Sustainable energy and environment report 2024

Optimising energy efficiency: Comprehensive assessment and recommendations for a building in a maritime climate

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Executive summary

This report will provide (I) a review of the energy consumption characteristics of a building in a maritime climate, (II) propose five energy-saving strategies for reducing the carbon and energy footprint of the structure, (III) outline potential finance for capital investments and the associated payback for those savings, (IV) project the overall estimated reduction of the carbon footprint for the building for the first year based on the recommendations, and (V) conclude with final thoughts.

1. Energy consumption characteristics

The energy consumption characteristics of a building provide a qualitative understanding of how energy is consumed with a focus on the attributes, features and systems that influence how energy is used in that building. This analysis is useful in determining how a building's energy consumption and performance can be improved and how it can become more energy efficient. The key factors to consider are the location of the building and associated climate and seasonal variations, the buildings energy sources, the efficiency of existing heating and cooling systems, the use of insulation and appliances and the behavioural patterns of the occupants. This report will focus on the electricity consumption and consider the heating demands and system used for heating/cooling the building.

1.1 Location of house, climate, and its seasonal variations

The building is a two-story semidetached house with 3 bedrooms, 3 bathrooms and an area of 112 m2. It is south facing and situated on an elevated site two miles from the coast in southern Ireland and benefits from the local temperate climate with mild winters and cool summers (WorldInfo, 2023). It

was built in 2001 and was retrofitted with uPVC double glazed windows and energy efficient insulation.

Weather variations from year to year have a significant impact on the energy demand of a building associated with space heating and are often measured in degree days, the greater the number of heating degree days, the colder the weather, the heating period in Ireland typically falls between October and May. (Sustainable Energy Authority of Ireland (SEAI) 2022).

Given Ireland's maritime temperate climate and infrequent warm spells, natural ventilation by opening windows and creating cross-ventilation is effective enough for cooling indoor spaces during the summer months and an air-conditioning system for cooling is not required. Alternatively, with an average mean temperature of 5.4C in the winter period according to Met Éireann, the Irish National Meteorological Service, heating is required. The building uses a natural gas heating system and although natural gas is often considered a having lower carbon emissions than some alternatives, continued use perpetuates the dependency on an unsustainable fossil fuels.

1.2 Energy sources

The building relies on the combined use of electricity for lighting, appliances, electronic devices, water heating and cooking and natural gas for its space heating requirements. Natural gas meets over 30% of Ireland's energy needs, heating, and powering 700,000 homes and businesses and generating over 50% of the electricity Ireland uses. (Department of the Environment, Climate and Communications, Ireland. 2023). Moving to a more energy efficient provider that does not rely on fossil fuels is advisable. Indeed, according to SEAI, energy-related CO2 emissions from the combustion of fossil fuels accounted for 57% of Ireland's total greenhouse gas emissions in 2020,

a) **Efficiency of existing heating and cooling systems**

   The average energy consumption for the building averages 4,200 kW/h of electricity and 11,000 kW/h of gas annually so the energy consumption for the year is 15,200 kwh. The building has a Building Energy Rating (BER) rating of C2 and is not energy efficient.

b) **Use of insulation and appliances**

The building benefits from good insulation, the walls and attic are insulated with cellulose fibre which is a sustainable and energy efficient product manufactured with a high R-value of up to R-3.6. The windows have already been installed with triple-pane windows with low-emissivity coatings to reduce heat transfer as well as wooden window frames with low thermal conductivity. Furthermore, weather-stripping is installed around all doors and windows which successfully prevents drafts which is particularly important given the buildings elevated position. Floor insulation could potentially be considered for further installations with a view to improving energy consumption.

1.3 Occupant behaviour

There are two occupants in the building who work from home on a fulltime basis. They look to car share whenever feasible, walk and cycle to destinations within a 10k radius and make use of public transport when possible. While behavioural changes are not noted in this review as part of the energy saving initiatives, simple changes in behaviour should be considered to reduce the overall carbon footprint of the building. SEAI provide a list of recommendations towards energy saving recommendations in the home including the following

- Switch off appliances and electronic when not in use, at night and when not at home
- Use high-energy appliances such as washing machines and kettles sparingly
- Maximise the use of daylight and turn on lights only when necessary
- Be mindful of energy usage and consider batch cooking meals in advance
- Showers uses 20% of the energy compared to a full bath so limit usage
- Don't leave water taps running.

2. Energy saving strategies

The five energy saving options that will reducing the carbon and electricity footprint of that building require both physical and behavioural changes and are as follows:

2.1 Lighting upgrade

Current status

The house uses traditional lighting incorporating more than 25 incandescent light bulbs across the building. Incandescent bulbs are highly inefficient in terms of energy consumption as this type of bulb loses around 90% of its energy as heat. According to the Sustainable Energy Authority of Ireland (SEAI), optimising light distribution inside a building can reduce energy consumption and costs and incorporate the use of both natural and artificial light sources, however, it's important to consider the challenges that natural light can cause in terms of heat gain or direct sunlight.

Proposal: Replace the traditional lighting in the building with LEDs

Light Emitting Diodes (LED) are an efficient alternative to traditional lighting and can match the colour temperature of existing lighting with improved efficiency and a with a longer lifetime which also saves on energy. According to SEAI, the standard incandescent lamp has a colour temperature of 2,500 - 3,500 and efficacy of 5-20 LM/W and a lifetime of 2,00- - 3,00O hours as compared with an LED bulb to 2,700 - 8,000 k with an efficacy of 70 - 150 + LM/w and a lifetime of 25,00 - 75,000 hours.

Key parameters for LED bulbs should consider colour temperature, rendering and consistency and efficacy and lifetime. For example, while the standard incandescent bulb uses 60 watts of electricity which corresponds to approximately 800 Lumens, an LED bulb with 800 Lumens uses about 7 watts.

Potential savings

According to SEAI, the average weighted price for 1 c/kWh in Ireland is 0.26 €.
Estimating current bulb usage of 25 bulbs at 4 hours per day 6 days per week at an energy cost of 0.26 per kwh, the potential saving per month from switch to LED bulbs is €36.50.
This usage is an average estimate considering occupant movement from room to room and allowing for one day per week that does not include any light usage at all to facilitate a more accurate estimate.

2.2 Install smart home technologies

Current status

The building doesn't have any form of smart home technology or thermostat installed, however, given the unpredictable nature of the renewable energy and challenges in relation to adequate storage facilities for electricity at scale, a balance between supply and demand is crucial as the grid is placed under pressure.

Proposal: **Install smart grid technology in the building such as a smart meter.**

Deploying smart grid technologies such as smart meters and thermostats and automated control systems is crucial in terms of managing electricity demand and enhancing grid flexibility. Smart digital meters also help integrate electricity users into an intelligent grid, SEAI notes there is a broad lack of awareness and engagement in energy consumption with users typically relying on flat rate tariffs and suggest that smart grid technologies are pivotal in terms of increasing awareness. Arguably installing a smart meter at home not only reduces carbon emissions and raises awareness of the associated challenges but also has the potential to promote the adoption of further sustainable energy practices and contribute to a broader shift towards eco-friendly alternatives as users become more aware.

The European Union encourages citizen involvement through smart meters which empower users to optimise energy usage, benefit from lower tariffs and access to cleaner energy thus contributing to energy efficiency. According to the European Commission, data from pilot projects have shown that smart meters provide savings of €230 for gas and €270 for electricity per metering point (distributed amongst consumers, suppliers, distribution system operators, etc.) as well as an average energy saving between 2% and 10% based on data.

Through encouraging energy efficiency and reducing waste, smart meters support the development of renewable energy and a low-carbon future to meet Irelands carbon reduction targets so that it becomes more sustainable. It's important to note that Ireland's 2030 target under the EU's Effort Sharing Regulation (ESR) is to limit its greenhouse gas emissions by at least 42% compared to 2005 levels by 2030, this was increased in April 2023 from the previous 30% target (Environmental Protection Authority, 2023). ESBN is responsible for installing smart meters in homes at no cost.

(Bord Gais Energy).

Potential savings

According to the renewable energy provider SSE Airtricity, the cost of implementing the heat pumps is approximately €16,300, however, there are grants and loans available to finance this implementation as noted in point 3. Finance for Capital Investment.

2.3 Upgrade heating system

Current status

The house uses natural gas heating with energy consumption of 11,739 kWh over one year. Natural gas is primarily composed of methane, a potent greenhouse gas and is converted into carbon dioxide (CO2) when burned for heating. The European Academies' Science Advisory Council (EASAC) European Scientists on the Future of Gas report 2023 argue that there is no alternative to replacing natural gas with renewables immediately since climate change is accelerating at such a rapid rate and recommends a complete ban on the installation of new gas boilers.

Proposal: Replace the natural gas system with a more energy efficient alternative in the form of heat pumps

According to the International Energy Agency (EAI), from a technological perspective, heat pumps are central to the global transition to sustainable heating and are three-to-five times more efficient that natural gas boilers. They suggest that the deployment of heat pumps in line with national climate targets can reduce carbon emissions by half a gigatonne by 2030.

Reliant on renewable energy source, heat pumps provide a more energy efficient and sustainable solution to domestic heating than traditional heating systems in Ireland using oil or gas thus contributing to carbon reduction targets and reducing the carbon footprint of the heating sector. In the Climate Action Plan 2023 CAP 23 Changing Ireland for the Better, the Irish government sets out a roadmap to halve carbon emissions by 2030 and implement the legally binding carbon budgets and sectoral emission ceilings of the Climate Action and Low Carbon Development (Amendment) Act

2021. In addition to previous targets such as 40,000 heat pumps by 2020, CAP 2023 commits to a nearly zero energy building (NZEB) standard by 2025, and zero emission building standard by 2030 with a focus on a National Heat Policy Statement to accelerate district heating scheme delivery in 2023 (Eolas) and a 40 per cent reduction in emissions for residential buildings by 2030. Indeed, the Irish government offers grants and incentives to encourage heat pumps installation in residential homes. Furthermore, the use of heat pumps improves the overall energy efficiency of a building and combined with insulation upgrades and other energy saving measures can significantly reduce energy consumption and reduce carbon emissions.

Potential savings

According to the renewable energy provider SSE Airtricity, the cost of implementing the heat pumps is approximately €16,300, however, there are grants and loans available to finance this implementation as noted in point 3. Finance for Capital Investment.

2.4 Solar PV installations

Current status

The building relies on electricity from and natural gas for all its energy requirements and these sources are completely reliant on fossil fuels which are inefficient and unsustainable.

Proposal - implement rooftop solar photovoltaics (Solar PV)

Solar PV are made from semiconductor materials which release electrons when exposed to photons of sunlight, this electric charge creates a direct electric current (DC) which is converted to alternating current (AC) by an inverter so it can be used domestically to power appliances. Consisting of panels, a solar PV system can be mounted externally on the roof of the building or externally in adjacent land such as a garden and connected to the building electrical loads. According to SEAI, a 1kW solar PV system would require 3 or 4 solar panels and surplus electricity can be stored or exported into the local electrical network. Given the climate in Ireland and solar PV systems and according to SEAI, 75% of the electricity produced annually is between May and September and therefore unused electricity can be exported to the local grid noting the potential trade-off between

reducing energy exported to the grid and the cost of energy storage systems. Given this additional cost, the preferred option for this building is to export the excess energy to the grid.

To determine the best system to install, it is important to:

- assess the buildings current energy consumption, the effect of the climate which is a temperate maritime with mild winters and cool summers in Ireland) and the space available for the panels to determine the size of the system and its efficiency
- appoint a registered SEAI solar PV company

Potential savings

According to the renewable energy provider SSE Airtricity, the cost of installing 6 photovoltaic panels 6x385Wp - PV (2.31 kW) is approximately €8,500, however, there are grants and loans available to finance this implementation as noted in point 3. Finance for Capital Investment.

2.5 Energy provider

Current status

The building's energy supplier uses non-renewable sources of energy which has a negative impact on the carbon footprint of the building.

Proposal: Switch to a renewable energy provider

Switching to a green plan will reduce the carbon footprint of the building and will support Ireland's climate change strategy and contribution to broader sustainability goals. For example, the European Union (EU) Renewable Energy Directive (REDII) includes mandatory targets for Ireland to be met by 2020 to promotes the growth of renewable energy. The first target relates to overall renewable energy share (RES) otherwise known as the overall RES target, a binding EU-wide target was set for overall RES of 32% in 2030 and as noted in the National Energy and Climate Plant (NECP) 2021-2030, Ireland's overall RES target is 34.1% in 2030. (SEAI, Renewables 2023).

The recommendation is to consider SSE Airtricity, one of the largest provider of wind power in Ireland 100% green energy and an operational portfolio of 29 onshore wind farms.

3. Finances for capital investment

The financing for the energy saving measures and the required capital investment can be sourced from a combination of grants and loan and combined with the savings in energy bills as a result of the implementation of the energy saving strategies. It's important to note the energy costs prior to implementation of the energy efficiency plan including the annual electricity bill at €1,917 and the gas bill of €1,609

3.1 Grants and loans

Examples of financing include grants and contracts include:

a. SEAI general
b. SEAI Solar Electricity Grant can help finance Solar Photovoltaic panel installation from SEAI registered companies to generate renewable electricity for homes built and occupied before 31st December 2020
c. Energy performance contracts with third-party providers
d. Bord Gáis Energy Smart Plans for free electricity at the weekend.

3.2 Systems upgrade outlay and costs

As outlined in the energy saving strategies, the natural gas hearing system will be replaced by energy efficient heat pumps, the traditional lighting will be updated with LEDs and 6 solar panels will be installed on the roof the building by a renewable energy provider, SSE Airtricity which have been approved by SEAI. SSE Airtricity evaluate the cost of this implementation and include the figures for the available SEAI grant and SSE Airtricity as well as the cost of a green loan and estimate the cost of the project and the potential savings below. The energy consumption and the carbon footprint of the building will be reduced by also switching to the renewable energy provider and this can also be added to the evaluation.

Current annual energy costs

Electricity	Natural gas

Electricity: 4200 kWh Annual cost: €1909 Monthly cost: €159.08	Natural gas: 11,000 kW Annual cost: €1,578 Monthly cost: €131.50
Current electricity and natural gas payment	
Annual cost: €3,487 Monthly cost: €290.58	

Post efficiency plan implementation

Renewable energy payment
Green loan: €210.33 Estimated energy plan savings monthly: €125.48 Estimated energy plans savings annually: €1505.76 Estimated energy saving KWH/3962 x New monthly cost: €375.43

Energy efficiency plan implementation costs

Heating and lighting upgrade and solar panel installation – estimated costs	
Implementation costs	**Estimated costs**
Lighting upgrade: €150 Heating upgrade: €16,300 Solar panel installation: €8,500	Project Cost: €24,950 SEAI Grant — €3,893 (minus) SSE Airtricity Discount — €1,039 (minus) Net Project Cost: €20,018 Net Project Cost (Including interest): €25,239.6

Energy efficiency plan finance

Finance Method: Green Loan Fixed Normal Rate: 4.8% Term: 10 years Annual Repayments: €2,522.16 Monthly Repayments: €210.18	**Financial gains** Estimated Grant Aid (SEAI): €3,893 Discount (SSE Airtricity): €1,039 Total Grant Aid and Discounts: €4,932 Estimated Annual Energy Savings - 10-year view - €1,505.74 Estimated Monthly Energy Savings - 10-year view -€125.48

Methodology to determine energy cost savings

The energy costs before and after the energy efficiency implementation can be calculated using the formulas below.

Total saving: €1,505.74 annually

4. Estimated reduction of the carbon footprint

We need to:

- calculate the carbon footprint of the building prior to implementing the energy efficiency plan.

- calculate the carbon footprint of the building after implementing the energy efficiency plan.

4.1 Methodology for calculating carbon footprint

We can use a SEAI tool or other online carbon calculators to calculate the carbon footprint of the house prior to, and after implementing the energy efficiency plan or convert the energy usage of the building prior to and after implementing the carbon emissions using the following formulas based on

Table 1.1: Building energy usage and carbon emissions before and after implementation of energy saving strategies over one calendar year.

Source	Annual Energy usage KWh/Yr)	Carbon emissions Ireland 354g CO2 per kwh
Total energy consumption	15,200 kW/h	5380.8 kg 5.38 tonne
Energy savings	3,962 kW/h	1402.5 kg

4.2 Total reduction

The carbon footprint of the house has been reduced from 5.38 tonne to 3.89 tonne in one calendar year by installing solar panels, upgrading the heat system to heat pumps and replacing incandescent bulbs with LEDs. Further reductions based on Smart meters are likely but hard to estimate, in addition, the carbon footprint of the house will again be reduced by the move to a renewable energy provided.

5. Conclusion

The holistic approach presented in this review not only addresses the specific energy consumption characteristics of the building but also provides practical and feasible strategies to enhance energy efficiency, reduce carbon emissions, and contribute to Ireland's broader sustainability objectives. The financial aspect is important in terms of the feasibility and cost-effectiveness of implementing these strategies. The net project cost which includes grant aid, and discounts also provides a transparent view of the economic implications over a ten-year period and underscores the economic viability of this proposal. In addition, sourcing a green loan with a fixed normal rate is

beneficial as it ensures a structured approach to financing while also aligning with the long-term nature of the energy-saving strategies. The estimated reduction of the carbon footprint of the building while cost-saving and energy efficient also aligns with broader climate action initiatives and contributes to Ireland's commitment to reducing greenhouse gas emissions.

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