in DLR should be investigated further. Other low cost fuels for DH systems can come from geothermal sources, heat pumps or solar thermal farms which are now common-practice solutions in Danish low temperature DH systems. Smart grid enabled electric boilers and heat pumps incorporated in DH supply systems which are timed to switch on/off when electricity prices are low/high can take advantage of low electricity costs and also help to integrate more fluctuating renewable energy on the grid.

Local Electricity Production Potential

The regulations in Ireland forbid the provision of what is termed a 'private wire network'. This means that you may not supply electricity to other buildings which are not on the same property as the building which is

[7] Waste heat is heat which is lost to the atmosphere during industrial and manufacturing processes, rather than heat obtained from waste.

producing the electricity. This means, if a building is producing electricity and there is a surplus to what they require to cover their own demand, they must release this surplus electricity through the national grid, or store in some way for their own future use. There are possibilities for large producers to establish contracts and sell this surplus to the grid, but there is currently no electricity supplier offering payments[8] for surplus energy to micro-generation[9] units.

This means, when analysing electricity demand of buildings and possible local sustainable solutions to meet this demand, it will be in terms of individual systems per building rather than in terms of group electricity schemes. This limits the possibilities for technologies such as CHP units as they will be more suited to industrial or large commercial consumers who have large electrical and heating requirements, and who can apply for grid connections, or in large district heating systems where the sale of electricity to the grid can help to offset the costs of heat production.

In terms of individual building renewable electricity solutions, the main technologies used which are at an advanced stage are wind turbines, solar photovoltaic (PV) panels and hydro-power turbines. The potential to use these technologies will depend on the building's location in terms of space for wind turbines and wind speeds, south-facing roof space and over-shading, and proximity to a suitable hydro source, respectively. Biomass-fed CHP units are another alternative to producing renewable electricity, and are not dependent on locational characteristics, as biomass can be imported like any other fuel. Again, biomass CHP units are more suited to commercial or industrial circumstances than households due to high upfront costs and the size of demand needed to ensure economic viability.

Energy Character Areas

Energy demand mapping is used as a tool in energy planning to define energy character areas. The individual energy characteristics of an area are used by planners to define the appropriate energy solutions or planning policies to be considered for strategic development zones, local area plans or county-wide development plans.

For example, an area with mature residential dwellings in low density suburbs can often have poor thermal performance and therefore high heat demands per building. In most cases, these areas have little variety of building use and many different building owners, which make it less favourable for communal energy solutions and more suited to individual micro-generation technologies such as solar thermal and heat pumps.

In contrast, town centres or areas of regeneration which have a high building density made up of old and new buildings with mixed use such as hotels, offices, retail and apartments, are more suited to development of large scale heating and cooling networks. Although there will be numerous building owners and facilities managers involved, these building types are likely to be accustomed to the processes involved in procuring energy services and therefore will be more likely to engage in projects offering energy savings.

Once these areas have been defined as suitable for individual or group energy schemes, the energy character areas can be defined further by overlaying renewable energy potential mapping in order to see which areas are most suitable for development of RE supply. For example, areas suitable for group energy schemes which are located in peripheral semi-rural areas may be situated close to bio-fuel supplies produced within the region, and can therefore agree long term supply contracts with local suppliers and benefit from low transport costs.

It is important to note that the resulting specific energy characteristics of each small area will have a different best-fit energy solution, which may incorporate energy savings and/or a mixture of technologies. There is no one definitive energy solution that is applicable to all areas, and once an area is identified for further investigation it is important that all available solutions are evaluated in terms of socio-economic cost-benefits. The main attributes to consider when assessing the economic feasibility of implementing various energy solutions will be the availability and suitability of low cost renewable sources in the area, the cost to retrofit current energy systems, and the current and predicted future costs of the fuel source being replaced.

All energy data used in this SEDA is based on delivered energy and not primary energy consumption, and therefore losses involved in delivering the energy, i.e. electricity transmission grid losses, are not accounted for. Spatial energy demand in terms of agricultural land has been considered, but the amount of agricultural

[8] There was a payment available through application to the ESB for micro-generation, but this scheme ceased in December 2014.
[9] Micro-generation is termed as generators rated up to 25 Amps on single-phase systems (most household systems are single-phase) or 16Amps on 3-phase systems (ESB, 2015).

land in the DLR area is negligible, and so the contribution of agricultural energy is a very small fraction of the total energy use.

The following sections in this chapter outline the results and methodologies of each area of energy use, namely residential, commercial and municipal building energy, and the overall total energy use in DLR.

Spatial Energy Demand Analysis

Introduction

This section outlines the methods and results of calculating and mapping current energy consumption in buildings within the DLR area. Currently there is no publicly available actual energy consumption data for every building in DLR, and therefore a methodology was devised in order to estimate this energy use based on best available empirical data. The results are then attached to a geographic location in order to visualise it spatially. The data is accumulated and analysed through the use of MS Excel software and mapped using QGIS open-source mapping software.

From analyses of spatial demand mapping practices in other countries, and the availability of matching data across all sectors, the main sets of energy data which will be created and mapped are:

- Total Energy Demand
- Total Heat Demand
- Heat Demand Density
- Total Electricity Use
- Total Fossil Fuel Use
- Total Annual Energy Costs

There will also be a breakdown of the energy use into the three sectors of Residential, Commercial/Industrial and Municipal energy use, which will each have their own relevant maps created. The agricultural sector has not been mapped due to its relatively low energy consumption in DLR. The total area farmed in DLR is less than 1% of that in the county of Dublin. Of this, the majority is tillage and sheep farming, neither of which are direct energy intensive activities. Thus, the impact of the agricultural industry on the energy demand of DLR is negligible and will not be mapped in this report.

The energy data of DLR, including all analyses listed in bullet points above, will be mapped and presented in a grid format, and will be further explained in this section. For the residential sector, there will be additional maps created, for example, showing average BER ratings in each area and areas at high risk of energy poverty. These maps will be presented per ‘Small Area’, the reason being that all information has been calculated per small area and thus, a grid format would bring no greater clarity. The residential data acquired from the CSO (Central Statistics Office) is aggregated by the geographical breakdown of ‘Small Areas’ (SA). A SA is an area of population comprising between 50 and 200 dwellings, created for Ordnance Survey Ireland (OSI) and the CSO, and is designed as the lowest level of geography for the compilation of population statistics. The SA is therefore created on the basis of residential density, rather than building density, and there can be SAs which cover a large land area and may contain many non-residential buildings. Within the small and densely populated urban areas, SAs provide a very suitable method of mapping spatial energy demand. However, when mapping the more rural areas in DLR, it can be difficult to assess where the demand is concentrated within these large, sparsely populated SAs. For this reason, the energy demand of DLR will primarily be mapped on a 500m x 500m grid, developed for the purpose of this report.

This report presents DLR's energy consumption over 587 individual grid squares. While this number of subdivisions is less than the 760 individual small areas, the uniformity of the grid distribution means that each square is directly comparable. This is particularly important when assessing heat density for district heating purposes. As can be seen in Figure 2, this scale of grid format provides a more detailed level of analysis for the large SAs and a more amalgamated breakdown for the smaller, more densely populated SAs. As the European standard is to perform Spatial Energy Demand Analyses on a 1km x 1km grid, it is considered that a 500m x 500m grid will provide satisfactory detail in results, while also relating to the scale of DLR.

The commercial and municipal energy calculations include location point specific information, thus making it easy to attach and amalgamate to any grid size. However, it is necessary to attribute the aggregated residential energy demand of the SAs into a grid of similar proportions. This is achieved by breaking down all SA shapes into small grid squares. Each grid square is then assigned a portion of the SA's residential energy information, proportionate to the level of housing present in this grid square. The level of housing is determined using a digital OSI map, showing building footprints in DLR. This provides a more accurate level of spatially related energy demand for all sectors.

While the grid format is used as the primary means for representing energy information in this report, the initial five maps will be presented using SA breakdowns. The reason for this is that these maps (Figures 6, 8, 9, 10 and 11), all represent information either solely dealing with BER data or data that is calculated "per household". This means that this information is intrinsically linked to SA data and presenting the information on grids would serve no additional purpose other than pixelating the image.

Figure 2 : Maps Showing Examples of Small Area (Left) and Grid (Right) Breakdowns in same location in DLR

Energy Use in Dún Laoghaire- Rathdown

The latest figures estimate that less than 1% of all energy use in DLR comes from locally produced renewable energy, as seen in Figure 3, and instead there is a large dependence on imported fossil fuel sources such as gas, oil, diesel and petrol. There is easy access to the gas grid throughout DLR, and gas is therefore the main fuel source used for heating requirements. The national electricity supply is also based predominantly on gas-fuelled power plants. This means DLR is very susceptible to price increases and shortage of supply of gas in the European market. Ireland imports around 95% of its natural gas requirements[10], meaning billions of Euro annually is exported to pay for these resources. If DLR could increase its ability to meet even a small percentage of its energy demand with local sustainable resources, it could retain a substantial amount of money within the Irish economy and increase security of supply.

Electricity in Ireland has high CO_2 emissions per kWh due to the supply mix on the national grid, which, in addition to gas (~50%), is supplied by peat (12%) and coal (25%) plants, and nearly 50% of the energy from these fuels is lost during transformation and transmission. The high cost of electricity, along with high carbon emissions and reliance on imported fuels are only more reasons for DLR to look to producing its own sustainable energy locally.

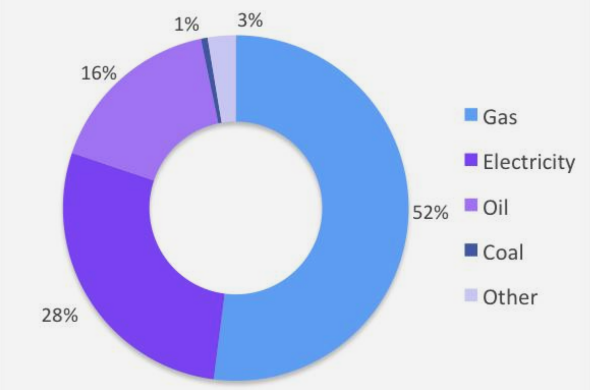

Figure 3 : Final Energy Use in Buildings by Fuel Type in DLR

Sector	Total Energy (TWh)	Total Heat (TWh)	Total Costs (€millions)
Residential	1.95	1.71	165.97
Commercial	0.64	0.36	71.76
Municipal	0.01	0.01	0.77
Total	2.60	2.08	238.50

Table 1 : Energy Breakdown per sector in DLR

[10] This is currently lowered due to the production of gas at Corrib, but will return to previous import capacities when this resource runs out, predicted to be 3-4 years

Using the current European best practice methodologies in energy demand analysis, it is possible to calculate the overall energy use for all buildings in DLR. This is broken down for each sector in total energy demand, heat demand and annual costs in Table 1. As seen in Table 1, the residential sector is by far the greatest contributor to energy demand in DLR.

The local authority area is primarily comprised of suburbs and grassland, with a few commercial hubs such as Dún Laoghaire, Sandyford and Blackrock. As will be explained later in the Commercial Sector Analysis, the size and activity of these businesses result in a relatively low energy demand.

Housing and BER Analysis in Dún Laoghaire-Rathdown

As well as accounting for the highest portion of demand, the residential sector also provides the most detailed results due to the comprehensive data resources available. From the CSO 2011 Census, it is possible to analyse the housing stock by type, period built and spatial distribution per Small Area. The breakdown of the total DLR housing stock is shown in Figure 4: DLR Housing Stock by Type and Period Built.

The most common housing type in DLR is semi-detached, accounting for 40% of total households, while the period of 1971-1990 accounted for the most new builds, at 36%. Only 28% of dwellings in DLR were built post 1990, making it a relatively old housing stock. In the two most recent construction periods, apartments have been by far the most built housing type, accounting for 71% of all households built post 2000. Apartments will have a lower external wall exposure than other building types, such as detached or semi-detached, thus requiring less energy per square metre and resulting in a better BER rating.

From the application of actual BER data, further described in the Residential Sector Analysis, it is possible to produce a graph of estimated BER ratings for the entire housing stock in DLR. The graph in Figure 5 shows the number of dwellings in each BER rating according to the type of dwelling. Of these, the most common energy rating is C, with a 32% share, while 27% have a rating of D. Only 12% have a rating of B or higher, while 29% have a rating of E or lower. The energy efficiency of apartments is notable in Figure 5, as their share of the total increases as the rating rises.

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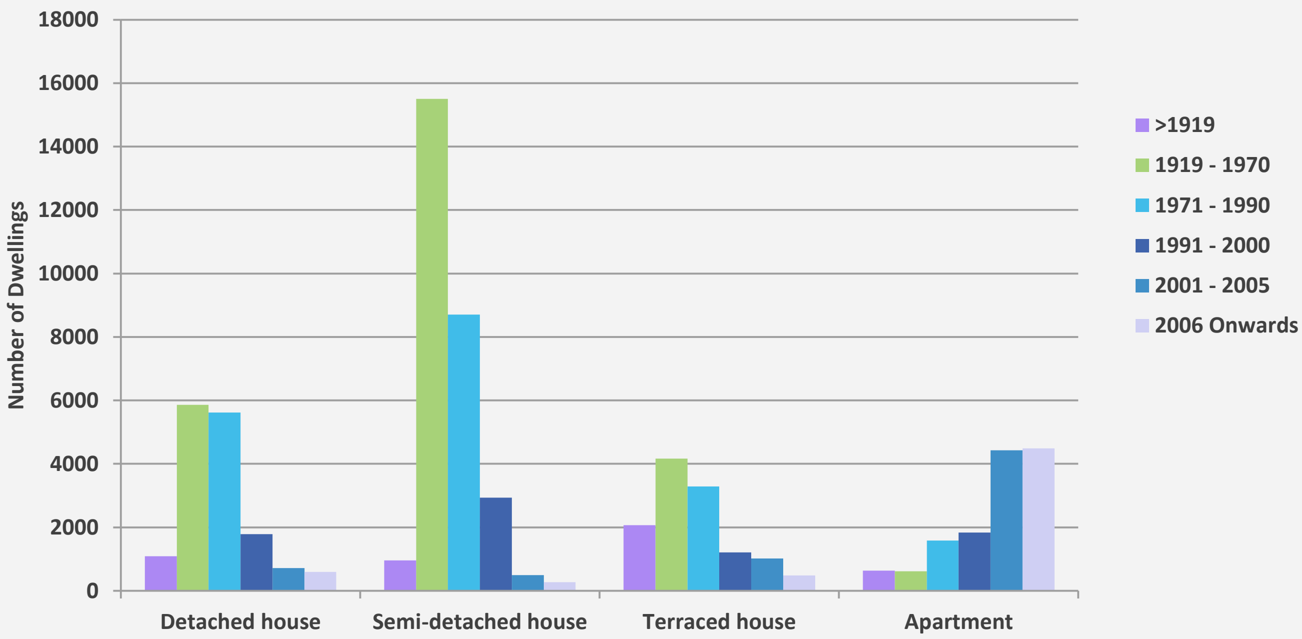

Figure 4 : DLR Housing Stock by Type and Period Built

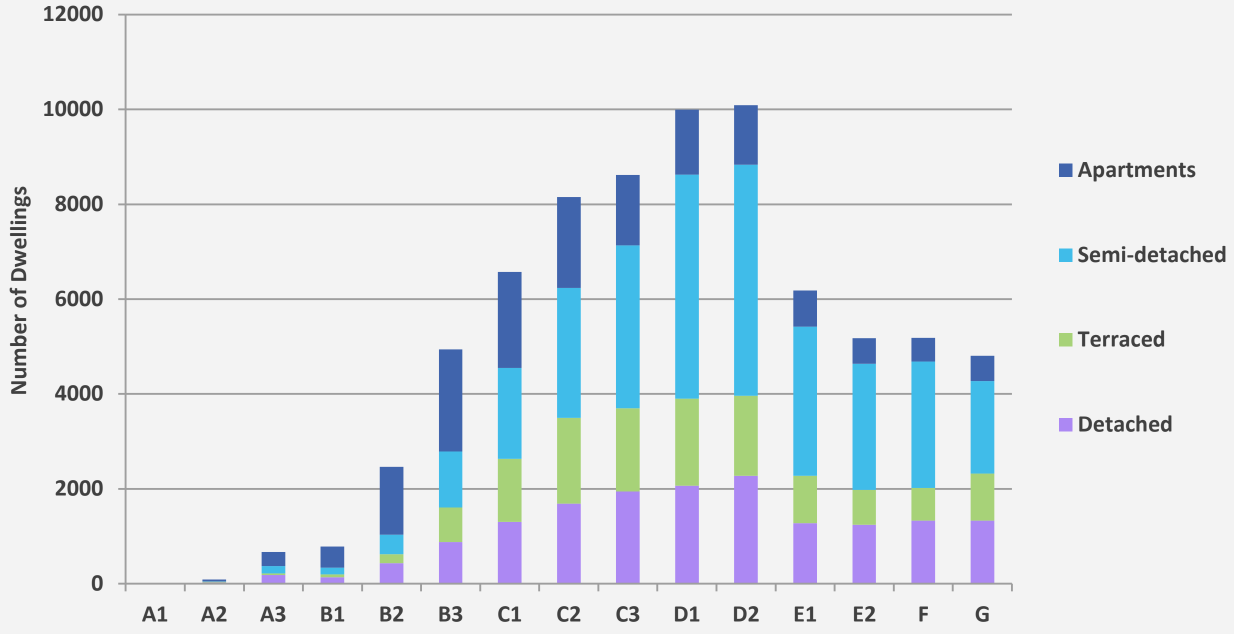

Figure 5 : Building Energy Ratings for all DLR Households per Building Type

The graph in Figure 6 shows the energy ratings of all DLR housing according to period built. A direct correlation between the construction year and energy rating can be seen as the lower F and G ratings are dominated by pre 1970 builds, while all A rated properties were built post 2006. It is the lower rated, old households that should be given first priority in any plans for energy efficiency upgrades in order to move them from the lower ratings up to at least high D or C ratings. This will also help to improve situations for those at risk of energy poverty.

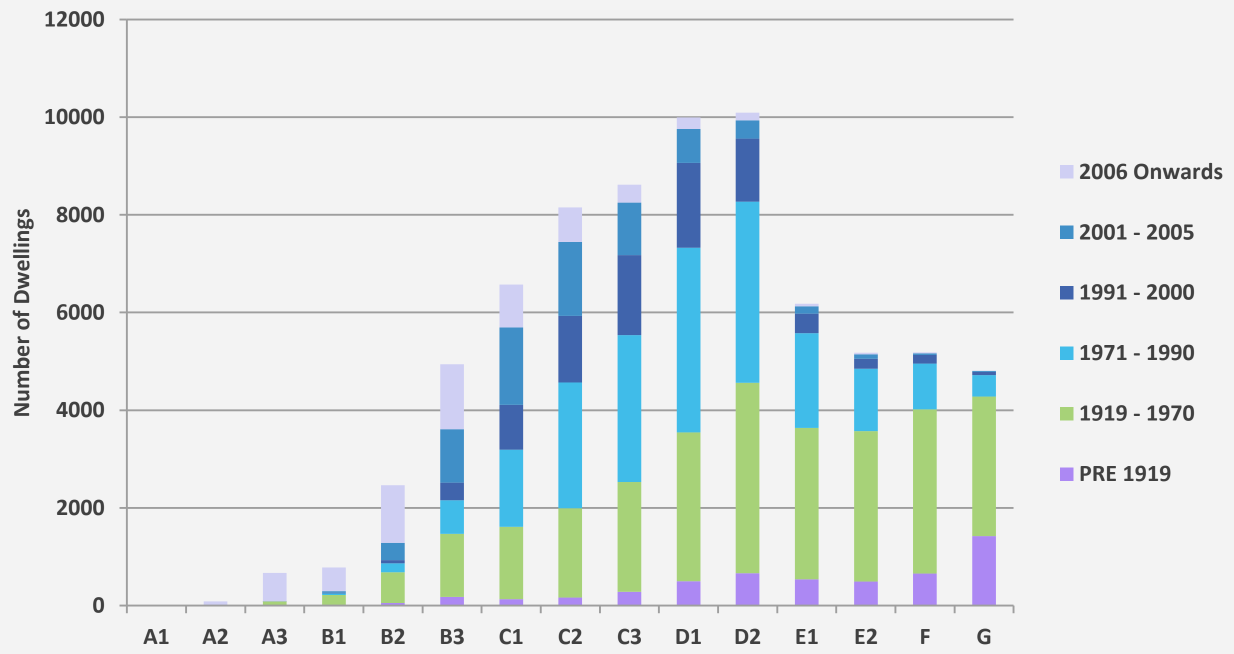

Figure 6 : Building Energy Ratings for all DLR Households per Construction Period

These results help to visualise the current state of energy use in the DLR residential sector and inform the local authority when creating energy strategies for the region. The following chapter outlines the background methodologies and results of the Spatial Energy Demand Analysis, which places this energy consumption within a spatial context.

Residential Sector Energy

Methodology

Two main datasets which provide high levels of accuracy and detail are used in order to estimate the energy use in each dwelling in DLR; they are the National Census from the CSO and the National BER Research Tool from the Sustainable Energy Authority of Ireland (SEAI). At the time of the last Census in 2011, there were 85,896 permanent private households in Dún Laoghaire-Rathdown. Of these, 10,110 are considered to be vacant and as such, do not have energy consumption attributed. Due to an increase in housing demand, it is assumed that some of these may now be occupied. Additionally, preliminary results for the 2016 Census announced an increase of 4.4% in the Dún Laoghaire-Rathdown housing stock compared with 2011 figures. However, at the time that this report was written, the spatial distribution of these increases, both in new builds and filled vacancies, was not available and so, is not included in these calculations.

For the purpose of this report, the CSO compiled special tabulations presenting the number of dwellings by type and period built in each small area in DLR. These attributes have a considerable effect on the theoretical energy demand as they can often define what building standards were in place during construction, level of insulation, exposed external wall area, etc.

In line with data protection, the CSO was required to 'hide' data where the breakdown could possibly allow identification of individual households. In these cases, the CSO gave a figure of '<3' where the number of households in a breakdown category was either 1 or 2. In calculating the housing stock, each '<3' was replaced with '1', and so the energy use will be underestimated rather than overestimated. It is better to underestimate the demand, as, for example, for a group heating scheme to be feasible, the area will need to have a high heat density, and so an underestimate of heat demand is better. Also, the number of instances of '<3' were few, and replacing with '1' means that only 1,977 dwellings are unaccounted for throughout the region, which is 2.6% of the total. The total number of dwellings used for calculations is therefore 73,809.

In order to attach energy data to the housing breakdown, the National BER Research Tool database[11] from the SEAI was used to find an average energy profile of each housing type and housing age in each area within DLR. The BERs only assess the energy requirements of the building itself and do not take into account electricity used for various appliances, therefore additional electricity use associated with appliances has been applied based on figures from the SEAI's Energy in the Residential Sector 2013 report (SEAI, 2013 (b)).

The BER dataset has been broken down into four DLR postcodes, four housing types (detached, semi-detached, terraced and apartments), and seven building periods, with periods chosen to match those grouped by the CSO and to reflect new building regulation introductions. There were over 56,000 BERs analysed and 84 subsets of data created to represent the variety of housing types, ages and locations. These profiles were then applied to the CSO housing data breakdown.

The representation of BERs in each postcode area is shown in Table 2.

Postcode	Number of SAs	Total Dwellings Used for Calc	Number of BERs	% Represent-ed
Dublin 14	99	9,008	5678	63%
Dublin 16	71	7,108	5421	76%
Dublin 18	56	5,486	9491	173%
Co.Dublin	534	52,207	36159	69%
Total	760	73,809	56749	77%

Table 2 : Representation of BERs in Each Postcode Area

Overall, there is a 77% representation of BERs to total dwellings in DLR used for these calculations. However, all postcodes in DLR overlap into other regional authorities, and so there is a higher representation of BERs. This is an unavoidable consequence of the difference in postcode and local authority boundaries, but should not hinder the accuracy in energy estimates as a household will not use more or less energy because it is on one side or another of a regional boundary. Additionally, a higher number of BERs analysed should provide a more refined average.

[11] The BER database is constantly updated, and so it is important to state that for this project, the database was accessed on the 31st July 2016.

As previously described in the introduction, the energy demand is primarily presented in a grid format. However, all maps with information calculated "per household", including Figures 6, 8, 9, 10 and 11, will be visually presented through the spatial distribution of small areas.

Results

BER Analysis

From the comprehensive datasets available, it is possible to draw many conclusions about the residential energy demand in DLR. By using the methodology outlined, BERs have been generated for every dwelling in DLR. This is represented in Figure 9, showing the average BER for each Small Area. As previously mentioned, the most common rating among dwellings in DLR is a 'C' rating, totalling 32% of the housing stock. Figure 9 however, appears to be heavily dominated by 'D' rated dwellings, represented by the colour yellow. This is due to many 'D' rated SAs being located in the more rural, less densely populated areas, and consequently having greater land areas.

The highest average BER is a 'B', found in the Carrickmines area of DLR, and includes the new apartment complexes at The Crescent. In this SA, 92% of all dwellings are apartments. As previously mentioned, apartments will have less externally exposed wall and roof area than other dwelling types, leading to lower energy demands. Additionally, apartments tend to be newer buildings, adhering to more stringent building codes. This is true in the instance of this SA, as all dwellings have been built post 2001, and 85% of these were built after 2006.

This correlation between construction year, dwelling type and BER rating is even more evident throughout the top 10 energy rated SAs. Of all dwellings in these SAs, 93% are apartments. Furthermore, 99.5% of these were built post 2001.

This correlation is also present in the other extreme, for those SAs where dwellings achieve low energy ratings. While no SA in DLR achieved an average BER of G, there are 95 SAs with a BER of E or F. Within these SAs, 73% of all dwellings were built pre 1970. This correlation is found to be exponential, as within the 10 poorest energy rated SAs, 94% of all dwellings have pre 1970s construction years.

Within the 10 lowest energy rated SAs, the predominant housing type is terraced, accounting for 46% of the share. This suggests that there are many old terraced households within DLR in significant need of energy upgrades, and these should receive the most urgent attention in these efforts. Many of the lowest rated SAs are concentrated around the Dún Laoghaire area, in electoral districts such as Dún Laoghaire - East Central, Dún Laoghaire - West Central and Dún Laoghaire - Glasthule. A number of E and F rated SAs are depicted in Figure 8 around Clarinda Park. The majority of houses in this area would be old terraced houses.

The results of the BER analysis show that, while better building regulations for new builds are effectively reducing the energy demands in new developments, the rest of DLR's dwellings are becoming older and less efficient. To really reduce energy use in this area, these households need to be retrofitted with sustainable solutions. With rising costs of rent, a real concern is always the number of rented dwellings which have very poor BERs. There needs to be more incentives or deterrents introduced to enable landlords to make their properties more energy efficient and less costly to keep warm.

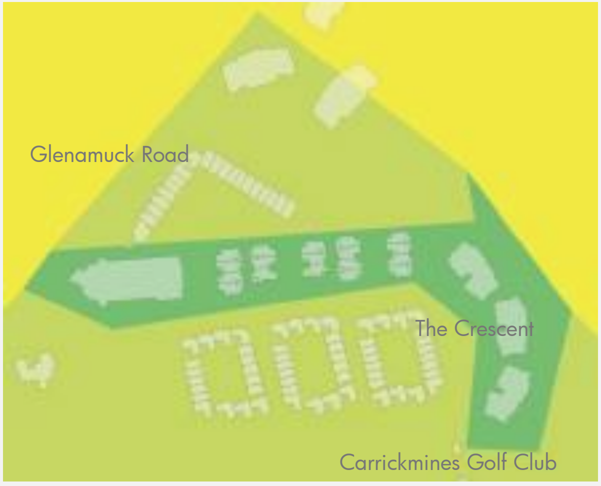

Figure 7 : Average B and C ratings (dark and light green respectively) in newly developed areas of Carrickmines.

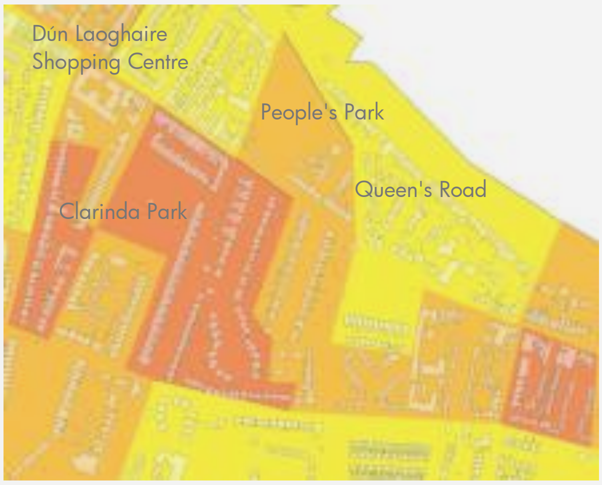

Figure 8 : Average E rating (orange) and F rating (red) around Dún Laoghaire

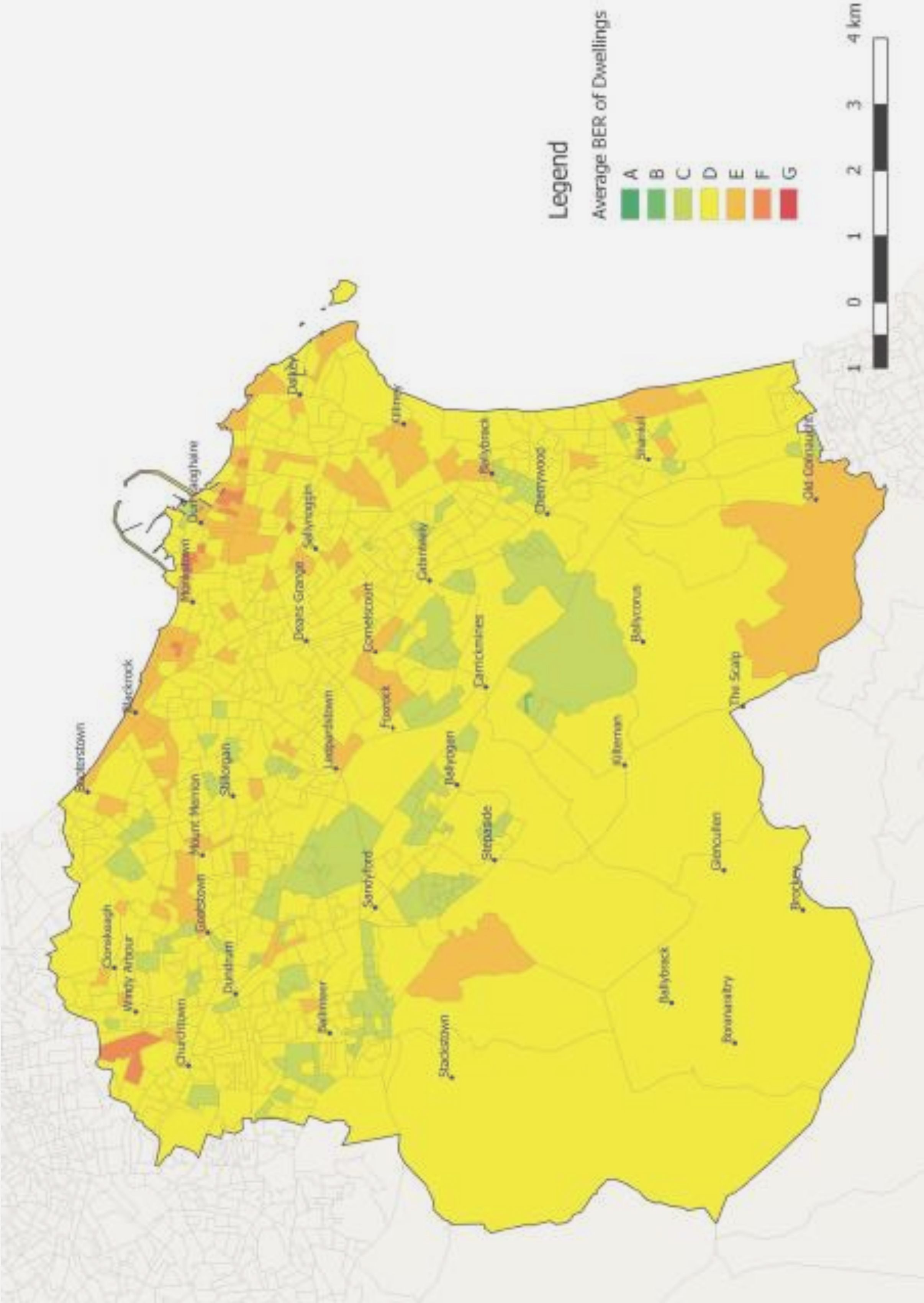

Figure 9: Average BER of All Dwellings in Each Small Area

Energy Use per Household

The next map in Figure 11 shows the average energy use per dwelling in megawatt-hours (MWh). The green and dark green areas have low energy use per dwelling, with the light yellow band representing the average energy use in DLR. This is between approximately 24 and 30 MWh per year. In comparison, the national average energy use per household is around 20 MWh (SEAI, 2013 (b)), meaning DLR is considerably above the national average.

The areas that performed well in the average BER calculations predictably have a lower energy use per dwelling, as mapped in Figure 11. Dwellings in the newly developed areas near Carrickmines, Belarmine and Sandyford tend to have smaller sized dwellings, often comprising of apartments or modern terraced developments, and therefore require less energy to maintain thermal comfort. This correlation between floor area and energy use can be seen in comparing Figure 11 and Figure 12. Here we again can see that it is the built up and more densely populated areas of DLR that tend to have smaller internal dwelling areas. However, there are newly developed areas shown which have low energy use per dwelling even though some have larger dwellings than those found in the other areas.

In Figure 11, the areas of orange and red have above average use per dwelling, and in some cases, over three to five times the average energy use of a dwelling in the dark green areas. The southern SAs of DLR are much less densely populated than the residential hubs of Blackrock, Dún Laoghaire and Stillorgan. In these more sparsely populated areas, land is not as valuable or sought after and as a result, houses are often much larger and detached. These dwellings also tend to be of an older construction period, the housing stock accumulated over many decades rather than being built in the early 2000s construction boom.

Energy Costs per Household

The estimated energy costs per household are mapped in Figure 13. Many areas shown here with higher than average energy costs overlap with areas shown in Figure 11 to have high energy use per household. However, there are other areas which have high costs, not due to the size of the dwelling, but due to the fuel used for hot water and space heating, and efficiencies of heating systems. As seen in Figure 10, the main fuel used for household space heating in DLR is natural gas, accounting for 73% of the share, but many apartments are electrically heated using storage heating units and some households have oil boilers due to distance from the gas grid. Many households also have electric showers or electric immersions for hot water.

The fuel prices used in this analysis are based on SEAI's Domestic Fuel Cost Comparisons (April 2015), and electricity and gas prices per kWh have been applied to each household according to the usage price bands. Domestic electricity rates in Ireland are the second highest in Europe, and third highest when all taxes and levies are included, just behind Denmark and Germany (eurostat, 2016). Oil fuel costs used to be more expensive than natural gas, but the price has dropped recently and now oil is close to the same cost per kWh of gas.

The areas in dark green have very high energy costs, many of which are located in the more rural areas with large housing units. However, the five SA's with the highest energy costs are located in the suburban ED of Foxrock-Carrickmines. The housing stock in these small areas consists primarily of detached and semi-detached dwellings, built pre-1970. There is a significant correlation between energy costs and dwelling floor areas, as can be seen in Figures 12 and 13, where the area of Foxrock is among the highest in both regards.

The lighter green areas have lower costs, but are still relatively high per household, with many smaller households paying over €2,000 per year for energy. These costs can make up a large part of a households' annual income, and can cause households to be without heat in the winter season. Again, it is not surprising that the areas coloured light yellow, indicating low energy costs, are those which also feature the smallest floor areas and lowest energy usages per dwelling.

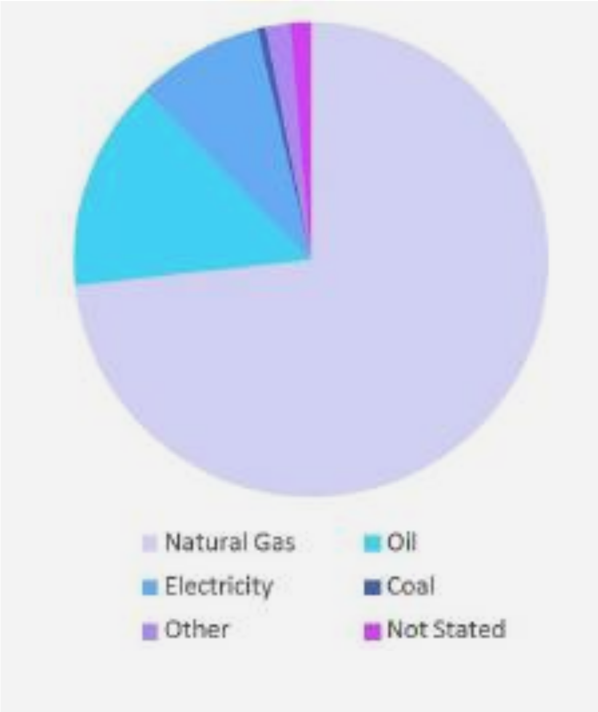

Figure 10 : Heat Fuel Use in DLR (CSO,2011)

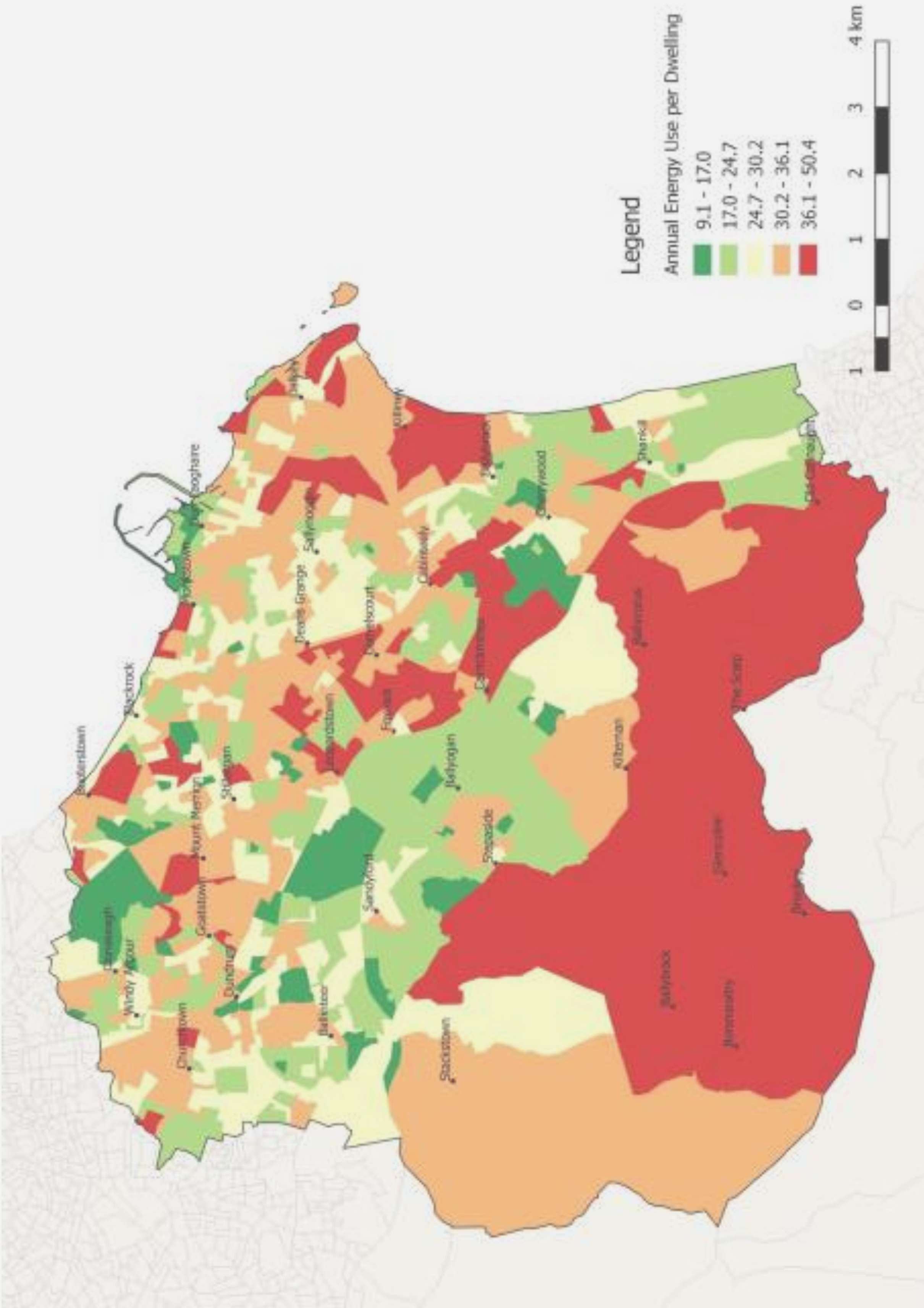

Figure 11 : Average Annual Energy Use per Dwelling in Each Small Area

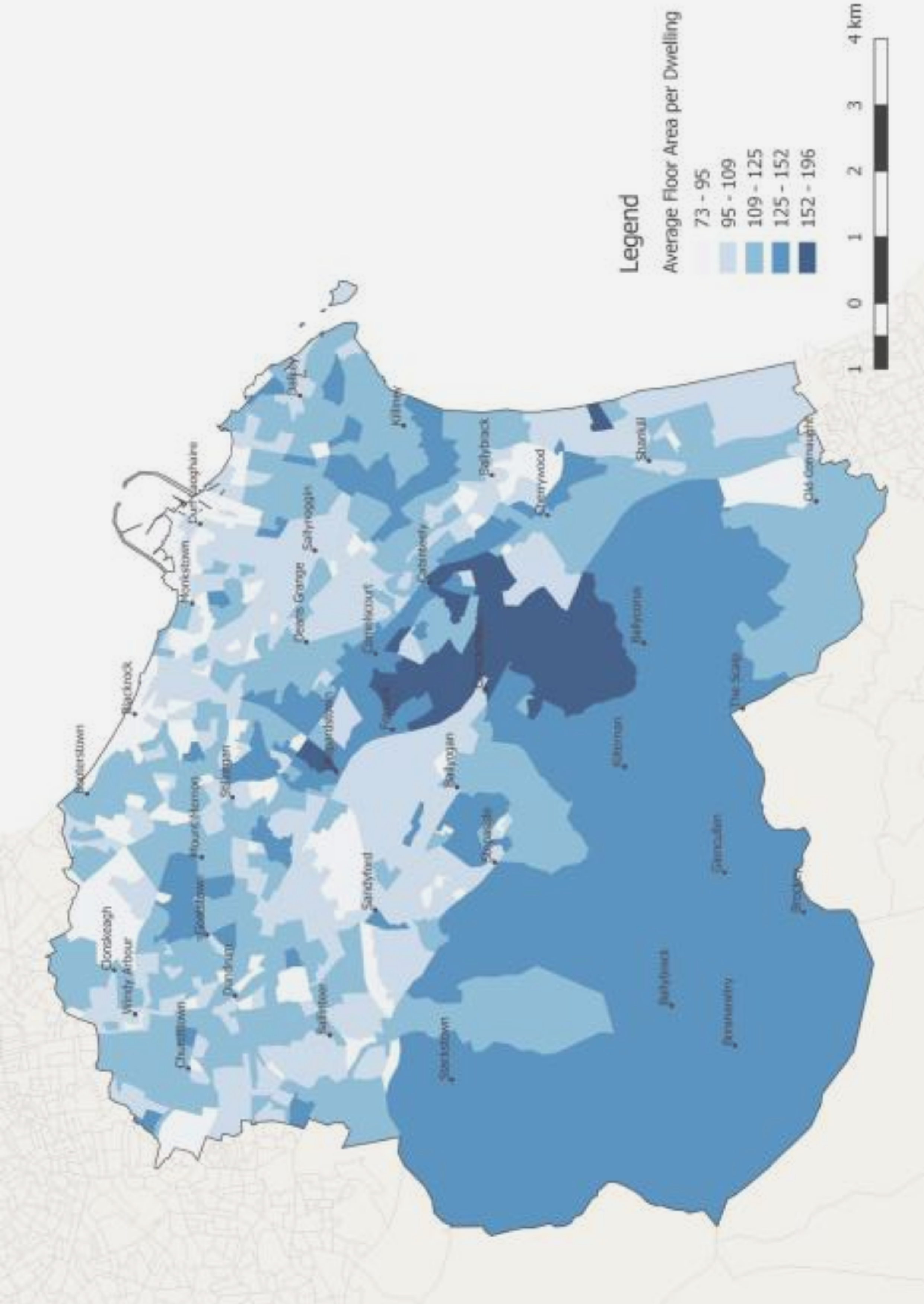

Figure 12 : Average Floor Area of Dwellings in Each Small Area

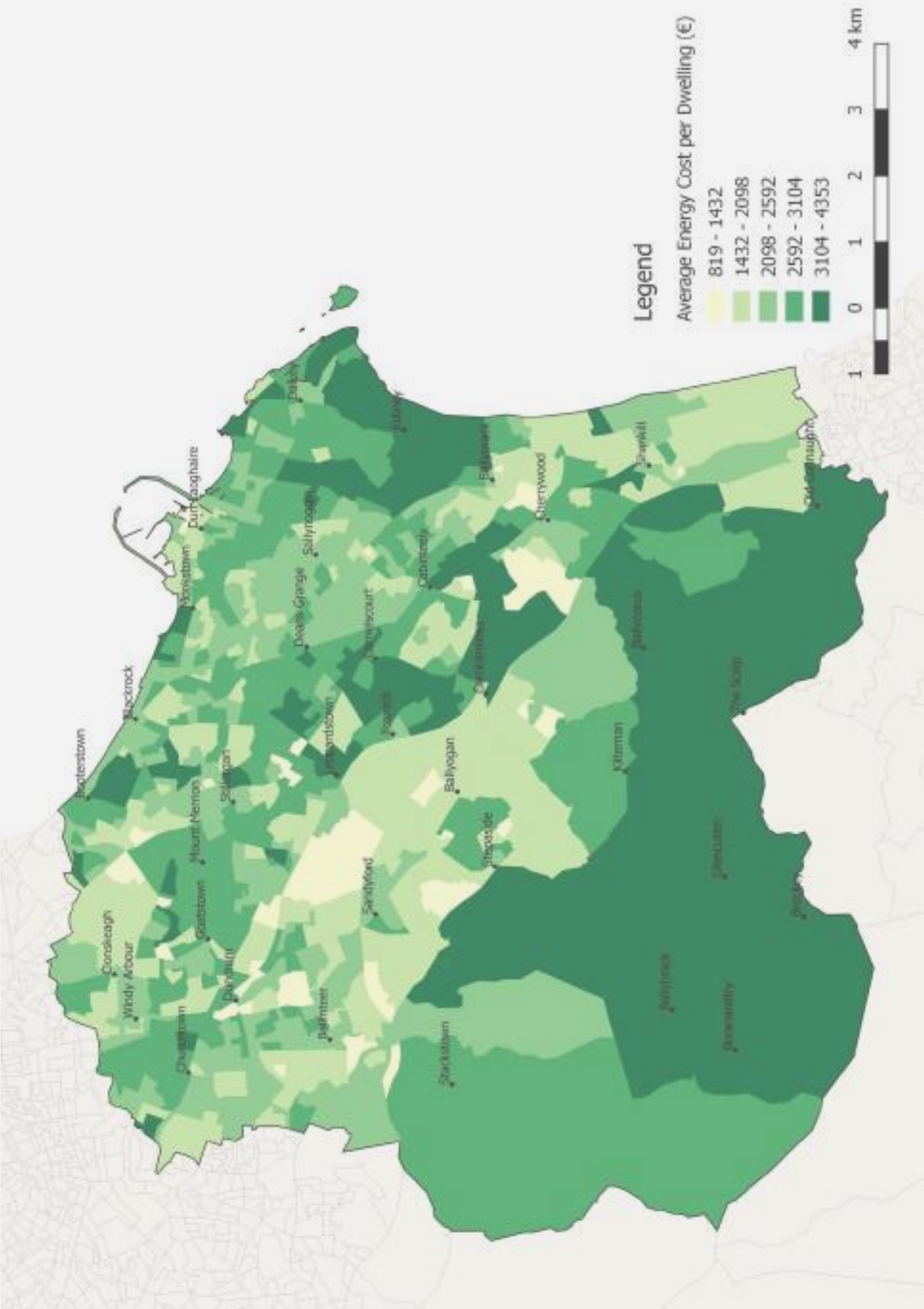

Figure 13 : Average Annual Energy Costs per Dwelling in Each Small Area

Areas with High Risk of Energy Poverty

There is much difficulty in defining energy poverty and how to target those worst affected, as outlined in the then Department of Communications, Energy and Natural Resources' (DCENR) consultation paper on a new affordable energy strategy (DCENR, January 2015). Someone suffering from what is termed energy poverty is said to be unable to heat or power their home to an adequate degree. Three factors which influence this are household income, cost of energy, and the energy efficiency of the home. Without knowing the income levels in each small area to compare with estimated costs from this analysis, the best way to try to map areas most at risk of energy poverty is to overlap the known data and compare calculated energy costs with levels of unemployment in each small area[12].

The DCENR defines energy poverty as spending above 10% of annual disposable income on energy (DCENR, 2014). In areas where there is above 30% unemployment, there is a sizeable proportion of households who can be assumed to be on a social welfare income. An average social income per household is said to be €327 per week, equating to roughly €17,000 per annum (ESRI, 2011). In this instance, annual energy spends of over €1,700 would push these households into energy poverty. Thus, Figure 14 identifies two small areas, in the Electoral Districts (EDs) of Dún Laoghaire West - Central, close to the town centre, and Killiney South, near Loughlinstown, whereby 30% or higher of the workforce can be said to be at risk of energy poverty. Additionally, there are a further two SAs, one located in Killiney South and another in Dundrum - Balally, which both have over 30% unemployment and close to €1,700 per household in energy costs. These SAs are illustrated in the darkest shade of pink in Figure 14. This method of targeting takes into account the ability to pay for energy and energy efficiency ratings. There are 209 households in these most at risk areas in total, and it is recommended that further analysis is carried out on these households in order to find the best-fit solution to reducing their energy costs, and include this housing in future efficiency retrofit schemes.

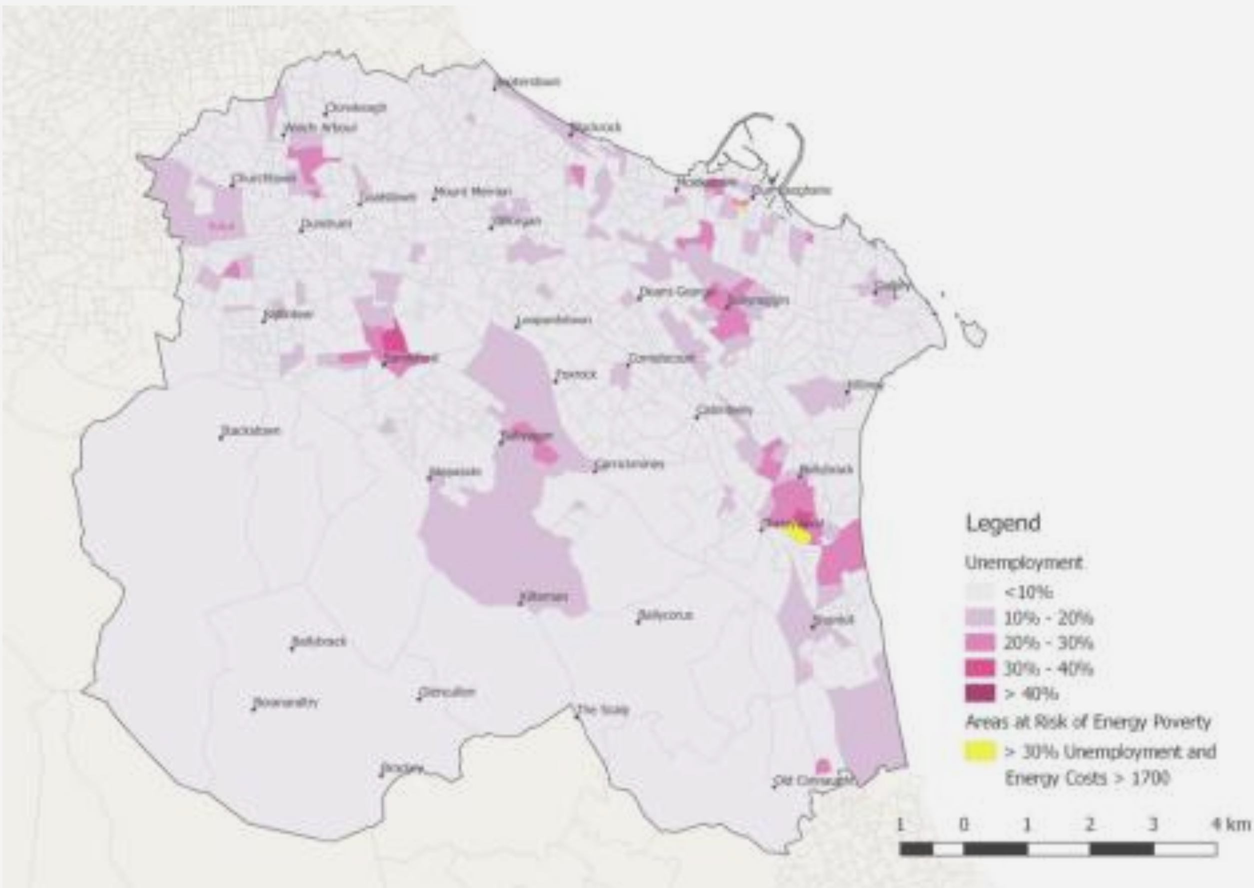

Figure 13 : Areas Most at Risk of Energy Poverty

[12] The data for unemployed or unable to work comes from the 2011 Census, as there is no more recent data available at a small area level. The 2016 Census is due to be released, and these figures can then be updated to reflect the upturn in the economy since 2011.

Total Residential Sector Energy Demand

The total annual energy demand, total annual electricity demand and total annual fossil fuel demand of the residential sector are shown in Figure 15, Figure 16 and Figure 17, respectively. The total energy demand map shows the areas in DLR most responsible for the energy use of the residential sector. These areas should be targeted for energy efficiency awareness campaigns and education on renewable energy solutions for households. The energy demand is also broken down into electricity demand and fossil fuel demand to show areas which can be targeted for different renewable energy solutions.

Areas with high electricity usage can be prioritised for rooftop PV installations, or in some suitable cases, micro-hydro or micro-wind power, to offset some of their electricity usage. Households with electrical heating systems such as storage heating should consider replacing old systems with new, high efficiency smart electricity storage systems or where practical, replacing with a wet system which can incorporate heat pumps, solar thermal and geothermal heat sources. Many apartment complexes were fitted with all-electric systems due to low cost and ease of installation. A group scheme with a central high efficiency CHP plant in such complexes can supply electricity and heat to the building and reduce overall fuel usage and costs. The biggest problem with many apartments, bed-sits and flats in the county is they are rented, and the tenants cannot make the big changes required to reduce their energy costs, and there are no incentives for landlords to upgrade the energy efficiency of their properties, especially in the current market where there is a lack of rental properties available.

Areas with high fossil fuel usage cause the highest amount of local air pollution, particularly those which burn solid fuels such as coal and peat. From census data, the highest percentage share of coal or peat used as a main heating fuel in any small area is around 8%, which is relatively low in comparison to rural areas which do not have access to the gas grid. Open fires and stoves are often used in dwellings as secondary heat sources and so it is likely the number of dwellings which use solid fuels is underestimated when looking at main heating fuel only. With the local pollution and CO_2 emissions caused by burning coal and peat, and the very low efficiencies of open fires (around 20%), it is important to ensure households switch to sustainable and cleaner forms of fuel such as wood, wood chips and wood pellets, and install highly efficient stoves in place of open fires. It is relatively cheap to install a wood fuel stove, and this not only reduces negative effects on the environment and health, but also saves money due to much higher efficiencies of up to 90%.

The majority of the fossil fuel used in dwellings in DLR is natural gas and, in a smaller share, home heating oil. Areas which have high levels of oil and gas used for hot water and space heating requirements should be encouraged to find renewable or sustainable alternatives. For individual building based systems, there are many proven and well established technologies which can greatly reduce a household's reliance on fossil fuels; these include air, water and ground source heat pumps, solar thermal panels, heat recovery ventilation systems, and biomass-fuelled boilers or stoves. These solutions should be supported and included in home energy improvement grant schemes. For suitability of areas and households for each renewable energy solution, see section on renewable resources.

District heating is a shared heating system with a central heating plant which feeds heat to each household on the system. As discussed in the introduction to this chapter, DH should be prioritised in areas of sufficiently high heat density. DH systems are likely to be more economically feasible if there are large commercial or industrial customers also on the system, due to high heat demand over long periods year round, but there are also many successful stand-alone residential schemes in operation. There are two areas with a heat demand density of over 250 TJ/km^2, suggesting a very high residential heat demand and these are around the Broadford housing estate in Ballinteer and an area of housing in Dún Laoghaire town centre south of Georges St Upper. Critically, there are 59 grid divisions with over 150 TJ/km^2, exceeding the Danish rule of thumb for feasibility of a District Heating system. It may be more economically advantageous for groups of housing with heating systems which need to be replaced and in areas of high heat demand density to consider a cooperative DH scheme. DH can be expensive to retrofit due to ground works required for pipelines, and so DH is particularly suited to areas undergoing roadworks for other infrastructure, new housing developments or housing close to existing or planned DH schemes. DH feasibility will be further analysed later in this section when commercial and industrial energy use is combined with residential energy and the resulting total heat density is mapped.

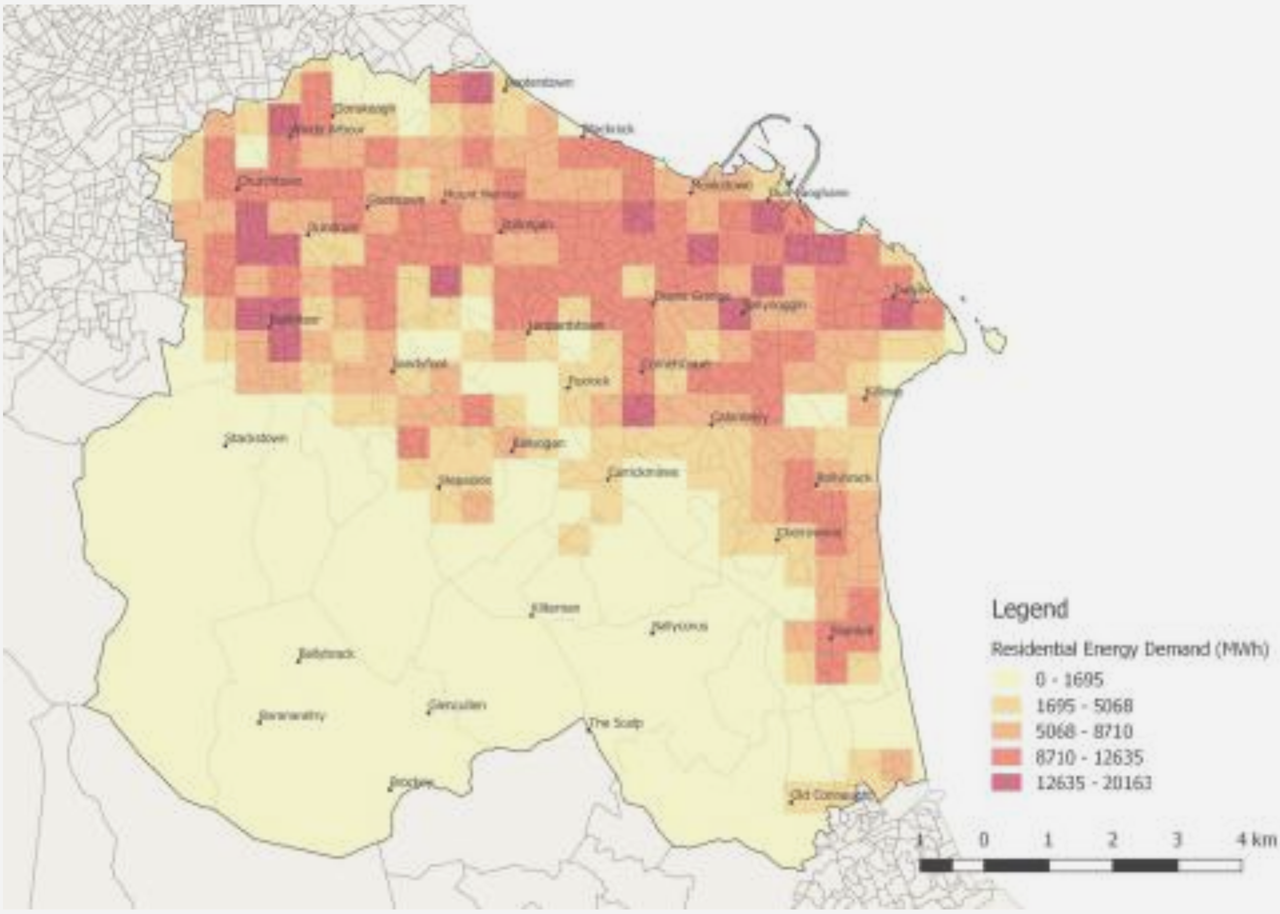

Figure 15 : Total Annual Residential Energy Demand (MWh)

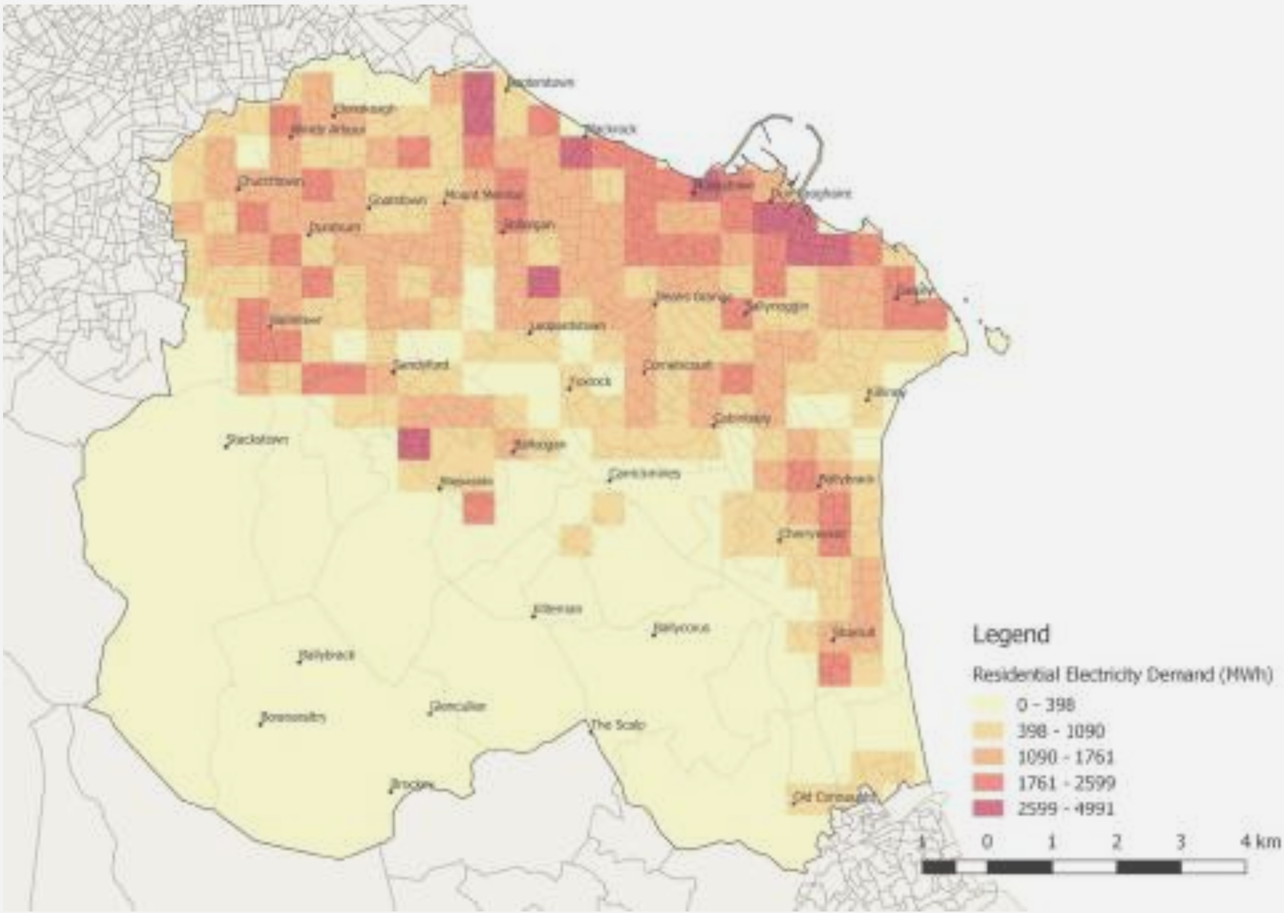

Figure 16: Total Annual Residential Electricity Demand (MWh)

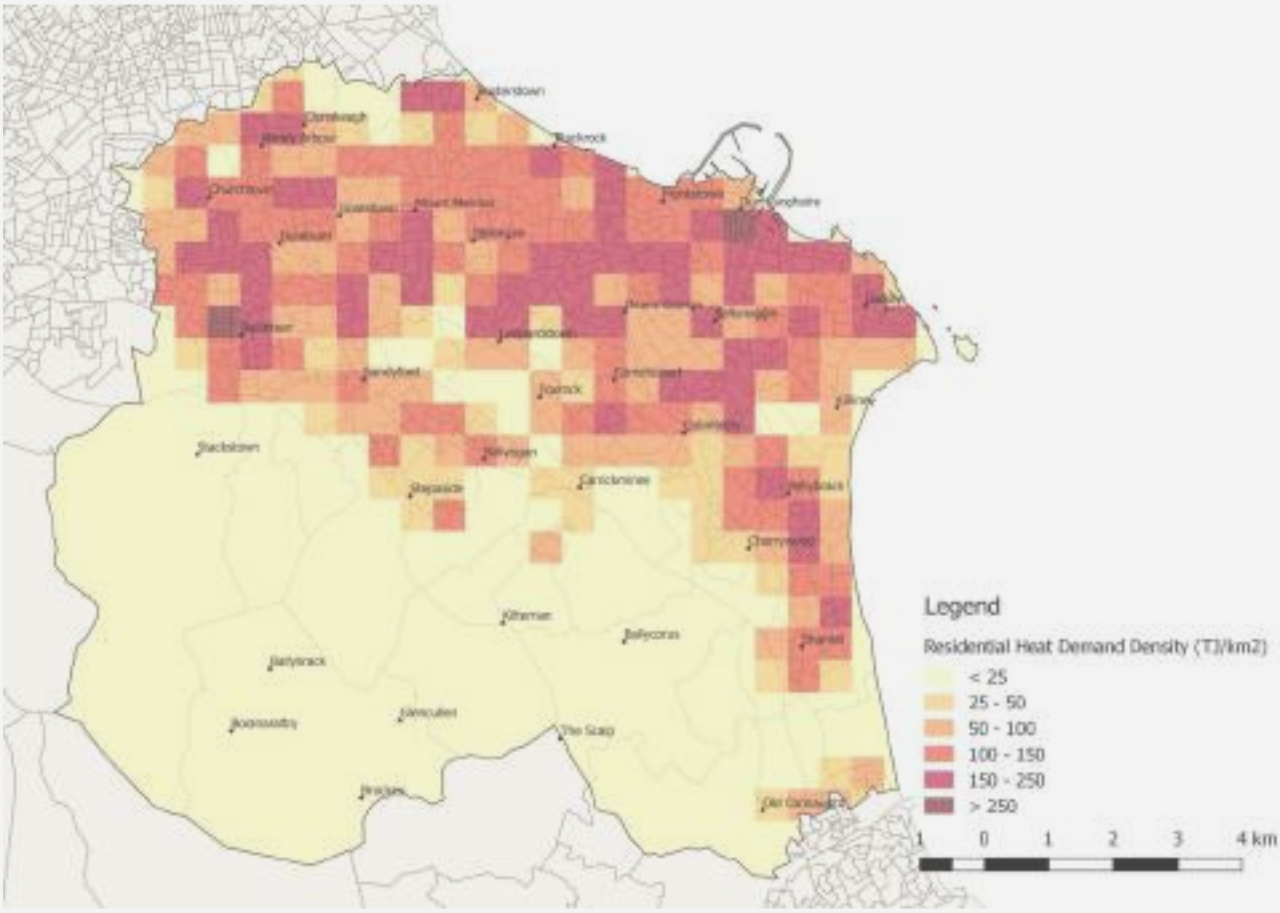

Figure 17 : Residential Heat Demand Density (TJ/km2)

Commercial Sector Energy

Methodology

The commercial sector in DLR (which includes services, manufacturing and industrial activities) has very little real metered energy data publicly available for research, and it is therefore difficult to estimate the energy demand in every building in the county used for such activities. The most well established source of energy data for the commercial sector comes from the UK's Chartered Institution of Building Services Engineers' (CIBSE) technical documents. This data is widely used in Ireland for modelling commercial sector energy consumption, and is used for the comparison benchmarking in Display Energy Certificates (DECs) in Ireland. CIBSE provides energy benchmarks which are divided into annual electricity use per meter squared floor area and annual fossil fuel use per meter squared floor area for numerous service and industrial activity types. The benchmarks used in this study come from CIBSE Guide F: Energy Efficiency in Buildings 2012, and CIBSE Energy Benchmarks TM46: 2008 (CIBSE, 2012) (CIBSE, 2008).

To match these benchmarks to each commercial activity in DLR, the Valuation Office (VO) provided a list of 5,181[13] commercial properties within the county boundaries, which included the business activity type, i.e. pub, hairdresser, office, etc., the floor area, and the latitude and longitude coordinates of each listing. This allowed an estimate of energy use for each commercial building based on CIBSE benchmarks applied using floor area and business type, and each building can be mapped and linked to a small area polygon. Some properties listed by the VO contained errors in coordinates and were missing essential data. After these had been filtered and discarded, the 5,165 properties remaining were analysed and mapped.

The floor area measurement used by the VO for different building uses, found in the VO's Code of Measuring Practice for Rating Purposes 2009, often differs to the floor areas used to measure energy use in the CIBSE guides. In these cases, a correction factor has been applied where applicable, for example to convert gross floor area to sales floor area, etc.

Estimating the costs of energy associated with commercial energy use is difficult as the CIBSE energy benchmarks only break down the energy use into electricity and fossil fuel consumption. The only available source of information on fossil fuel types used in this sector is from national level studies, which give a breakdown of fuels used in the industrial and services sectors, and so this is used to give an estimate of fossil fuel types consumed. Using this data will have the unwanted effect of pricing more energy use according to oil prices rather than gas prices, as there will be higher use of gas in the DLR area compared to national usage due to the penetration of the gas grid in Dublin. Therefore, costs allocated to fossil fuel uses are likely to be slightly overestimated for this sector. The costs used are from the latest SEAI *'Commercial/Industrial Fuels: Comparison of Energy Costs*', which includes all taxes and standing charges, and costs are allocated to each building taking account of the price bands used in gas and electricity pricing.

Results

The map shown in Figure 20 shows the location and energy use of each commercial property in DLR. Each location has been mapped individually to show exactly where in each small area the business is located, and shows clusters which may overlap into other small areas. Each location is marked with a coloured circle, with colour representing annual energy usage in MWh. The orange and red circles illustrate a higher than average energy use. A zoomed-in section of the centre of Dún Laoghaire can be seen in Figure 18, and the individual business locations can be identified. In this figure, the majority of activity is seen to be centred along George's Street, with many SMEs located along this route. Other areas with significant amounts of commercial activity include Blackrock, Dundrum, and Stillorgan.

Figure 18 : Dense concentration of commercial activity along George's Street in Dún Laoghaire

[13] It is important to note that it is not guaranteed that this is an exhaustive list of businesses and there may be some businesses unaccounted for.

Despite these areas containing the highest concentrations of commercial properties, the vast majority of these are involved in retail and the service industry, often SMEs with relatively small floor areas. On the immediate outskirts of these urban hubs, the activity tends to be more industrial, with larger buildings and higher energy demands. Stillorgan Industrial Park and Sandyford Industrial Estate, depicted in Figure 19, are prime examples of this. These industrial estates account for the highest area of demand in the local authority area and serve to spatially disperse the energy demand in DLR. Other areas of similarly high commercial energy demand, at Dundrum and Cornelscourt, are both consequences of the presence of large shopping centres.

The grid areas with the highest commercial energy use, above approximately 24 GWh annually, are shown in red in Figure 21. Businesses in these areas should look at cooperative ways to reduce energy consumption through shared energy systems and infrastructure, shared investments in medium scale renewable installations, and recycling of waste heat. The industrial estates, such as in Stillorgan and Sandyford, depicted in Figure 19, have buildings with large roof spaces and little over-shading issues which are ideal for commercial scale solar PV installations. These installations can greatly off-set a business's energy costs, as the panels will produce most during the day during business hours and will offset expensive daytime electricity rates. Commercial activities which produce waste heat have the opportunity to sell this heat to neighbouring businesses to meet heating requirements, thus increasing efficiency, reducing cooling requirements, and creating additional revenue.

Figure 19 : High energy demand and high volume of commercial activity within Stillorgan and Sandyford Industrial Estates

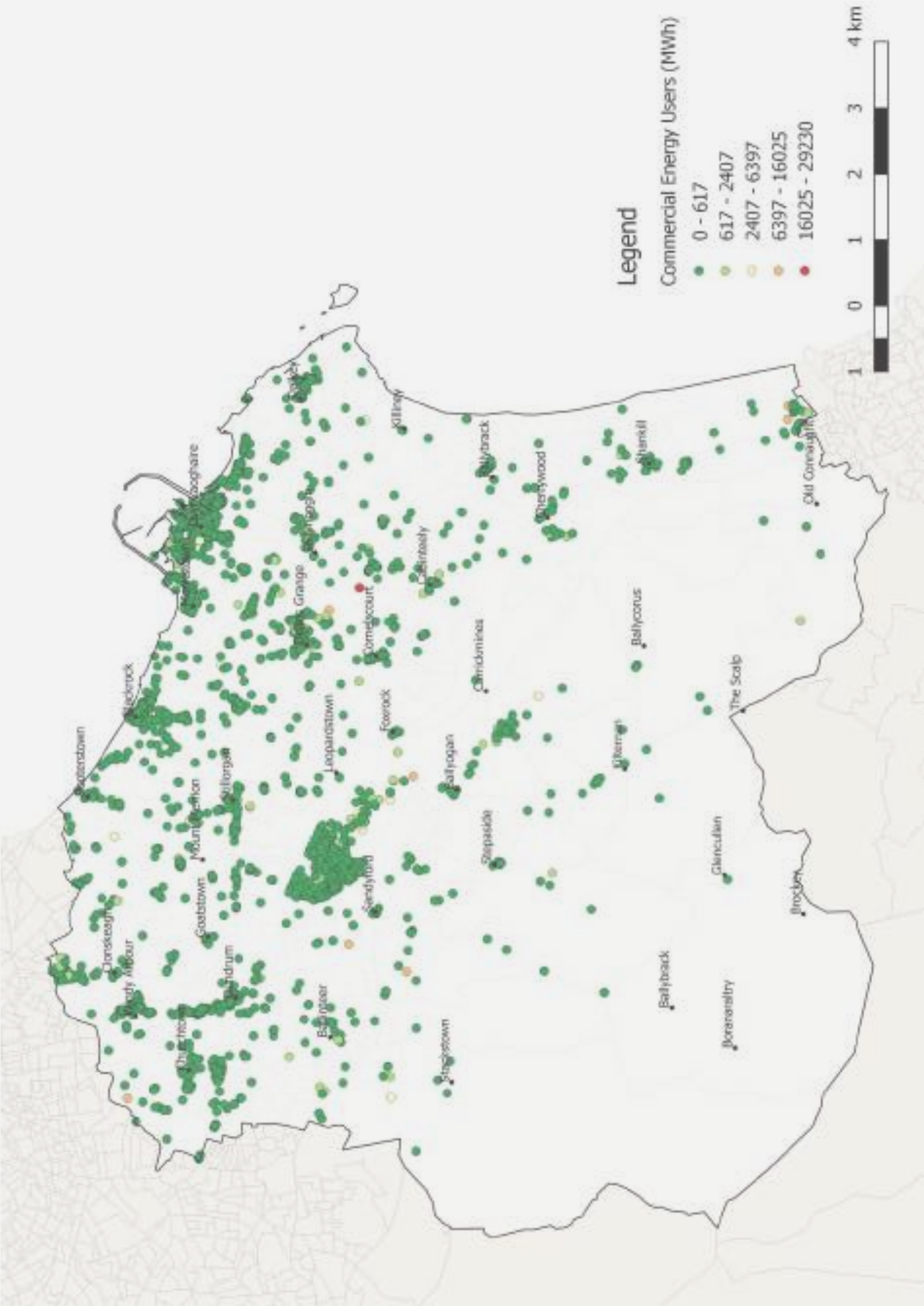

Figure 20 : Commercial Energy Users (MWh)

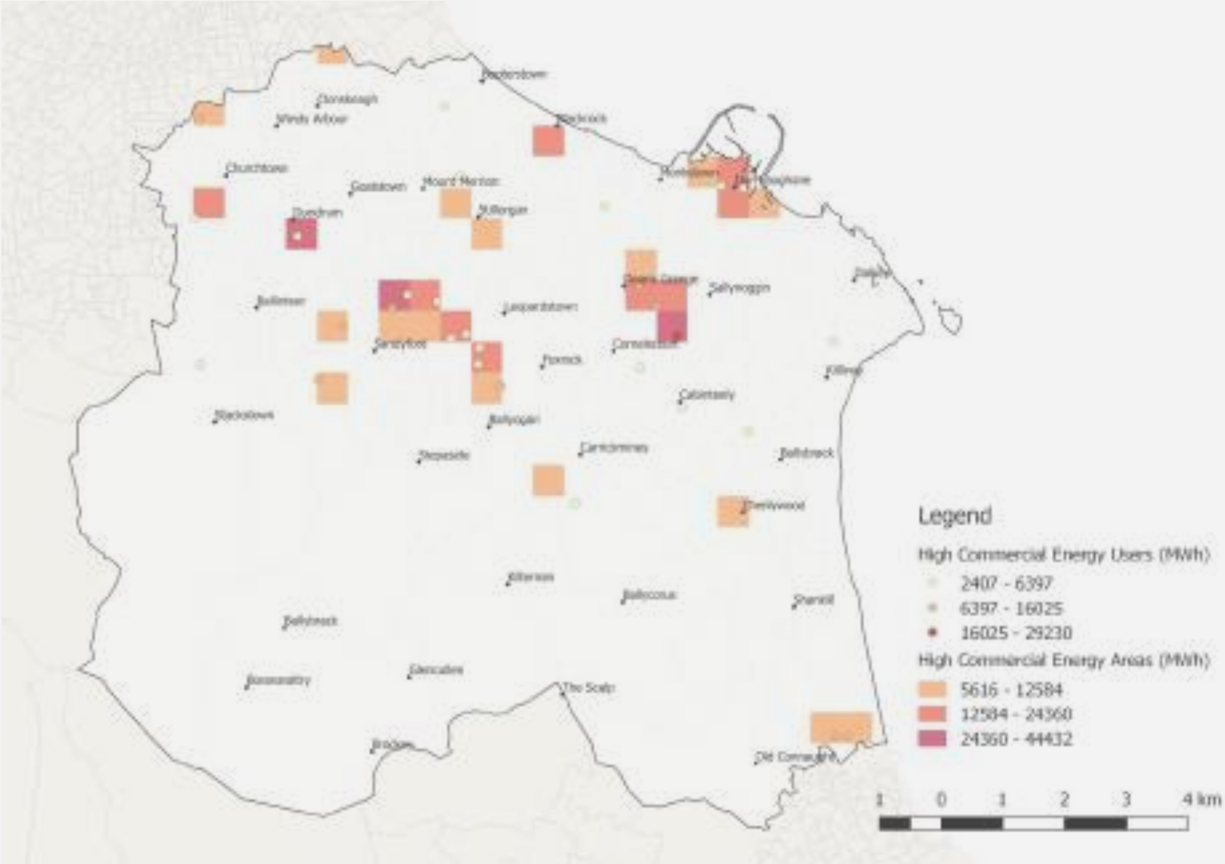

Figure 21 : Areas of Highest Annual Commercial Energy Use

Total Commercial Sector Energy Demand

The map in Figure 22 shows the total annual commercial energy usage across the entire DLR region. The areas highlighted which have high energy demands largely overlap with the clusters of commercial businesses seen in Figure 20. However, there are some outlying areas showing high demand based on one or two very large energy users, located away from any commercial or industrial hubs. For example, the area in light orange near the Wicklow border, at the Old Connawood area, contains very little retail or other commercial properties, yet includes two large factories. These are energy intensive facilities which drive up the commercial energy use in this area. Most other areas of medium to high energy demand are found in the very small and concentrated urban hubs, such as Dundrum, Dún Laoghaire and Blackrock.

In Sandyford and Stillorgan Industrial Estates, this analysis includes 726 separate commercial facilities, with an annual energy demand of 125 GWh, accounting for almost 20% of total commercial energy demand in DLR. The property uses in this area are predominantly offices, warehouses and clinics. The high energy demand of these businesses and proximity to each other within these industrial parks mean that they are in ideal positions to become energy "prosumers", whereby they actively produce as well as consume energy.

Installing large PV arrays is a common cost reduction strategy for many large commercial businesses in Europe, including Lidl, Aldi and IKEA. Additionally, many large companies have also employed wind power to supply their own demand, such as the four 3MW turbines installed in Cork Harbour by the large pharmaceutical companies based there. In DLR, the considerable amount of low lying, rural land toward the south of the county makes it suitable for wind turbine installations. There is a real opportunity for the businesses based here to create an energy group and work together to reduce their energy use and costs, and at the same time help DLR to become more sustainable.

The electricity demand of the commercial sector is shown in Figure 23, which largely overlaps with the areas of high demand, predominantly features the industrial estates and retail hubs of Dún Laoghaire and Dundrum.

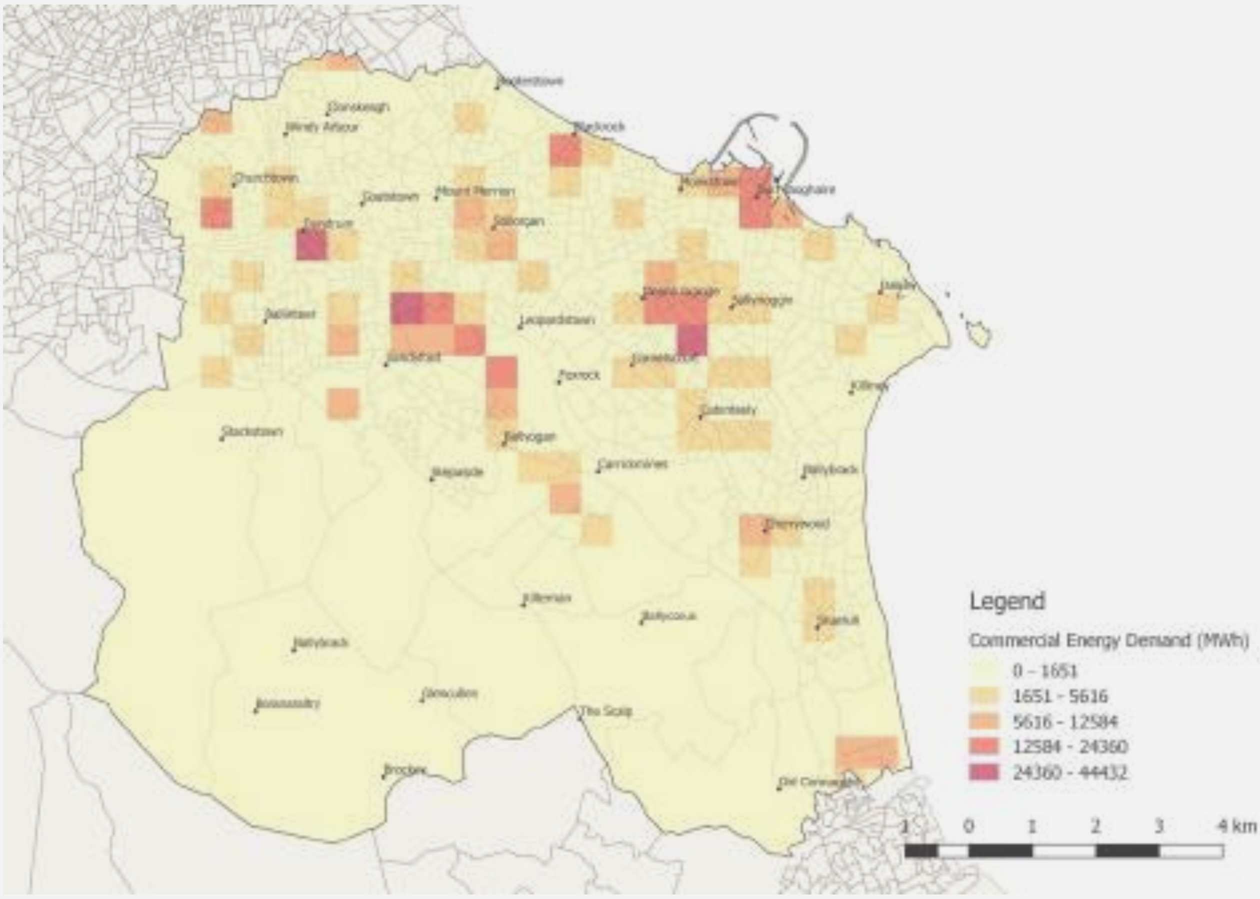

Figure 22 : Total Annual Commercial Energy Demand (MWh)

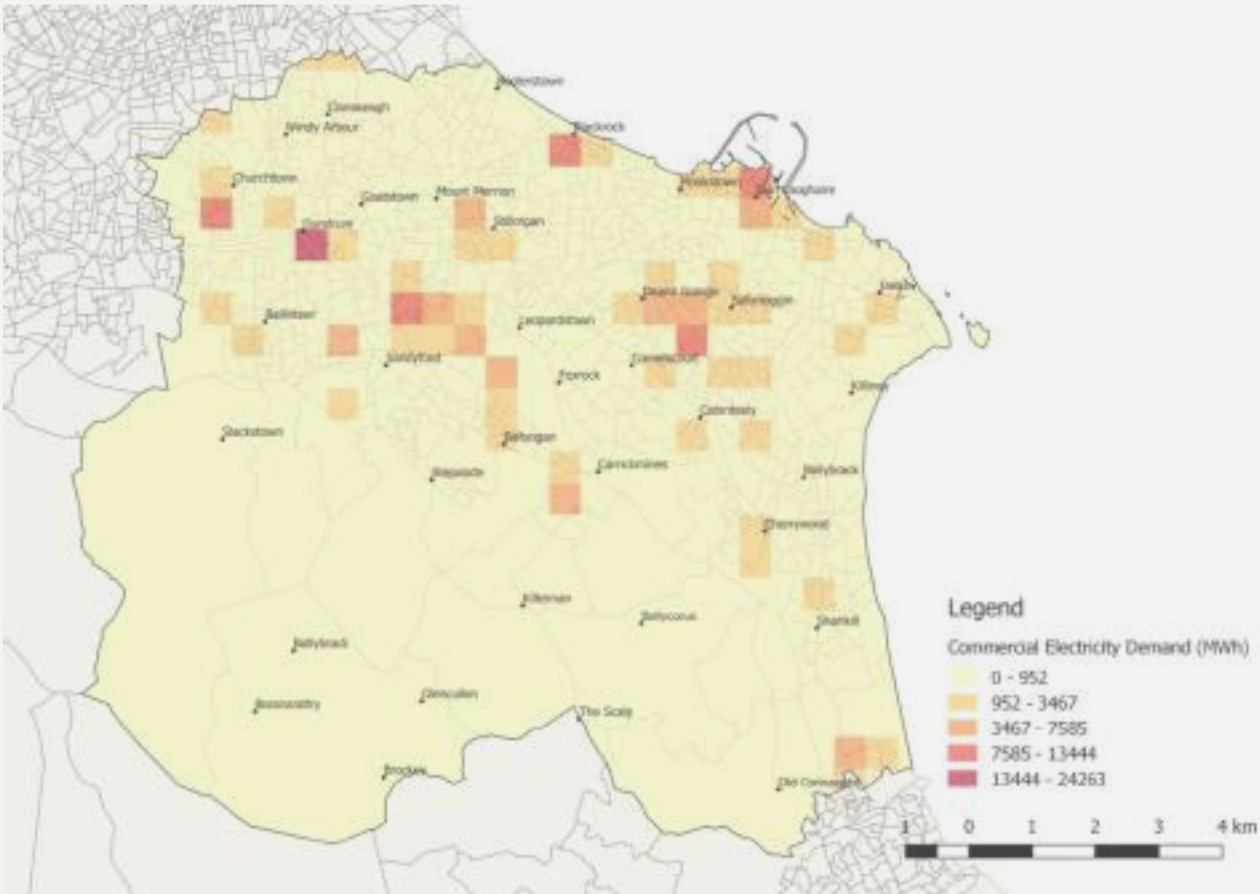

Figure 23 : Total Annual Commercial Electricity Demand (MWh)

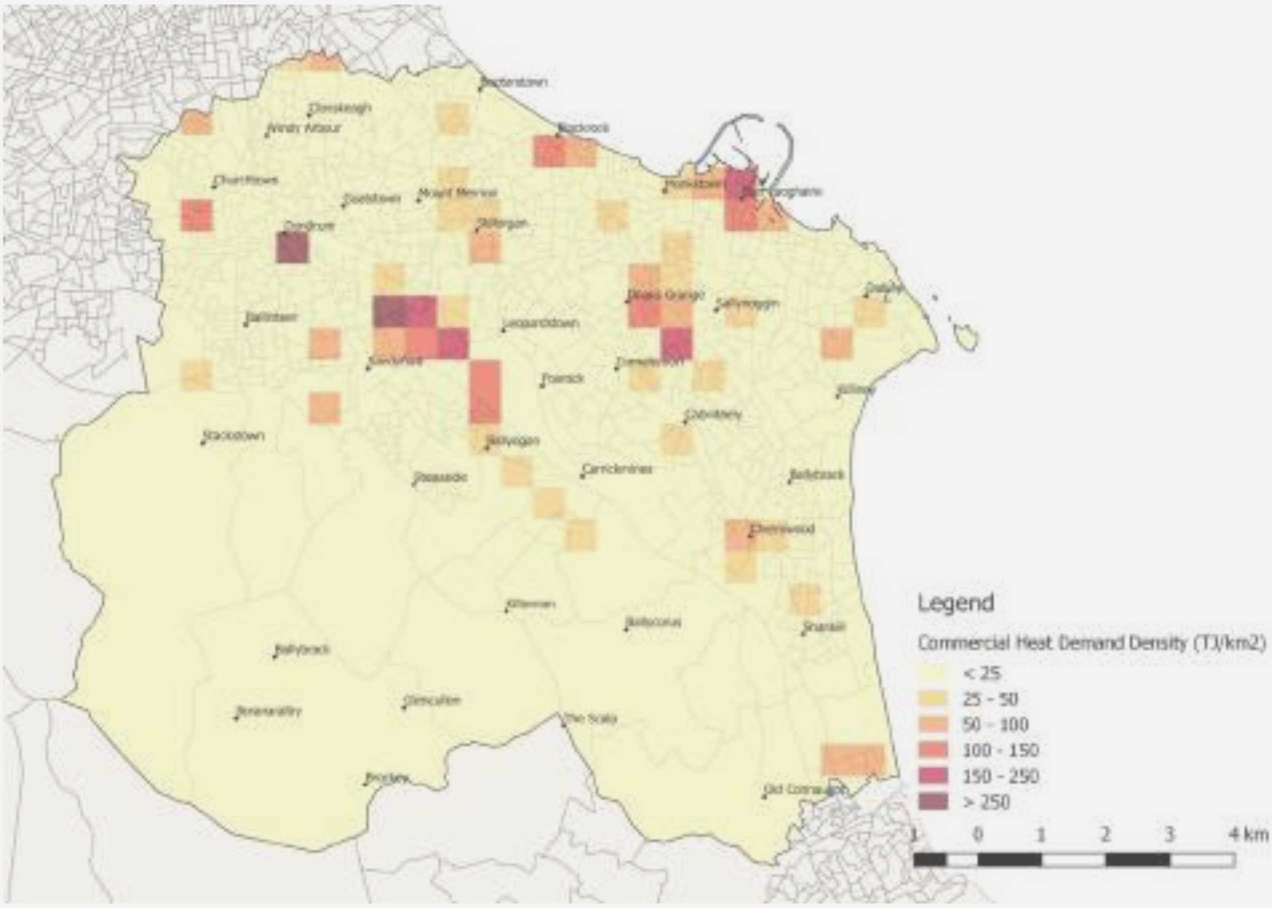

Figure 24 : Commercial Sector Heat Demand Density (TJ/km2)

Furthermore, the commercial heat density is mapped in Figure 24. As discussed previously, heat density is used to measure suitability for DH schemes. The commercial sector is particularly suitable for DH as it will typically have longer hours of demand than the residential sector, meaning a higher load factor for the centralised heating plant. Buildings with a steady 24 hour load, particularly public sector buildings like hospitals, are most economically suitable and are sometimes referred to as anchor loads.

Figure 24 shows that there are six areas within DLR that have enough commercial heat demand, >150 TJ/km^2, to make a district heating scheme feasible. Of these, two areas are considered to be particularly attractive, one of which is in the centre of Dundrum, while the other is within Stillorgan Industrial Estate. Both of these benefit greatly from the adjacency of densely populated residential areas, which is important for expanding the DH network, improving financial viability. DH possibilities will be discussed in more detail when the commercial sector energy use is combined with other sectors and total heat density is mapped.

The annual costs of energy for businesses in each small area can be seen in Figure 25. In total, the commercial sector in DLR spends approximately €71 million annually on energy costs. Aside from the taxes, utility and network charges, the majority of the rest of this revenue is exported to pay for fossil fuel imports. It is not known how many of these businesses are auto-producers, but in terms of renewable energy, the only market assessment of renewable energy in Dublin carried out by Codema (Codema, 2013) shows there is approximately 32MW installed commercial RE installations in the county of Dublin. This commercial renewable capacity amounts to approximately 106 GWh of production annually, and only a share of this is produced within the DLR area. This is a very small share of the total 1,360 GWh consumed annually, but there are positives in that these successful installations can be highlighted and replicated as best practice examples. One such installation is the 850kW wind turbine located at County Crest in Lusk. It is the only large wind turbine in County Dublin and reportedly supplies 60% of the horticulture company's electricity demand.

If more energy was produced locally through the use of local resources by local companies, more of the money spent on energy could be kept within the Dublin area and boost the local economy.

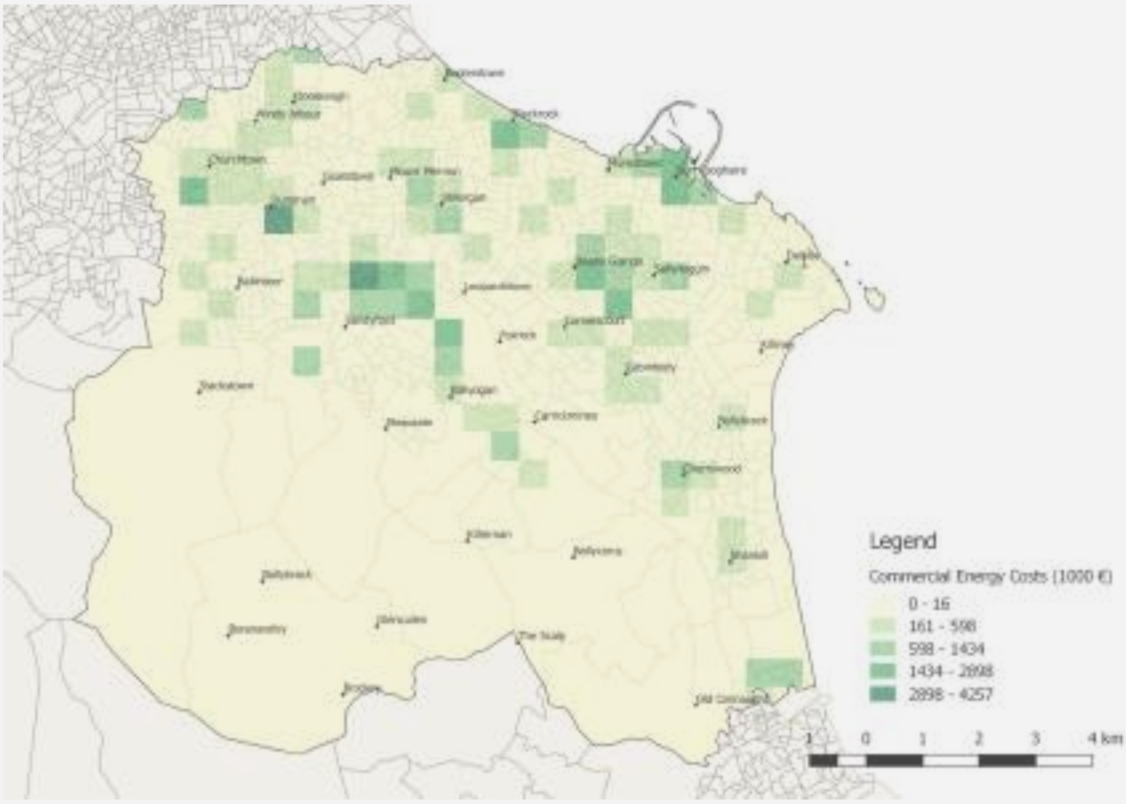

Figure 25 : Commercial Energy Costs (MWh)

Municipal Sector Energy

DLRCC is responsible for the energy use in a number of buildings within the county which provide services to the local authority area. There are over 400 known building-based energy accounts where DLRCC is responsible for the energy used. Municipal energy consumption data was available through the public sector Monitoring and Reporting tool, which lists each available electricity and gas account. After removing those accounts listed as having a zero energy demand in 2015, there are 250 energy accounts mapped. Some of these sites are located outside of the DLR boundaries. The building addresses[14] were geocoded to attach to the energy data gathered for each small area. The energy use is metered energy, and as such, is actual rather than estimated energy use.

Figure 27 shows all of the DLR energy account locations and energy use mapped. These buildings tend to cluster around the urban hubs in DLR, such as Dún Laoghaire and Stillorgan. DLRCC's County Hall building, shown below in Figure 26, has an energy demand of 2.47GWh per year. Furthermore, the Meadowbrook Leisure Centre contributes to the other dark red coloured grid division in Figure 28, with an energy demand of 2.48GWh per year.

Figure 26 : Municipal energy users including DLR County Hall

The other large energy users shown in orange and red in Figure 28 are mainly made up of similar large office buildings, fire stations and leisure centres, with some other buildings such as art museums and elderly homes also having high energy demands. These buildings also have very high energy costs, particularly those with high electricity demands due to the high cost of electricity. Other sites which may not have very high energy use, but the energy use of the site is all electrical energy, also rank highly in terms of energy costs, such as electricity provisions for halting sites.

The areas within DLR with the highest municipal energy demand can be seen in Figure 28. Those highlighted in orange and red are areas with either one large energy user, or an accumulation of different buildings which are located very close to one another, such as areas where a mix of public leisure centres, libraries, community halls, senior citizen housing and County Hall are within close proximity. Additionally, the top five consuming DLRCC buildings are listed below in Table 3 below. DLR is primarily a suburban, residential area and so it is not surprising that the three of these top five are public amenity facilities.

DLRCC Building	Elec (GWh)	Heat (GWh)	Total Energy (GWh)
Meadowbrook Leisure Centres	0.24	2.24	2.49
Civic Offices, Dún Laoghaire	0.85	1.63	2.47
Monkstown Leisure Centre	0.11	1.63	1.74
Loughlinstown Leisure Centre	0.54	0.95	1.49
Ballyogan Depot	0.49	0.18	0.67

Table 3: Top energy consuming DLRCC buildings

Implementing good practice in energy management in public buildings and leading the way in sustainable energy practices in the public sector is a good way to showcase sustainable solutions, as the public will often visit these premises, and also to encourage commercial building users by leading by example.

[14] Approximately 50 of these account addresses could not be geo-coded and therefore could not be mapped. Although every effort has been made to obtain accuracy, those which have been geo-coded may not be at the exact location of the building but within the same general area.

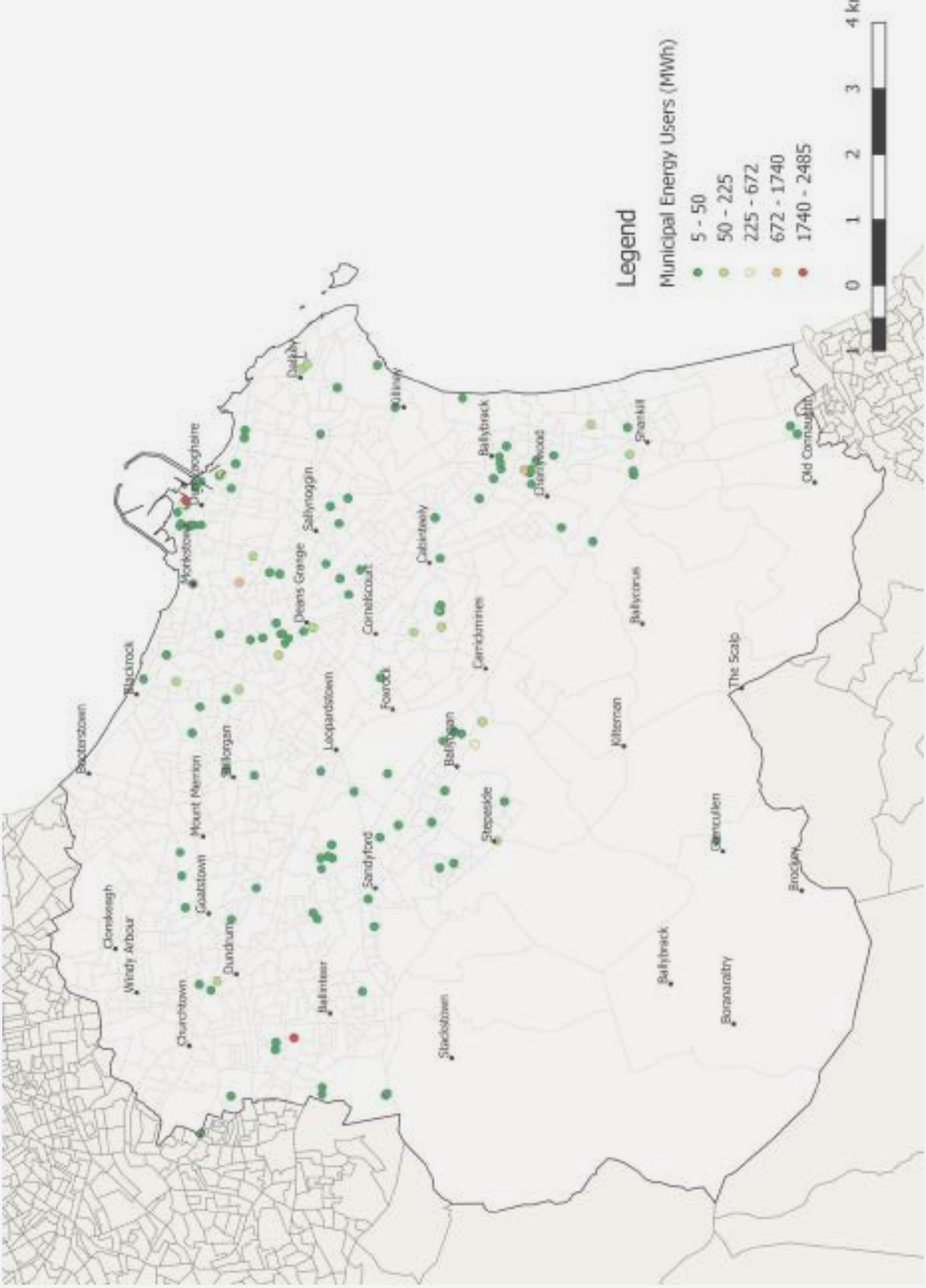

Figure 27 : Municipal Energy Users (MWh)

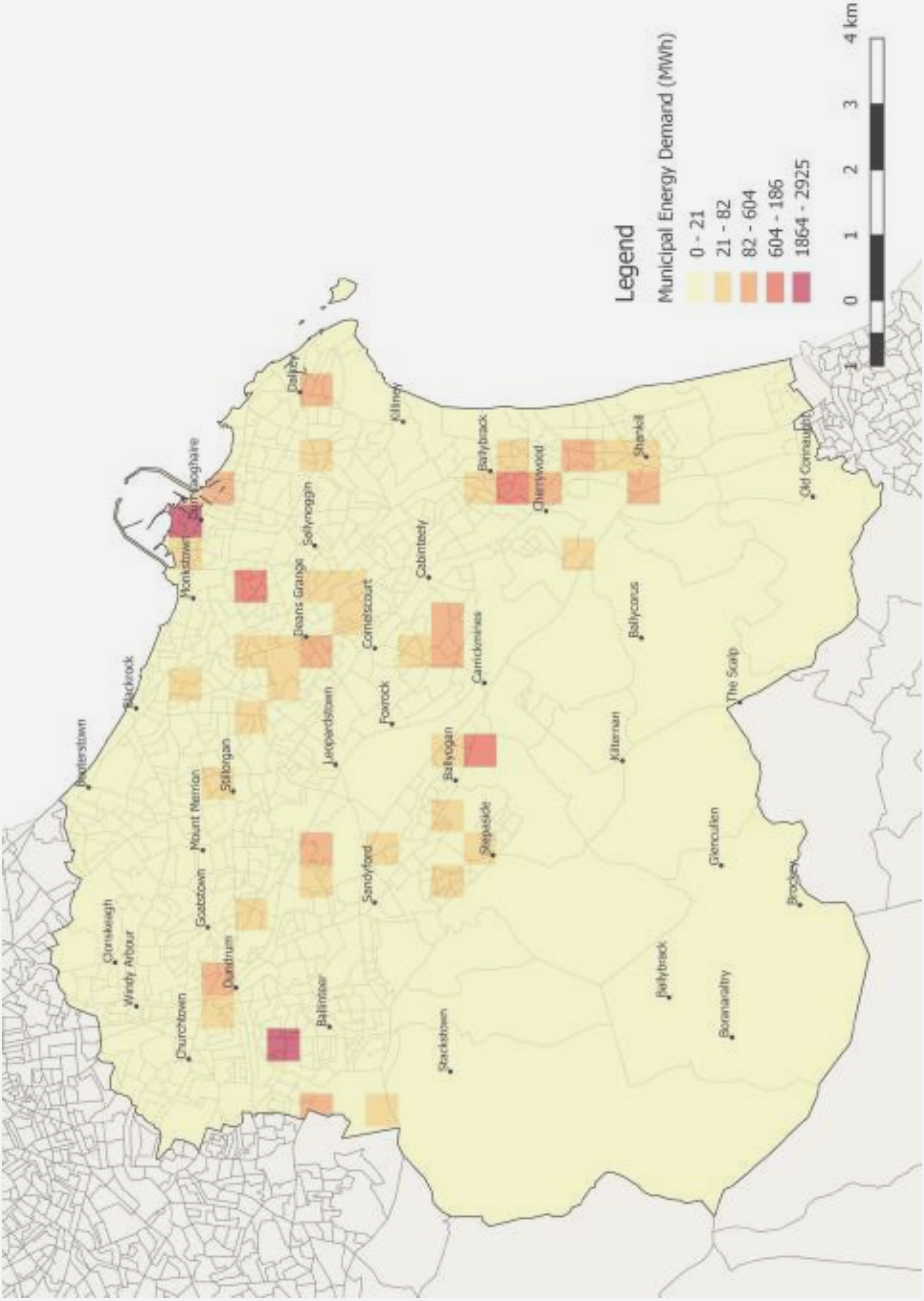

Figure 28 : Total Annual Municipal Energy Demand (MWh)

Total Energy in all Sectors

This section examines the resulting total energy demand throughout DLR once all residential, commercial and municipal energy demands are combined.

Total Energy Demand of All Sectors Combined

The total direct energy use in all sectors analysed in this SEDA is 2.60 TWh annually, as illustrated in Table 3. Of this, 2.08 TWh is used to meet heating demands which is equal to 80% of overall energy use. This is a vast amount of energy being used to heat buildings, which in the case of DLR, are primarily residential, and should be of first priority when addressing issues of sustainability. This will be further discussed in reference to district heating later in this section.

Due to the current energy mix in Ireland, especially for the heating sector, this means that fossil fuels provide the vast majority of energy consumed in DLR. The difference between fossil fuel use and heat demand takes into account fossil fuel consuming machinery in industrial and commercial practices.

A map showing the total annual energy demand throughout the county can be seen in Figure 29. The highest areas of energy use are dominated by those with large commercial activities such as Dundrum, Cornelscourt and Sandyford. The range of demands coloured dark orange represent mainly built up residential and lower scale commercial areas. DLR is visibly divided between the densely populated areas from Ballinteer to Killiney, and the less populated, rural areas to the south. Within the former, there are a number of areas of higher activity and demand, such as Dún Laoghaire, Stillorgan, Blackrock and Dundrum, but for the most part, demand is reasonably evenly distributed. Residential population is seen to be the greatest indicator of energy use as it accounts for 75% of the total demand.

Additionally, there are a number of outlying, non-residential areas of high energy demand, including a number of food preparation facilities near Old Connaught in the south of the county. These areas are just as important to target for energy reductions. Since these areas are further away from built up areas, they can have advantages for renewable energy integration, such as less traffic issues regarding transport of biofuels and biomass, distance from dwellings which may make it easier to implement small to medium scale wind power, and in terms of PV installations, potentially less over-shading issues from neighbouring high-rise buildings.

In order to match RE technology to energy demand, it is important to understand how much demand for heat, fossil fuels and electricity is needed in each area. Implementing a large CHP unit in an area to meet electricity requirements is no use if there is not sufficient local heat demand. Buildings with large heat demands, small electricity use and south facing roof spaces may be better suited to solar thermal installations than solar PV.

Figure 30 shows the total annual fossil fuel use throughout DLR. It can be seen that the distribution of fossil fuel use follows closely the distribution of total energy use, as fossil fuels are so dominant in every sector's energy mix.

The high use of fossil fuels in the residential sector, which is mostly used for heating needs, can be replaced with renewable and sustainable solutions. When looking to replace a gas or oil boiler, households should be encouraged to prioritise the most sustainable options. As mentioned earlier, there are grant supports for homeowners installing new gas or oil boilers, but no supports for biomass or biofuel boilers, or any heat pump systems. This limits homeowners' options, the only RE heating solution supported is solar thermal, but not all dwellings will be suited to this solution. Commercial sector buildings which are planning to install CHP units sized to offset electricity use could look at providing nearby households with heat, thereby allowing the CHP to run at high efficiency mode for longer, produce the maximum amount of electricity possible, and create an additional revenue stream. As can be seen in the maps, there are plenty of heating demands in close proximity to large commercial buildings.

Sector	Total Energy (TWh)	Total Heat (TWh)	Total Electricity (TWh)	Total Fossil Fuel (TWh)	Total Costs (€millions)
Residential	1.95	1.71	0.32	1.62	165.97
Commercial	0.64	0.36	0.25	0.39	71.76
Municipal	0.01	0.01	0.00	0.01	0.77
Total	2.60	2.08	0.58	2.01	238.50

Table 4: Energy Demand Breakdown per Sector and Fuel in DLR

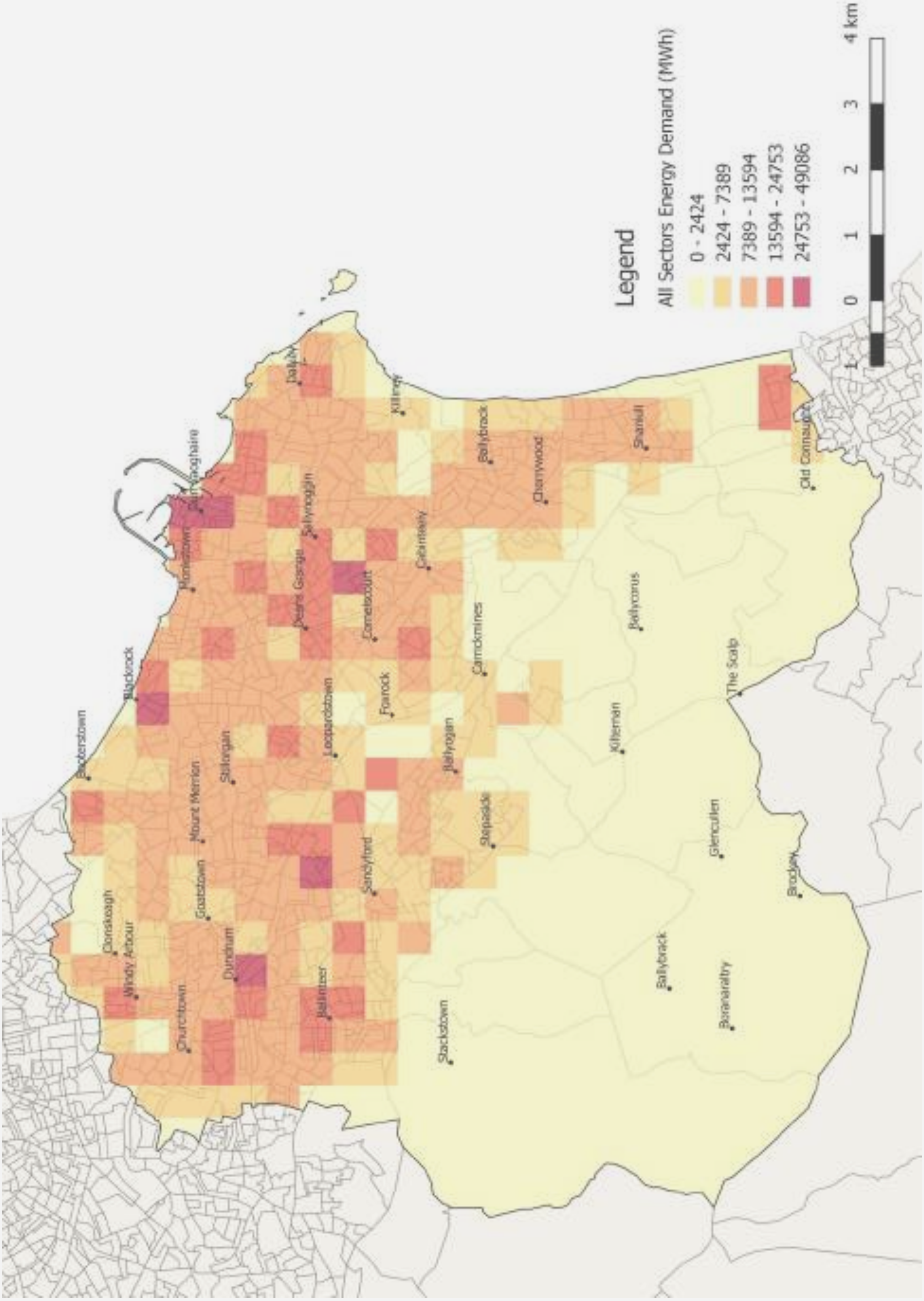

Figure 29 : Total Annual Energy Demand of All Sectors (MWh)

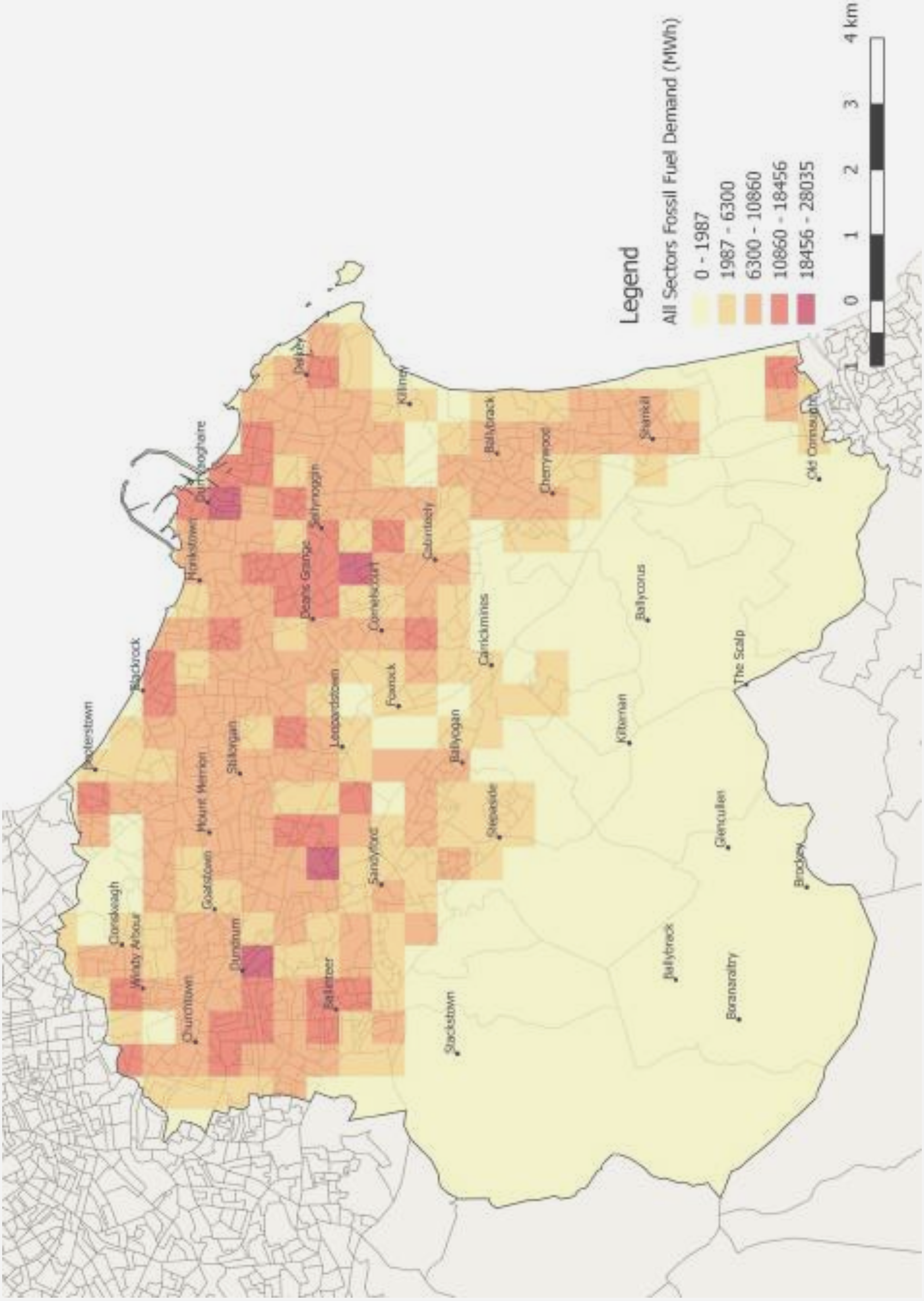

Figure 30: All Sectors Fossil Fuel Demand (MWh)

The total electricity demand in DLR is presented in Figure 34. In contrast to the demand of fossil fuels, the distribution of electricity demand does not follow that of total energy demand so closely. The highest levels of electricity usage tend to be in areas dominated by commercial and industrial activities, not residential. This is because most residential areas will typically have 25% or lower electricity share of total demand, while commercial applications tend to require more electricity. These areas will most benefit from a source of low cost renewable electricity to offset the high costs of grid electricity. In terms of alternatives, wind, hydro and solar PV are all well-established renewable electricity generating technologies, with bio-fuelled CHP a highly efficient sustainable option for businesses which also have a heat demand.

The total cost of energy use annually in DLR is €238.5 million; €166 million in the commercial sector, €71 million in the residential sector and just €0.77 million in the municipal sector. The areas with the highest energy spends are highlighted in dark green in Figure 35. The highest energy spends interestingly correlate with areas of high electricity demand, particularly in areas of high commercial energy consumption. The costs in the areas shown in dark green range from €2.3 to €4.6 million annually.

District Heating Potential

As discussed in the introduction, heating is fundamentally a local and regional issue and national level energy strategies often do not deal with heating effectively. As there is no national heating grid, in the same way as there is a national electrical grid, there is no real way to deal with heating from a top down approach. Typically, heat is provided by individual heating plant and equipment within each building, fuelled mainly by gas in the case of DLR.

DH is a real way to influence the way we currently think about heating provision. This more holistic approach to meeting heating requirements means one large highly efficient renewable or sustainably fuelled heat plant can supply almost all of the heating requirements to numerous buildings without the need to pressure each individual to install a new renewable heating system in their building.

The heat density of each grid division is shown in Figure 36. Using the same thresholds for DH viability typically used by Danish energy planners in their own municipality areas (150 TJ/km^2), there are a number of areas in DLR that would be classified as suitable for DH. A more detailed map of this area is shown in Figure 31.

As discussed in previous sections, the areas with the most highly concentrated heat demand are those with considerable commercial activities present. However, it is highly preferable for these anchor loads to be adjacent to residential communities in order to maximise possible demand and improve viability. There are also many areas dominated by residential buildings containing 150 - 250 TJ/km^2 heat densities which would also be deemed very suitable for DH schemes. This is particularly the case with Dún Laoghaire as the commercial hub is situated adjacent to the residential areas of Monkstown and Killiney. These areas have an ageing housing stock and dwellings with old heating systems which have low efficiencies. Many of these housing units will soon look to replace these systems, and implementing a DH system instead of multiple individual fossil fuel boilers will create lower heating costs due to economies of scale and will allow easier integration of RE and waste heat sources into the heating systems of these homes.

Another area of high potential, depicted in Figure 33, is the commercial and retail hub of Dundrum, situated around 1.5km from Sandyford Industrial Estate and surrounded by the built up residential areas of Dundrum, Ballinteer, Stillorgan and Goatstown. The distance to Dublin City Centre is just over 4km, so it is very possible that a future DH system could connect the intensely concentrated commercial activities in Dublin City to a growing residential and commercial population in DLR. An interesting precedent is presented in Figure 32, whereby the Copenhagen DH system (the largest DH system in Denmark) was established in Copenhagen City Centre, and the network has expanded all the way to Roskilde, which is approximately 40km away.

Figure 31 : High District Heating Potential in Dún Laoghaire

Figure 31 : The Greater Copenhagen DH System (Danish Energy Agency)

The network can expand to these areas by connecting new heat generation facilities along the route, such as large CHP plants, waste heat from cement factories, incineration plants, etc.

Anchor loads for DH systems are loads which allow the heating plant to run for longer hours (e.g. 24-hour demands), have a more steady load than other demand types (less large peaks in demand), are likely to be based in the same building for a long time, and are in the public sector as they are likely to be a more financially secure customer. Locations of these type customers are highlighted in Figure 37, with the green squares representing hospitals, nursing homes, large industrial facilities with heat demands, leisure centres, colleges, and fire stations. Yellow stars are municipality buildings with high heat demands which can become crucial guaranteed customers in a municipality-led DH project.

The red markers in Figure 37 represent potential industrial waste heat providers. Waste heat sources can generally be provided at a much lower cost than other heat sources, and can therefore have a very positive effect on DH system economics. The industries highlighted include large concrete works and large factories. The exact amount and usefulness of this waste heat should be further analysed, along with sources which are not highlighted such as CHP plants which are under- utilised.

As previously mentioned, heat demand accounts for 80% of DLR's building energy demand and is currently almost entirely supplied by imported fossil fuels. If DLR can implement sustainably fuelled DH schemes in areas of high demand, it will have a huge effect on current fossil fuel use and CO_2 emissions, and the overall sustainable image of the county. This SEDA gives the local authority the information they need to begin the process of effectively planning for DH networks throughout the DLR area.

Figure 33 : Areas of High Potential for District Heating Scheme around Dundrum

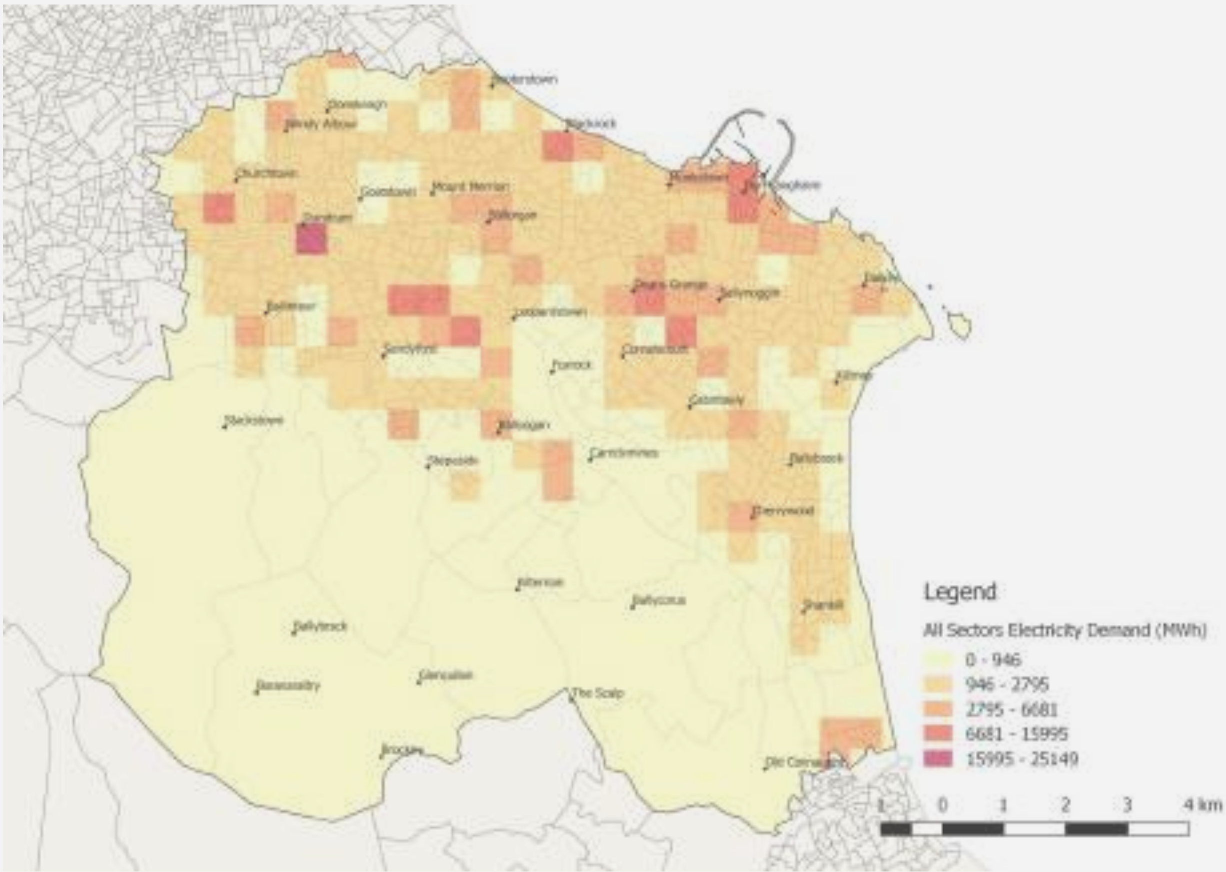

Figure 34 : All Sectors Electricity Demand (MWh)

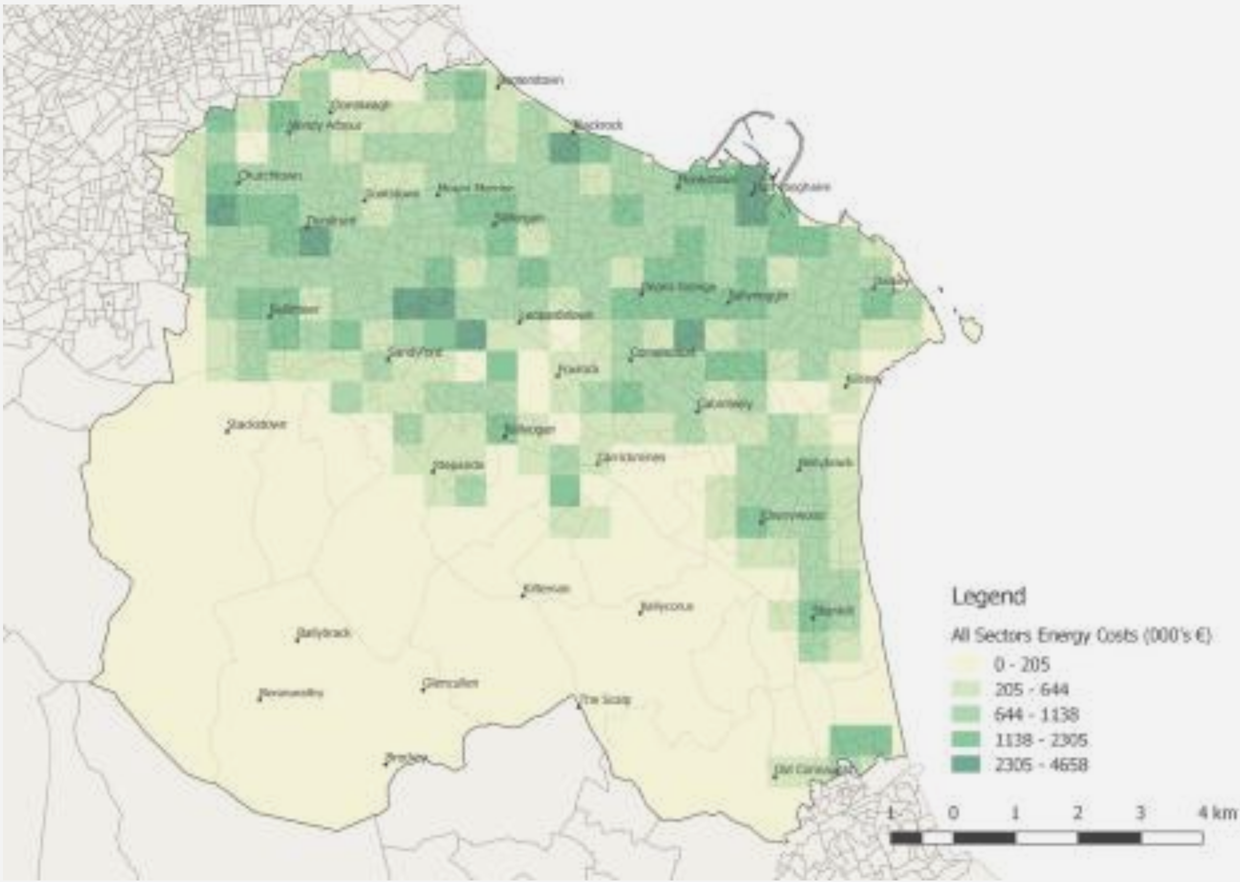

Figure 35 : All Sectors Energy Costs (1000's €))

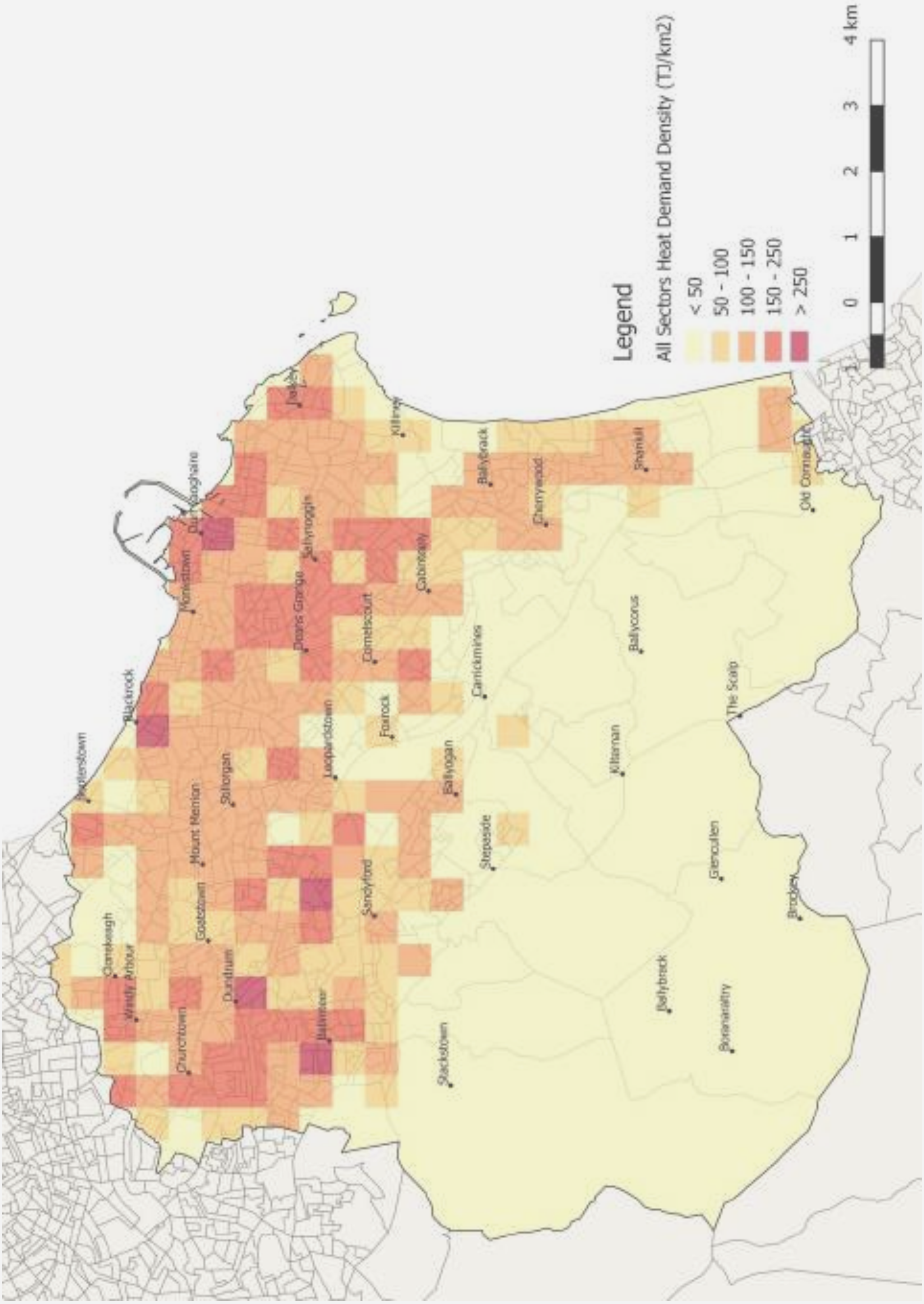

Figure 36 : All Sectors Heat Demand Density (TJ/km^2)

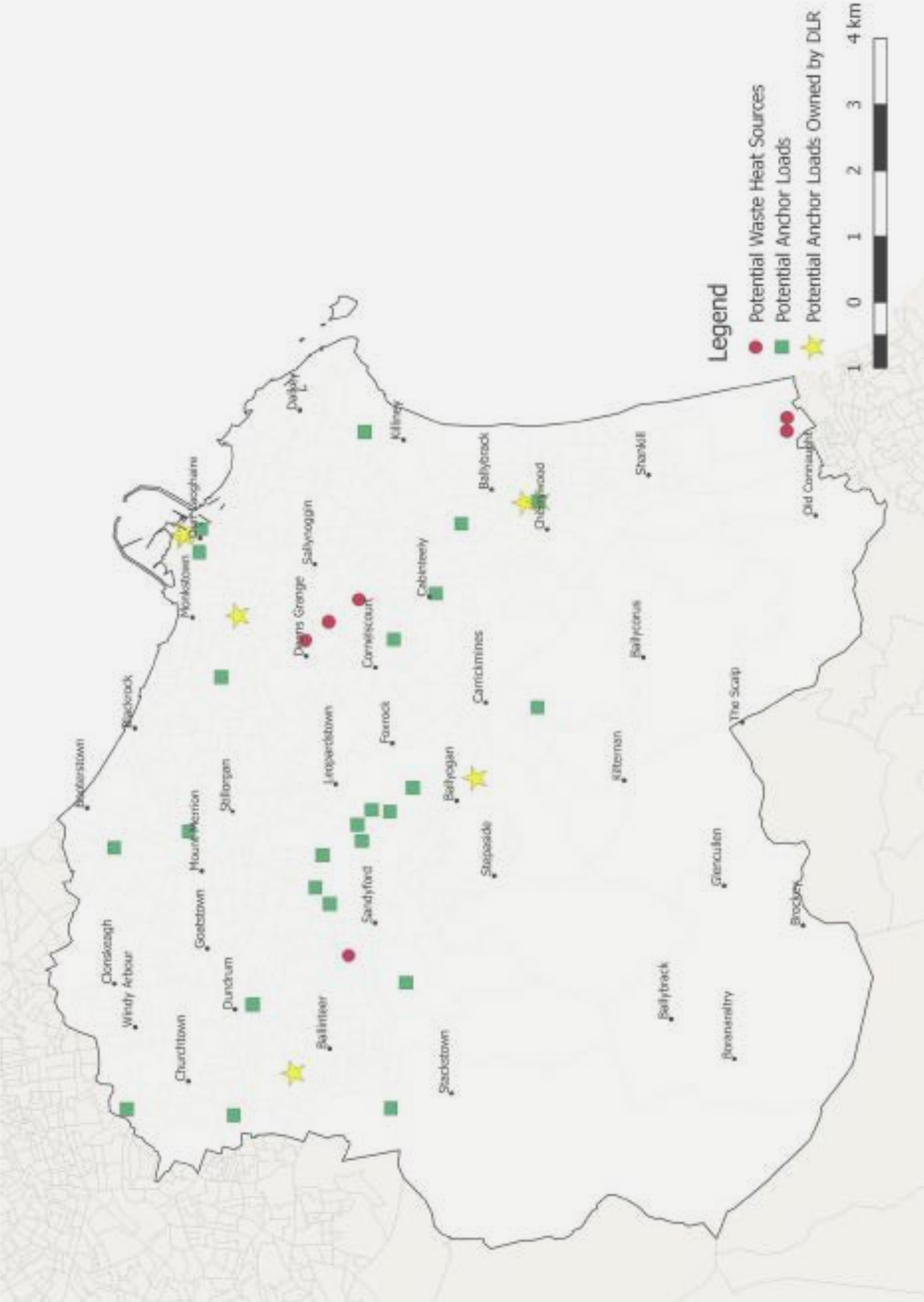

Figure 37 : Potential Anchor Loads and Waste Heat Sources

Renewable Energy Resources in Dún Laoghaire-Rathdown

The SEDA has shown a spatial representation of the energy demand in DLR. The type of energy demand and location of this demand is specific to DLR due to many influencing factors such as the building construction periods, availability of fuels in this area, topology, geography and urban and spatial planning regulations. This region will also have renewable resource potential specific to its landscape, influenced again by many local factors such as the geology, anemology, hydrology, geography and urban and spatial planning regulations of the area.

Important to note in terms of financial feasibility of all small-scale renewable installations is that there are currently no feed-in tariffs being offered for power fed to the grid from micro-generation installations. This means that the size of these installations needs to be carefully matched to the owners' own power demands so that all power produced is used and not exported without payment. Commercial scale installations can negotiate a power purchase agreement with utilities and can apply for Renewable Energy Feed-In Tariffs (REFITs) which are available depending on eligibility.

Geothermal Resources

Geothermal energy is solar energy stored in the form of heat within the earth's surface, heating the soil itself or groundwater beneath the surface. It is used to produce heat to meet building heating requirements, and can produce both space and hot water heating, but is most commonly used for low-temperature space heating.

The makeup of the soil and bedrock in DLR will affect the suitability and potential to exploit geothermal resources. Geothermal resources are classified into 'shallow' and 'deep' geothermal resources. Shallow geothermal is a relatively low temperature heat source found up to 400m below the surface which is boosted through the use of a heat pump to useful heating temperatures. Deep geothermal involves drilling boreholes deeper than 400m below the surface to obtain higher ground-source temperatures usually hot enough to use directly. A good example of geothermal energy in Ireland is IKEA's 1.5 MW installation at their store in Dublin 11. The project consists of seven ground source heat pumps, 150 boreholes, and is the largest of its kind in Ireland or the UK.

The Geological Survey of Ireland (GSI) Shallow Geothermal Energy Resource Project has produced maps which show the shallow geothermal energy suitability of areas across Ireland. The maps show the suitability of different types of systems (open loop and closed loop) and for both domestic and commercial applications. These maps can be accessed on their website at http://www.gsi.ie/Mapping.htm. As can be seen in Figure 38 DLR has a significant area classified as suitable for closed loop geothermal energy. In relation to this, the south-west is where the majority of this resource is currently known to be available. Additionally, there are many areas classified as probably suitable and possibly suitable for geothermal technology. This suggests a considerable resource could be available to the inhabitants of DLR. With regard to open loop geothermal, there appears to be no very promising areas, aside from a few regions in the north and south where there are "possible" resources.

The GSI has also produced a homeowner manual for ground source and geothermal energy which explains the whole process and terminology involved, and estimated costs of installations, which can be found on http://www.gsi.ie/Programmes/Groundwater/Geothermal.htm

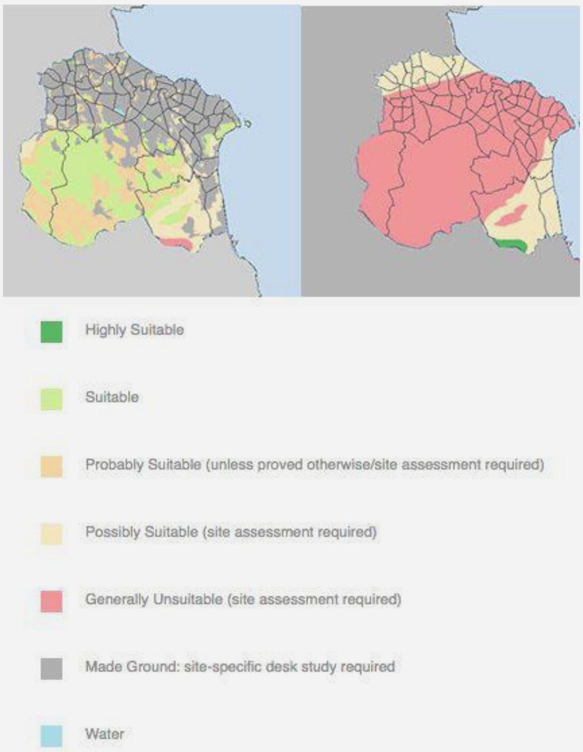

Figure 38 : Maps showing the vertical closed loop geothermal (left) and open loop domestic geothermal (right) suitability within DLR county (SEAI, 2004).

Wind Resources

Wind turbines are a well-established technology for producing electricity and Ireland's vast wind resources contribute greatly to the renewable national electricity mix. In DLR, there is a wide variety of land use. In the urban and residential hubs such as Blackrock, Dundrum and Dún Laoghaire, wind power technology may not be suitable due to the lack of space, low altitude and disruption of laminar flow caused by buildings and other obstructions. However, there is a significant amount of lower populated, rural land in DLR which could facilitate wind turbine installations, given the support of the local communities. This has already been achieved by Lusk based vegetable producer, County Crest in Fingal. Here, an on-site wind power installation creates an example for how businesses in DLR can use local renewable resources to reduce their energy costs and carbon footprints. There are some other stand-alone turbines in the county of Dublin, many of which have been identified in Codema's RE market assessment, which can be downloaded at this link:
http://www.codema.ie/images/uploads/docs/Renewable_Energy_Report.pdf

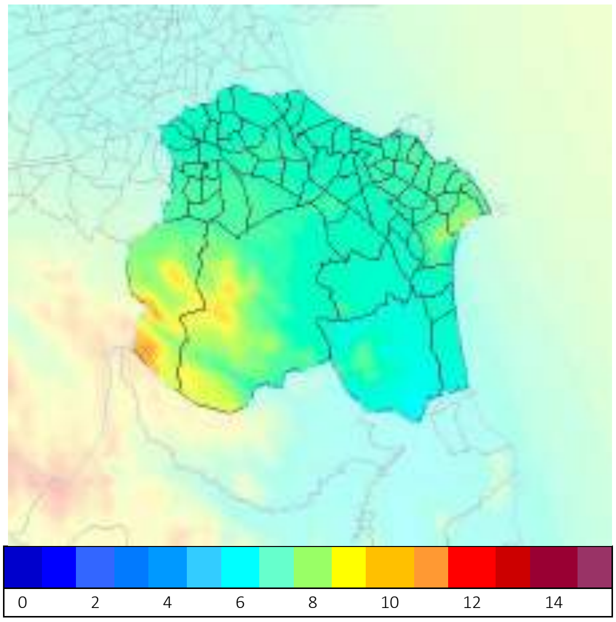

Figure 39 : Map Showing Average Wind Speed in DLR

SEAI provides a wind atlas of Ireland, which gives approximate average wind speeds throughout the Republic of Ireland. These speeds are available at varying heights. Figure 39 depicts the wind speeds approximated for 75m heights. DLR is seen to have average wind speeds around the 6 – 7 m/s mark, while higher areas in the south have up to 10 m/s average wind speeds. These areas of higher wind speeds include Stackstown, Rockbrook and Glencullen. DLR's maritime location also means that near shore wind projects may be a possibility.

Hydro Resources

Hydroelectric power involves the production of electricity through a generator which is powered by the force of moving water. It is used at very large scales in some countries which have vast river resources and high mountainous areas, such as Brazil, where hydropower provides over 75% of the country's electricity. The biggest hydro sites in Ireland are found at Ardnacrusha, Cathleen's Fall and Pollaphuca, the latter being fed by the River Liffey. Suitable sites are sites where there is a running flow of water year round, where this flow has a high fall height (or head height), and where re-routing the water resource through a turbine will not have a negative effect on the environment. Schemes can either use the flow of the river directly ("run-of-river" schemes) or build a small dam or reservoir to increase the flow when the river has a low flow rate. A site assessment measuring the quantity and speed of flowing water should be conducted to evaluate the potential hydro power output. A very useful guide on how to develop small scale hydro power is available from the European Small Hydropower Association at the link: http://www.esha.be/fileadmin/esha_files/documents/publications/GUIDES/GUIDE_SHP/GUIDE_SHP_EN.pdf

DLR has no large rivers, but has many other smaller rivers and streams, in total around 30. There is no water flow data available for hydro resources in DLR. For the most part, it is quite a flat land area, and so head heights on these waterways will not be very substantial. The higher the head height, the higher the flow speed of water and the more power can be generated. However, there are some areas closer to the Dublin Mountains that would be more suitable. There are currently no hydro plants in operation in DLR and feasibility studies would need to be carried out to gauge the suitability of these areas.

Solar Resources

Solar energy production involves using the energy from the sun to produce either heat or electricity. Solar thermal installations use the heat energy from the sun to heat water and solar photovoltaic (PV) installations convert energy from light into electricity. The only resource needed for these installations is a space which is facing the daytime sun direction (south-southeast is best in Ireland) and is free from nearby tall obstacles which may cause over-shading issues.

Figure 40 : Solar Suitability Map, Copenhagen

From analysis of actual PV installations in DLR, the solar resources in Dublin allow approximately 800-1000kWh/kW/year to be produced with a south facing installation. A 1kW installation will therefore provide approximately one fifth of the average household's electricity requirements and save €250/year on electricity bills. If all houses (not including apartments) in DLR installed only 1kW of PV panels on their roofs, the potential output is over 67.5 GWh/year, which is nearly 20% of the residential sector electricity demand[15]. Solar power has real potential in DLR, and in order to further analyse the total solar electricity potential resource, a solar atlas which outlines the viability of each roof space should be created. Similar atlases have already been developed in other countries, such as that available in Denmark, an example of which can be seen in Figure 40. This map outlines each roof space and is colour coded to show if the roof is suitable or not suitable for solar PV.

The costs of solar PV installations have fallen over the last ten years due to increased demand. In 2014, installation prices were at €1.03/watt, with the panels themselves costing €0.56/watt (ISEA, 2014). A $1m^2$ panel will have a max output rating of approximately 0.25 kWp, depending on cell type and manufacturer. As mentioned at the beginning of this chapter, there is no feed-in-tariff available for small renewable electricity generators, and therefore the installation should be sized to the daytime load so that all energy is used within the building. This limits the size of installations in some cases, unless a battery system is installed to store the energy to use for night time demands, but this can add significantly to the costs.

Solar thermal collectors, which produce hot water rather than electricity, come in two types: flat plate and evacuated tube, where flat plate collectors are designed so they can be incorporated into the roof rather than being installed on the roof and the evacuated tubes are on-roof installations only. The tubes allow approximately 20% higher energy yield per m^2 of roof space than flat plate collectors. The heat is most often used for hot water demands, but is in some cases used for space heating where low temperature space heating is sufficient. A typical household installation will provide approximately 50-60% of the yearly hot water demand, depending on the roof space available. Around $1m^2$ of solar thermal collectors per person is a rough guide to the size of installation required per household (SEAI, 2010). The SEAI estimates costs of between €800 and €1300 per m^2, and they currently offer grants of €1,200 toward home solar heating installations. Solar thermal can be a more economical choice and a better use of roof space over solar PV for households with little or no daytime occupancy as the hot water will store in the insulated hot water tanks for use in mornings and evenings. Heating is the biggest reason for fossil fuel use in buildings in DLR, and off-setting this energy with renewable sources would reduce this dependence and reduce costs for homeowners.

Bioenergy Resources

Biomass is any organic material, like wood or plants, biofuels are liquid fuels made from the processing of biomass, and biogas is gas fuel extracted from the organic breakdown of biomass (anaerobic digestion). All energy derived from these sources is called bioenergy. Since organic material can be regrown, this energy is a form of renewable energy. Like any other fuel, biomass, biogas and biofuels can be transported to be used in any location. For sustainability reasons, the bioenergy sources should be sourced as close to the point of use as possible in order to lower the life-cycle energy.

With Ireland's large agricultural sector, there is a vast resource of farm waste that can be used for production of bioenergy. Rural areas are also ideal for growing bioenergy crops such as willow and miscanthus. The resources for growth or recycling of organic material in DLR are moderate. Although roughly half the land area is occupied by built up suburban residential areas, there is also a significant portion of rural land to the south capable of growing energy feedstocks.

The map in Figure 41 shows the suitability of land for miscanthus, oil seed, reed canary grass and willow growth. The purple area is all land which is unavailable, primarily located in the built up urban and residential areas in DLR, including Blackrock, Dundrum and Dún Laoghaire. There are a few areas in DLR, however, that

[15] Some houses will not have any south facing roof space, while others will have space for more than $1m^2$ of south facing PV panels. Apartment complexes could also install rooftop panels.

are deemed to have a medium to high suitability for growing energy crops, mostly in the south of the county. Much of this land is already occupied in agricultural production, so competition for land usage may be an issue.

Despite the vast potential for energy crop growth in DLR, a small amount of Spring Oil Seed Rape is the only energy crop grown in the county. Reasons for this include competition for land with food growth and animal grazing.

Currently, the biggest renewable energy source used in DLR is biomass. Biomass fired CHP units and boilers are widely used in commercial applications. Because biomass can be used in boilers just like any other fuel, they can easily be incorporated into existing wet heating systems. Like oil, the fuel must also be delivered in bulk and stored, so the only limiting factor is storage space and delivery access.

Even at a smaller scale, replacing open fires with wood burning or wood-pellet stoves will greatly increase efficiency and reduce costs and fossil fuel use. Wood logs are widely available and sold in many local grocery stores and petrol stations.

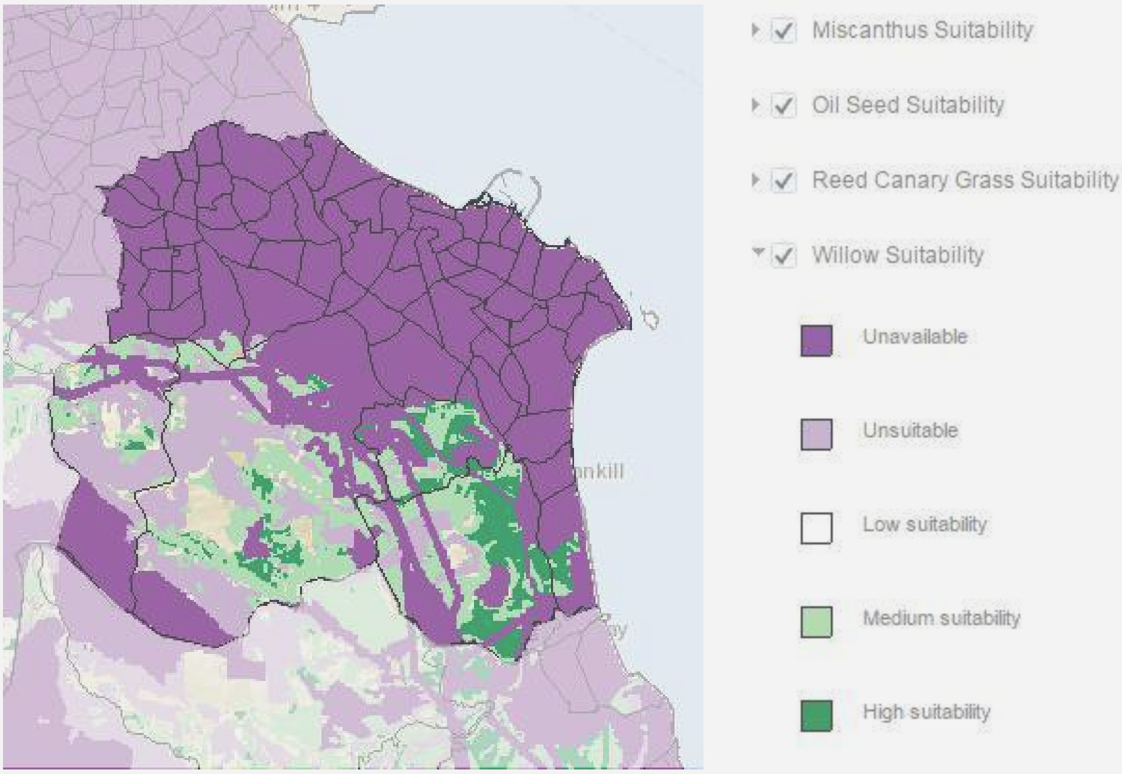

Figure 41 : Maps Showing Biofuel Crop Suitability in DLR

Heat Pumps and CHP

Although not specifically renewable technologies and not always reliant on the local resources, both heat pumps and CHP plants can use renewable fuels and have much higher efficiencies than traditional alternatives. Heat pumps use a low grade heat source, such as that discussed earlier from shallow geothermal sources, and increase the temperature through a compressor, operating on the same principle as a refrigerator. Depending on the input temperature, the heat pump will produce 3 kWh of heat for every 1 kWh of electricity input (a coefficient of performance (COP) of 3).

There are air, ground and water source heat pump technologies. Air source uses the ambient air temperature, ground source uses the solar heat emitted and stored in the earth, and water source uses solar heat stored in lake, river or sea water. Typically, ground and water sources will have a higher and steadier temperature than air source temperatures in winter, when heat is most required, and because of this will generally have higher seasonal performance factors. Air source heat pumps can be installed in any location, are relatively low-cost to install, and have gained popularity in households with low heating needs. They are often used in combination with CHP plants to extract useful heat from flue gases. Ground source heat pumps need either deep bore holes to be drilled vertically or lay horizontal piping over a much larger space but at a much shallower level. The drilling of boreholes is a much more expensive installation, but can yield higher temperatures and may be the only option if there is no space for a horizontal pipe installation. Water source heat pumps will need a nearby or onsite water source which can be diverted for use in the heat pump and returned to the source. All heat pumps are run on electricity, and the costs should be weighed up and compared to other renewable heating solutions with low or no running costs. Heat pumps are best suited to low-energy housing and in combination with other renewable solutions like solar thermal.

CHP plants are a highly efficient power production plant, which utilises the heat produced in the process of electrical generation. In traditional electricity generation, the efficiencies are as low 40%, with much of the energy lost in the form of waste heat. By utilising this waste heat, CHP units can achieve efficiencies of more than 80%. In order for this to be a suitable energy solution, there needs to be a heating demand as well an electrical demand at the same or a nearby location. A CHP plant will produce nearly twice as many kWh of heat as electricity. CHP units are commonly found in hotels and leisure centres as these facilities have both electricity and heat demands onsite. CHP units are ideal production units for DH systems as they can offset the cost of heat production by selling the electricity to the grid. There are currently incentives and feed-in tariffs supporting high efficiency and renewable CHP.

In order to be feasible, a CHP requires a significant level of local heat demand. In this sense, the densely populated areas of Dundrum, Dún Laoghaire and Stillorgan would all be suitable areas.

The renewable resources outlined above give an idea of the types of resources available in DLR and an indication of how suitable each technology is in this area. Reducing demand through energy efficiency is always a priority, and only then should the use of renewable resources be considered to meet remaining energy demand. Waste heat is not a renewable source, but is a source of heat which is currently lost to the atmosphere and its potential to be utilised has not yet been fully explored. A full assessment of the heat currently going to waste from industrial and manufacturing processes in the county is recommended.

Conclusion

This SEDA has identified the location of electricity and heat demands throughout the Dún Laoghaire-Rathdown area. This gives the local authority planners the tools to become involved in how DLR uses energy in the future and begin to integrate energy planning and spatial planning practices.

The analysis of energy use in DLR carried out in this report will inform the baseline energy and CO_2 emissions for the creation of Sustainable Energy and Climate Action plans. The SEDA enables a more efficient and direct approach to implementing energy action plans by representing the energy demand spatially and at a detailed level. The new mapping methodology to visualise the energy use in a grid format developed for DLR has improved the usability and accuracy of the maps.

In the residential sector, areas with the highest energy use have been identified, and also, importantly, areas most at risk of energy poverty. Targeting these areas first puts DLR on the path to effectively reducing the energy demand in the residential sector, which is the largest energy consuming sector in the county. Residential areas which have high levels of electricity and electrical heating consumption can be targeted for upgrades to high-efficiency electrical heating systems and renewable electricity sources to offset their use.

Areas that are an ideal match for DH systems are highlighted through the mapping of heat demand densities. The areas of highest heat densities are the strongest candidates for the first phase development of a DH system which would effectively lower the county's energy demand and fossil fuel use in the heating sector. The potential anchor loads and sources identified could be key stakeholders in the development of such systems.

Clusters of large commercial sector energy users identified can work together to reduce their energy demands and costs through projects which can capitalise on economies of scale. Creation of commercial sector energy groups or cooperatives can create knowledge sharing and help realise ambitious energy projects which may not be as economical or practical on an individual SME level.

This SEDA can now be built upon to create a strategic evidence-based energy plan for the county, which outlines a number of energy mix scenarios for the region based on evidence gathered on demand and resources. Further analysis of potential local sustainable resources is recommended so these energy resources can begin to be quantified and located, and then best matched with the demands already identified.

Quantifying large sources of industrial waste heat should be prioritised in this resource analysis, as it is potentially a very low cost heat source which is currently going to waste. With solar PV being a very suitable RE source in a suburban landscape like DLR, mapping and quantifying the solar resource space available is also a priority in terms of local RE electricity production. Additionally, there are many areas to the south in DLR that could be very well suited to onshore wind projects, given local acceptance. Location of planned future developments and their estimated energy use should be analysed further as these developments can be used to influence the energy use of existing surrounding buildings, particularly through shared heating systems.

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