D.3.2.2

Technical report on the benefits of energy retrofit to facilitate fossil fuel replacement.

Cork and Bodø Pilots

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Content

Cork Pilot

1.1Executive Summary

The Pilot Cork case study demonstrates the benefits of deep retrofitting, heat pump, solar, and storage installations at Kilworth House in Cork, showcasing improvements in energy efficiency and the replacement of fossil fuels. Kilworth House, built in 1952 with an extension in 2019, initially had a high BER of C3, indicating poor energy efficiency typical of Irish bungalows, which often feature cavity wall insulation and attic spaces. The full retrofit, carried out over three phases, raised the initial BER from C3 to A2 by incorporating airtightness measures, additional solar panels, batteries, and monitoring systems, achieving near-zero energy performance and reducing emissions by around 40% relative to the NZEB standard.

The retrofit at Kilworth used a fabric-first approach, with external wall and cavity insulation, airtightness, heat pumps, and renewable energy systems, aligning with national deep renovation strategies. The comprehensive upgrade was funded partially by SEAI grants. DCSix Technologies provided the Wattrics energy monitoring system, capable of real-time, high-resolution monitoring of electricity consumption and generation, supporting feasibility studies, audits, and operational optimisation.

Monitoring revealed that Kilworth's PV system could be carbon-negative in summer, with excess generation stored in batteries, and DCSix suggested switching to night tariffs to optimise energy use and savings. Initial data showed very low grid consumption and high photovoltaic self-consumption, with annual solar generation close to predicted levels, demonstrating effective renewable integration and potential for further savings with battery storage.

The Kilworth House pilot demonstrates that such comprehensive measures can bring existing homes to NZEB standards, provided substantial grant support and accessible financing are available.

1.2 Kilworth House Cork Pilot: Description of the Deliverable

Deliverable 3.2.1 Technical Report on the benefit of energy retrofit to facilitate fossil fuel replacements is part of WP 3 Flexible renewable solutions for the NPA region, and demonstrates the benefits of deep retrofit and heat pump, solar and storage installation, to enable fossil fuel replacement. This report is produced by PP3, NEC Insulation, and covers the implementation of one Pilot Project in Cork.

Kilworth House, Macroney Lower, Kilworth, Co. Cork**,** is a single-storey bungalow in the North Cork town of Kilworth. It was built in 1952, and an extension was added in 2019. The full retrofit was completed that same year. Before retrofitting, Kilworth House had a BER of C3 (188.89 kWh/m2/yr), which is high for a bungalow of that era. Bungalows are not inherently energy-efficient and usually require significant energy improvements due to poor insulation and, frequently, reliance on oil heating. The rating bungalows of this period is usually in the D1 to E2 range, so it's possible some retrofitting (e.g. attic insulation) might have been carried out before 2019.

Fig. 1 Kilworth House, external view (after 2019 extension and retrofitting) Source: Mark Kenny, owner

Bungalows such as Kilworth commonly have **cavity wall construction** with insulated concrete blocks. The most common method uses two concrete block leaves with an insulated gap (sometimes filled with polystyrene beads or PIR boards) to improve thermal performance. Bungalows also have an attic space and a pitched slate roof, which allowed ceiling level insulation.

1.3 Cork Climate:

Cork County experiences a mild oceanic climate characterised by mild winters, cool summers, and abundant rainfall. Temperatures rarely drop below freezing or rise above 25°C (77°F). The region also faces increased risks of extreme weather events such as flooding and coastal erosion due to climate change. Cork's climate is generally mild and wet, but it is experiencing the impacts of climate change through more frequent and severe weather events (storms, gales and bushfires).

1.4 Cork Stock Condition

Cork County's housing stock is similar to that of the rest of Ireland: mostly older (built in the late 1800s to the 1990s), with a growing number of new homes built to much higher energy standards. Existing homes are mainly located in urban and suburban centres (mainly Cork City, but also several towns and townlands. They are mostly of traditional design and construction, ranging from detached houses and semi-detached homes to traditional Irish cottages (often in rural areas), terraced houses, and, more recently, brick- or (unusually) wood-clad terraced and detached homes.

Existing stock, on average, ranks low in energy efficiency (see Table 1 below). Heating is usually provided from fossil fuels, either coal or peat, and more recently oil and gas.

The residential sector represents around 23% of Ireland's final energy consumption. The stock includes about 1.7 million dwellings, 50% of which were built before 1981 (the first building requirements were set in 1979).

Space heating accounts for about 61% of residential energy use in Ireland, with oil (47%), gas (25%), and solid fuels (21%) still providing the majority of the energy (SEAI, 2018a). This explains why reducing GHG emissions is a key objective of the energy efficiency programmes

1.5 Energy Retrofit Programmes in Ireland

Ireland has been implementing energy-saving programmes in the residential sector since 2000. Between 2000 and 2016, 375,000 homes received government grants for energy efficiency measures (about 22% of the dwelling stock).

Energy efficiency in households improved by 32% between 2000 and 2016; the average specific final energy consumption of dwellings fell from 230 to 156 kWh/m²/year (SEAI, 2018a).

The Irish government has introduced ambitious building renovation targets in its Climate Action Plan 2019 to help reach the 20% energy efficiency target for 2020, which was likely to be missed by 3-4% at the time, given the trends observed (SEAI 2019a). The goal of upgrading the energy performance of 500,000 buildings to a B2 Building Energy Rating (BER) by 2030 was set, which would require renovating 50,000 houses annually beginning in 2021.

The **Better Energy Homes** (BEH) scheme is the main SEAI (Sustainable Energy Authority of Ireland) grant support programme for domestic energy renovation.

BEH is based on standard SEAI minimum requirements for each action type, such as the use of registered contractors qualified for the scheme. SEAI periodically publishes a new call for proposals and related Application Guidelines, often with minor changes to requirements and the addition of pilot schemes.

1.6 BER rating of properties in Ireland

Energy efficiency in Ireland is usually measured using the Building Energy Rating (BER) system, which is based on the EC's EPBD Directive.

A BER is calculated based on the amount of energy the home requires for:

- space and hot water heating
- ventilation
- lighting

The calculation uses the Dwelling Energy Assessment Procedure (DEAP), which is contained in the software portal of the same name. This is Ireland's official method for calculating a dwelling's BER. The DEAP calculation framework is based on IS EN 13790 and draws heavily on the calculation and data used for the energy rating of dwellings in the UK.

The calculation is not based on a dwelling's actual number of occupants, the levels and durations of heating or hot water demand. It is independent of how the individual occupants actually use energy in the dwelling.

Factors considered are:

- The number of occupants is assumed based on the floor area
- The dwelling's heating patterns and temperatures are assumed to be the same across all dwellings
- Individual ownership and efficiency of particular domestic electrical appliances are not assessed

The BER rating is based on the building itself, its fabric, and installed systems, and is not an operational rating based on the energy consumption of occupants. This allows prospective buyers or tenants to objectively compare the energy performance of different dwellings on a like-for-like basis.

The BER assessor gathers all the information required to complete a BER during an assessment of your home. The BER assessor will survey each room in the house, including the attic and garage, if present. They will record the survey data in a survey form. The information they collect includes:

- the building's construction type
- year of construction of the original dwelling and any extensions
- floor dimensions, room height, window and door sizes
- the building's orientation
- insulation levels within the walls, roof and floor
- details of the space heating systems and heating controls
- hot water systems and water cylinders
- ventilation characteristics such as vents, fans and draft lobbies
- baths and showers
- lighting
- any renewable systems

Following the survey, the BER assessor will complete various calculations and input the information they gathered into the DEAP software. This software was developed for Ireland and takes into account the Irish climate, construction types, heating systems and occupancy patterns. The software then calculates the annual energy use for heating, lighting and ventilating the property.

1.7 Building Energy Ratings Trends

60% of the existing Irish housing stock has a medium-to-low energy rating, underscoring the need for energy upgrades in older properties to meet recently established targets.

Table 1: BER Ratings by Period of Construction

	% of row						
	Energy Rating						
Period of Construction	A	B	C	D	E	F/G	Total
1700-1949	0	3	12	18	19	47	106,549
1950-1999	0	5	34	33	16	12	379,532
2000-2019	11	21	49	14	4	1	331,835
Total	4	11	37	24	11	12	817,916

Source: CSO (2019)

Table 1: BER ratings of existing homes (Central Statistics Office 2019)

2.0 The Cork Pilot – Kilworth House, Macroney Lower, Kilworth, Co. Cork

2.1 Fabric First Approach

The retrofit of Kilworth House used the Efficiency First (E1) or Fabric First approach, which encourages applicants to demonstrate that energy efficiency improvements (wall insulation, roof insulation, and upgrades to windows and doors) are prioritised over the installation of renewable heating systems or other smart technologies. This E1 criterion is mandatory for residential projects, but it is not always practical for non-domestic projects. In any case, the eligibility criteria communicate a strong focus on energy efficiency measures.

The residential sector in Ireland is responsible for 40% of energy-related carbon emissions and 23% of final energy consumption. The government has set ambitious renovation targets; therefore, the Fabric First approach is an important feature in Irish building renovation and is applied across grant schemes.

Most energy efficiency grant schemes implemented by SEAI follow the Fabric first approach, more or less explicitly:

- Funding information recommends starting the project by looking at the energy performance of the building.
- The grants first highlighted in the SEAI communication on grants for households are the ones for fabric insulation actions.
- The grants available for heat pumps include a technical prerequisite that the building must have a minimum efficiency (BER) level of C3.

Other European countries do not appear to have adopted the Fabric First requirement as a condition of funding, but some nonetheless set high remuneration standards,

One example is the KfW loan programme "Energieeffizient Sanieren" in Germany, which gives out higher repayment subsidies for higher energy performance standards (30% for KfW-Effizienzhaus 85, 40% for KfW-Effizienzhaus 55).

2.2 Retrofitting Kilworth House

It is likely that Kilworth House had some basic retrofit carried out prior to that described in this Report. A typical bungalow of this period is likely to have a BER rating of between E and D. On initiation of the retrofit described in this Report, the property already had a BER of C3 (188.89 kWh/m2/yr and 38.68 CO2e/m2/yr). The initial retrofit likely included attic insulation and the installation of 3 solar panels (no battery storage), as noted by DCSix in their initial assessment.

In 2019, with part funding from the SEAI Better Energy Homes scheme, a further deep retrofit was carried out, raising the BER rating to B1(67.47 kWh/m2/yr and 14.81 CO2e/m2/yr). This represents a 36% reduction in energy use and a 38% reduction in CO2 emissions. This retrofit (which we will call Stage 1) included cavity wall insulation, external wall insulation, and the installation of air-source heat pumps, with heat distributed through radiators. The retrofit was part- funded by the BEH scheme, with a likely grant of €25,000 (50% of the cost).

This was followed by a Stage 2 retrofit, recommended by DCSix in their initial assessment of the property. This Stage included more airtightness, the installation of 10 additional solar panels (3 were already installed): 2 more on the roof and 8 freestanding on a nearby field, 2 storage batteries, an inverter, and the Wattrics energy monitoring system.

This second phase probably received funding from the SEAI Solar PV funding scheme, which is capped at €2,100 per home and an additional €500 per 5 kW battery, for a total of €3,100.

This Stage 2 raised the property's BER from B1 to A2 (39.45 kWh/m2/yr and 9.56 CO2e/m2/yr), which meets the NZEB standard. NZEB homes will be 70% more energy-efficient and emit 70% less carbon dioxide than those built to the Irish 2005 Building Regulations.

2.3 Works at Kilworth House

Retrofit works on Kilworth House included the following:

- 13 Solar panels (5 on the roof and 8 free-standing)
- Dual Hybrid Inverters
- 2 x 2.4 kW Pylontech Llion batteries
- Electric main heating system with a heat pump
- 100% draught stripping
- Balanced whole-house mechanical ventilation with heat recovery
- Heating systems controls

Figure 3. External Solar Panels at Kilworth House

The installation included 8 kW ground-mounted south-facing solar PV with a hybrid inverter & 4.8kw battery storage added to existing 3 kW east-west split solar PVs with dual inverter - the initial array having no battery.

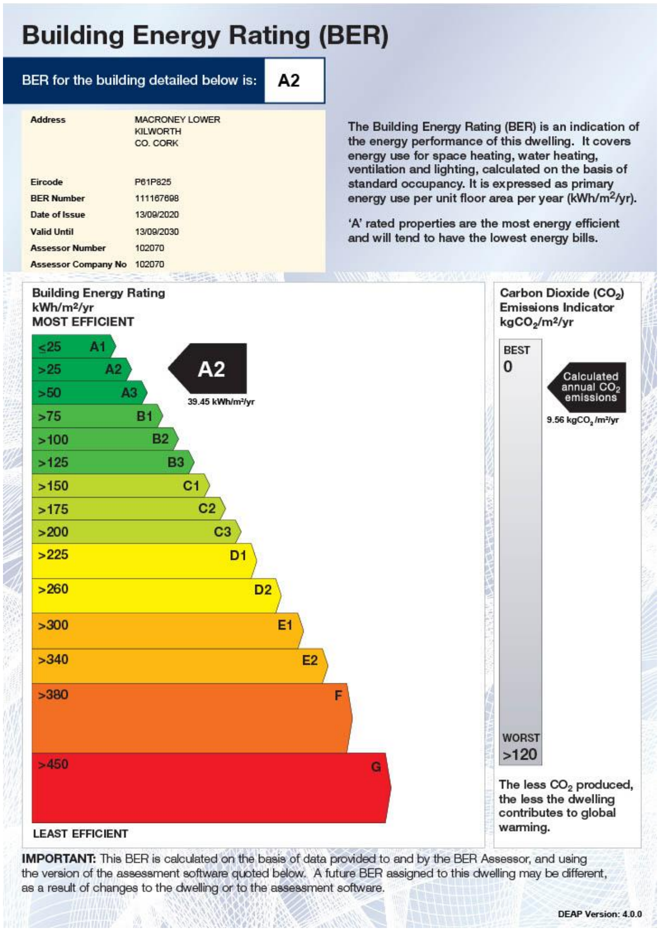


Figure 4: BER rating energy and CO2 equivalents for Kilworth House after retrofit (source SEAI 2019)

2.4 Replicability and scalability potential

With the residential sector responsible for 23% of final energy consumption and ambitious renovation targets in place, the Fabric First approach is an important feature in Irish building renovation and is applied across grant schemes. The other energy efficiency grant schemes implemented by SEAI also follow the Fabric first approach, more or less explicitly:

• The scheme information always recommends starting the project by looking at the energy performance of the building.

• The grants first highlighted in the SEAI communication on grants for households are the ones for insulation actions.

• The grants available for heat pumps include a technical prerequisite that the building must have a minimum efficiency (BER) level (see the example about the SEAI Heat Pump Grant).

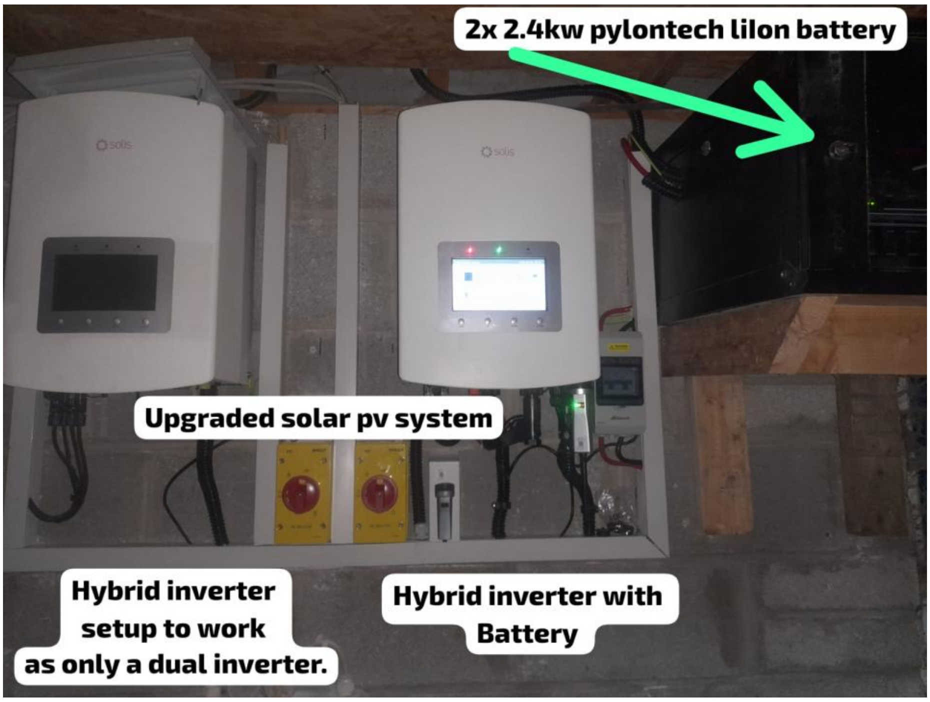


Figure 5. Inverters and batteries – Kilworth House Solar

The likely installation costs were circa €65,000. The BEH grant for the first phase at the maximum allowable was €25,000. The solar array and batteries likely received the maximum available grant of €3,100. The total SEAI grant was therefore circa €28,100, and the owner's match funding was around €36,900.

This is a very good decarbonisation result, but from the owners' perspective, it may be financially challenging. At this rate, the deep retrofitting of 500,000 existing homes in Ireland could cost up to €325 billion, with 56% of this cost, around €18.2 billion, to be paid by homeowners as match funding.

2.5 Energy Monitoring at Kilworth House. DCSix Technologies

DCSix Technologies is a small energy monitoring company based in Cork City. Their goal is to assist clients with improving their energy efficiency and decarbonisation measures through technology solutions. They have done this by creating a cost-effective, highly accurate, and reliable energy monitoring tool (Wattrics) that enables clients to conduct feasibility studies, carry out energy audits, create alerts, and build awareness of energy efficiency. It can also monitor the performance of on-site generation and is suitable for both single or three phase supplies.

2.5.1 The Wattrics energy monitoring system

The Wattrics system measures power in both real and reactive terms flowing through up to 14 individual circuits using a passive sensor that clips around one of the insulated wires in your distribution board, so there's no need to switch off the power during installation. Electrical usage data is then securely forwarded to their cloud server and stored in a designated database. This is accessible via a fully customisable web interface. From there, they perform a per-circuit cost breakdown and provide extensive insights into the households' energy usage. Energy consumption is also converted into real-time carbon emissions data using the grid's carbon intensity.

2.5.2 Wattrics' special characteristics

Wattrics has unique features that make the system effective. One is that it continues to monitor even when the internet connection goes down. The built-in SD card allows data to be saved locally with high resolution. This means that even when the internet goes down, the system will continue recording and upload them to the cloud once the connection is re-established. It also has an on-board real-time clock to ensure the time-stamp is always correct. Wattrics also supports automatic over-the-air firmware updates, so there's no need to connect it to a PC to get the latest firmware.

2.5.3 Parameters monitored by Wattrics.

At the Kilworth site, Wattrics is monitoring the building's main electrical supply and also sub-metered areas shown below:

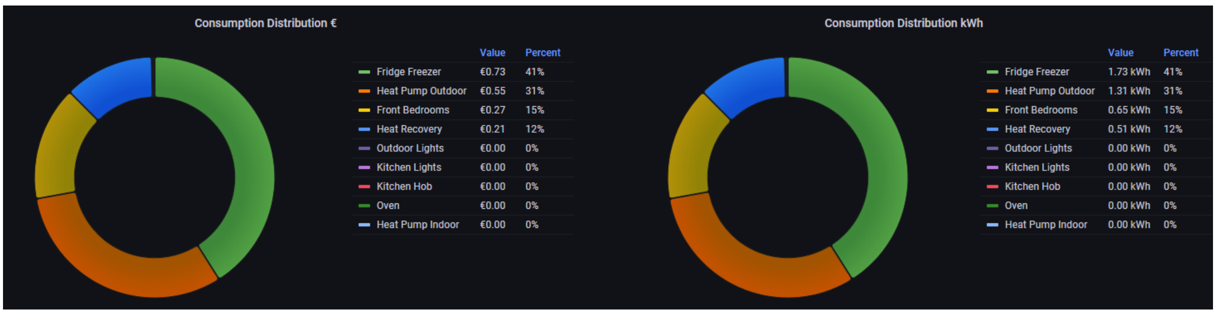


Figure 6: Parameters monitored by Wattrics (source DCSix 2024)

The main purpose of monitoring these parameters is to:

- Establish the benefits of the retrofit and installations in comparison to the per-work situation
- Ensure the system and all its components are operating correctly and optimally
- Establish the cost savings from generation.
- Establish energy savings

2.6 Energy monitoring initial findings

After a full retrofit, Kilworth House had a PV array that made the building carbon-negative in the summer months. At the start of energy monitoring, over 30 days, the building had a net energy export of 25kWh. In the initial assessment, DCSix noted that the building did not, on average, export less than 8kWh of electricity to the grid each day. DCSix therefore recommended that a battery energy storage system should be installed at this site to help increase the level of self-consumption of the PV.

Figure74. Energy Use and Carbon Accumulation in 24 hrs at Kilworth House (Source DCSix 2024)

Kilworth House also had an air-sourced heat pump (ASHP) installed. Wattrics monitored this system for 4 months; however, outside of the heating season, consumption and energy use were mostly down to water heating, which typically consumes around 2 kWh of electricity each day. DCSix suggested that the customer switch over to a Night Saver tariff, as over 65% of the building's electricity consumption is at night. Additional data was collected over the winter to determine the best tariff for the building.

3.0 Key Data collected (2024-2025).

- Total power use kwh/m2/year:

From Sept.2024 to Sept.2025, the building used 7kWh (it was basically net zero)

- Total solar power production//week (in monitoring period of at least a year):

From Sept. 2024 to Sept. 2025, the solar PV produced 4,897kWh.

- Total solar power stored in excess periods:

This data was not available to DCSix.

- Sun hours and temperature in the region of pilots (which, in general, will tell us of the potential to use solar energy in the Cork region):

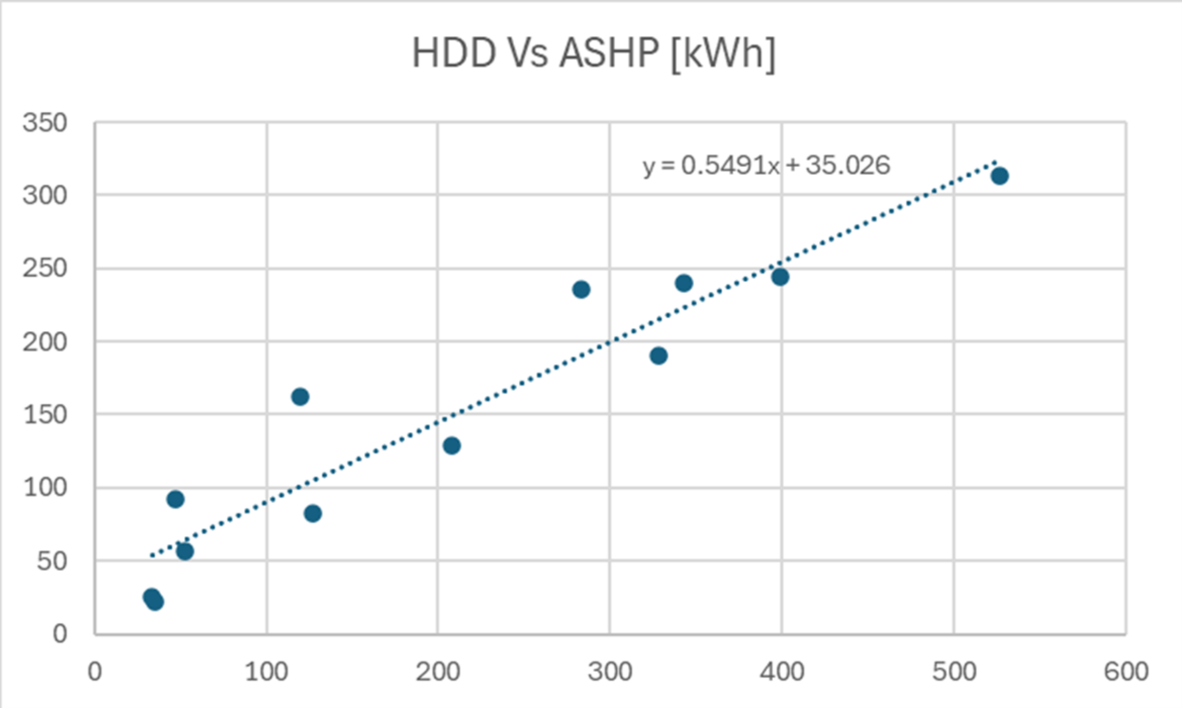
DC Six assessed this location, and the total predicted generation was, 4,914 kWh/year, so just 17kWh more than what was actually generated in the past 12 months.

Month	Solar Radiation(kWh / m2 / day)	AC Energy(kWh)
January	0.69	100
February	1.46	199
March	2.30	353
April	3.84	569
May	4.88	729
June	4.82	692
July	4.59	678
August	4.23	625
September	3.21	463
October	1.91	287
November	1.02	146
December	0.52	73
Annual	2.79	4,914

Graph 5: Solar radiation in 2024 (source DCSix)

4.7 Climate effect on energy use - sun hours and temperature in the region of the pilot.

The local climate, in particular the number of sun hours and temperature, will affect the efficiency of heat pumps. This is illustrated in the following graph:



Graph 6: Effect of local temperature on Heat Pumps 2024 (Source DCSix)

3.1 Cost calculations and pay off for energy technology investment.

Solar production in 2024 was 4,897kWh, and ASHP consumption was 2,488 kWh; the balance was sold to the grid, representing an energy credit of €522.48. Additionally, actual grid consumption was very low, resulting in significant cost reductions.

4.0 Outcomes and benefits.

4.1 Monitoring Results - Methodology Used.

The methodology used in the pilot is straightforward: a deep retrofit following the "fabric first" approach, with heat pumps as the main heat source, supported by battery storage and a substantial solar panel array that allows grid feed-in. The use of the night tariff was also beneficial. This should be a recommended model for deep retrofit using heat pumps.

4.2 Recommended application

The Fabric First approach is a best-practice standard for designing new homes and retrofitting existing homes. However, due to the high costs involved (particularly for existing homes), a reasonable level of grant support and availability of loan funding are required to mainstream it.

- Production of Guidelines

Producing guidelines based on this approach is desirable, as all components are easily accessible. However, training and clear guidelines will be needed for house owners and installers.

- Role of the Partnership.

The Partnership in this Pilot included NCE Insulation, a social retrofit promoter that provides services to home owners, local councils, community organisations, and housing associations, and DCSix Technologies, a specialist energy monitoring system developer and service provider based in Cork. This Partnership has been effective in collaborating on several successful projects in Cork and elsewhere.

- Comparison with other Pilots.

It would be useful to compare the approach taken to retrofitting and monitoring by this Pilot to that undertaken by the other HYBES Project Partners. NCE and DCSix have already replicated this approach in similar local projects. The approach could be replicated by other HYBES Partners and other property owners and managers.

4.3 Overall Results

The Kilworth House pilot demonstrates that existing properties can be brought to a Near Zero Energy Standard by applying comprehensive fabric retrofitting and air-tightness measures, and by using heat pumps, solar panels, and storage. The addition of an energy monitoring system and service, such as that provided by DCSix Technologies, demonstrates how such an installation can be kept operating optimally, any issues corrected and resolved, and costs, energy, and carbon emissions transparently quantified.

4.4 Conclusions

Reducing CO2 emissions in the domestic sector is a major challenge, given the backlog of existing homes in both the private and public sectors. In Ireland, the number of such dwellings is at least half a million, which are deficient in terms of energy.

The Cork Pilot shows that, through a combination of deep fabric retrofit and airtightness, and by using air-source heat pumps, PV panels, and storage for generation, with the aid of current public subsidies, it is possible to reduce the energy use and CO2 emissions of such properties to near-zero levels.

The Pilot indicates that the grant funding models available in Ireland rely (with the exception of higher level of grants for welfare dependents) on homeowners contributing circa 56% of the retrofit's total cost (€36,900 in this example). The repayment of a loan for this amount at current commercial rates would be circa €350.86 over 10 years. It is widely assumed that households should not spend more than 10% of their disposable income on energy to avoid energy poverty. As over 50% of Irish households have an income of less than €35,000, the majority of residents would run this risk.

Therefore, a higher grant level or/and/or means-testing of grant funding is required. That is assuming public expenditure can cover the required costs for such a programme at current funding rates.

In terms of energy monitoring systems and their value, the availability of tools such as Wattrics is essential for improving energy management and monitoring of energy system performance, and could lead to additional savings. Although it is hard to quantify the actual benefits, better energy management has been shown to reduce energy use by up to 20%.

In conclusion:

1. The Cork Pilot demonstrates that it is possible to raise the standard of an average existing home to NZEB through a combination of fabric retrofit and airtightness, air source heat pumps, solar PV and battery storage.
2. The Pilot also shows this approach is costly in terms of subsidy and homeowner investment (in our example, around one average household's yearly income). This level of repayment required seems to exclude around 50% of the population in Ireland.
3. Energy monitoring systems such as Watttrics are useful and could produce additional savings of up to 20% if backed up by improved energy behaviour.
4. The approach described is replicable and results in significant improvement. But it relies on significant state subsidy and homeowner investment. It is likely that these financial barriers will need to be overcome for this to be a mainstream solution.

5.0 Bodø Pilot

5.1 Executive summery Bodø Pilot Rehabilitation building. Effects of deep renovations task

The Bodø pilot, the Rehabilitations building has carried out deep retrofitting, and we have monitored the effect of this for three years. Monitoring has proven that the deep retrofit has improved energy standard of the building to passive-house standard. For 2025 energy use kwh/m^2 was reduced to 123,9 kwh/m^2 and energy savings have been reduced by 27% compared with pre-retrofit period. Even within an energy system as the Norwegian with low carbon energy carries the reduction in CO^2 emissions was about 11% compared to pre retrofit period.

5.2 Description of Pilots Rehabilitation building

One of Hybes energy pilots is the Rehabilitation building located at Gamle Riksvei 18. The rehabilitation service is part of preventive health care organisation of Bodø Municipality. Part of the building also serves as living room and flats for elderly and is functionally integrated in the neighbouring nursing institutions Stadiontunet. The premises is a 7-floor building with a ground area of 940 m^2 and the total building area is 7160 m^2.

1st and 2nd floor contains of two gyms, two smaller treatment rooms, a small therapy pool, meeting rooms, training kitchen, offices and expedition. The collective in Gamle Riksvei 18 is organized under Stadiontunet nursing home. The collective is located on the 3rd floor and 4th floor. There are 15 single rooms on each floor with shared kitchen and living room. The collective also provides home services to residents in the 5th-7th floor. The collective is staffed with 24-hour service and provides services by decision of the Allocation Office. It is the Allocation Office that prioritizes housing in the collective.

Late 2010ties it was decided to make a deep retrofit of the rehabilitation building and it was decided to highlight and implement climate and energy tasks during this retrofit process. Energy efficient goal was to reach nearly passive house standard of the rehab building. Maintenance inspection of the building concluded that the windows facing southwest were characterized by moisture penetration. As the remaining windows was assumed to have approximately 5 years back of service life it was considered to replace all windows. In addition, it was acknowledged that facades also had moisture penetrations, and that the wind barrier needed to be replaced.

Rehabilitation building after retrofit and energy task

The retrofit decision concluded with the following task: To post-insulate outer walls with 150 mm additional insulation, to replace all windows, to establish a new wind barrier and to replace part of the southeast and southwest facades with building integrated solar panels (BIPV). The reason to choose solar energy as energy source reflects the energy consumption pattern of the rehab building. The user profile shows that the highest energy requirement has its peak at the middle of the day. This pattern is in favour of solar and especially BIPV installations. This even though façade energy production would be influenced by the local shadow from Stadiontunet nursing home. To reduce this shadow effect BIPV panels are mounted from third floor and up on the rehabilitation building.

5.3 Construction and energy baseline of Pilot

To evaluate the effect and performance of solar energy on different parameters we need to define a baseline. In planning and design phase of Rehabilitations building several reports were produced to document the technical and energy performance of the building. The presentation and description below are based on these analyses and theoretical calculations which represents our baseline. This baseline will reflect theoretical calculations of passive house requirements for the building, expected energy consumption post deep retrofit and energy efficient task, LCC and LCA evaluations of the retrofit and energy task.

I the planning process a technical evaluation of passive house requirement after implementation of retrofit and energy measures was done. These calculations on minimum requirements for individual buildings components are shown in table 1.

Table 1: U-value for individual building components

Building element	Value existing building	Value building after retrofit	Values demanded Passive house
U-value outer walls	0,33 W/(m²K)	0,18 W/(m²K)	0,22 W/(m²K)
U-value windows/doors	2,0 W/(m²K)	0,8 W/(m²K)	0,80 W/(m²K)
Thermal bridge values	0,12 W/(m²K)	0,09 W/(m²K)	0,03 W/(m²K)
Airtightness[1] (air changes per hour)	3,50 h^{-1}	2,50 h^{-1}	1,5 h^{-1}
Specific fan power (SFP) [kW/m³/s]		2,0 kW/m³/s	0,6 kW/m³/s

Conclusions are that the building after retrofit won't fully satisfy passive house criteria and demands. However, if the ventilation system were replaced, the system would likely obtain a heat recovery of over 80% and a Specific fan-power value would fall to near passive house standard.

Also heat loss from the building body was estimated. In table 2, the u-value numbers show that heath loss will be just above passive house standard of 0,40 λ with a total heath loss of the Rehabilitations building of 0,46 λ.

Table 2: Estimated heat loss values Rehabilitation building

Heath loss	**U-value**
Heat loss figures exterior walls	0,09
Heath loss roof	0,02
Heat loss figures floor on ground/against the open	0,01
Heath loss figures glass/windows/doors	0,08
Heath loss thermal bridge	0,09
Heath loss infiltration	0,16
Total heath loss	0,46
Passive house demand heath loss table	**0,40**

5.4 Theoretical calculation of net energy performance of Pilot

The energy profile of the Rehabilitations Building before retrofitting and renewable energy task consisted of electricity from the power grid and heating from district-heating. Electricity from the grid comes from regional hydro power plants, and the district-heating plant produces heat from wood pellets.

[1] Air changes per hour (ACH) at a 50 Pa pressure difference

To evaluate the energy effect of energy efficient tasks, we calculate energy use before and after implementation of tasks. The total use of power before retrofit has been calculated using an online energy monitoring system (EOS), E-save, to monitor energy use. Bodø Municipality has invested in this digital tool to get an overview of energy use. Energy use before energy tasks is calculated as an average of total power use for the period 2013[2] to 2021. This calculation is shown in table 3, with an average power use 1367928,47 kwh and power use pr. m^2 of 191,05 kwh/m^{2}.

Table 3: Calculated average power use for the period 2013-2021

Year	**Total power use kwh**	**Power use kwh/m²**
2013	1468508,01	205,10
2014	1386871,42	193,70
2015	1426674,40	199,26
2016	1354702,39	189,20
2017	1259897,39	175,96
2018	1402260,82	195,85
2019	1196222,96	167,07
2020	1383099,76	193,17
2021	1433119,07	200,16
Average	**1367928,47**	**191,05**

The figures below show the energy use divided into different sources 2022-2024 per year and per month. District heating counts for approximately 50 – 60% of total energy consumption, with large variation over the year. In winter, the share of energy from district heating goes up to 75% of the total energy use, and down to 25% in the summer. Electricity consumption has relatively low variation over the year, with slightly higher consumption in the winter than summer, while the district heating takes up much of the added energy need during the cold months. Solar production happens between March and September.

[2] First year with district heating to Rehabilitation building is 2013. 2021 was the last year before retrofitting work started up in 2022.

Figure 1: Changes in distribution patterns of energy carries 2022-2024

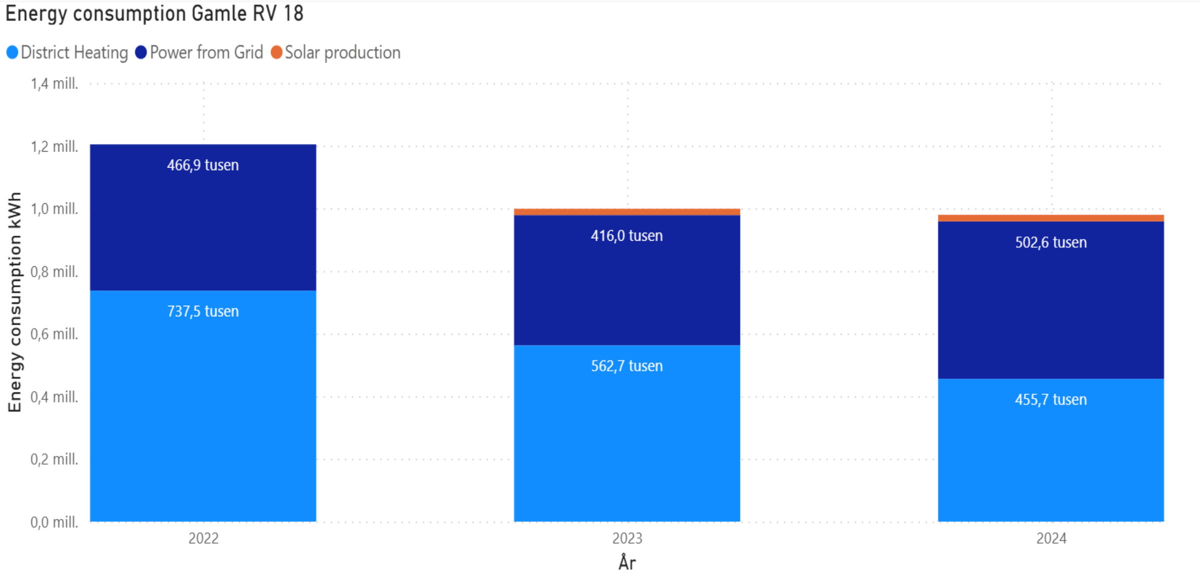
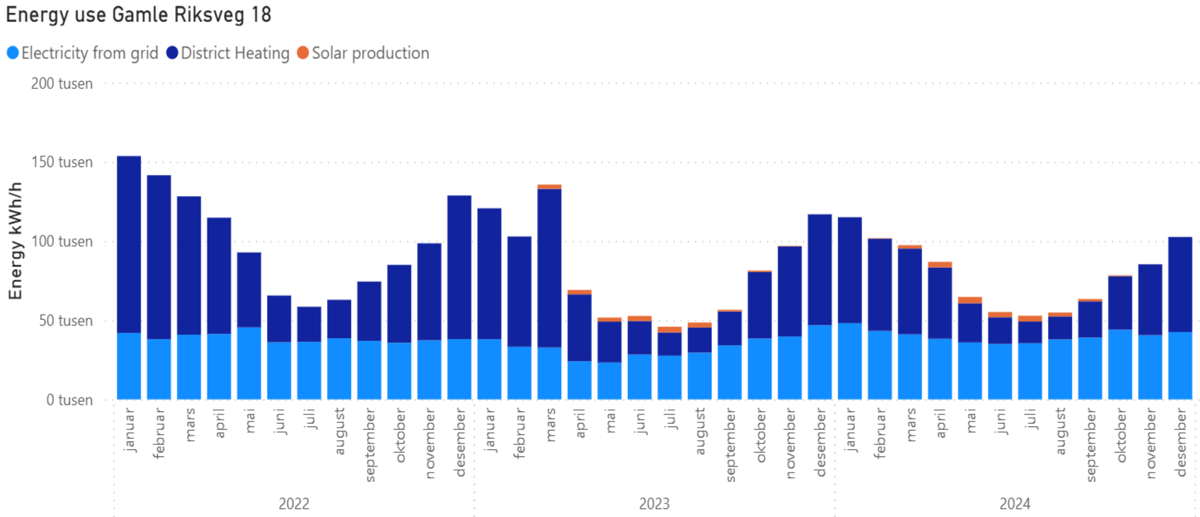


Figure 2: Monthly changes in distribution patterns of energy carries from 2022 to 2024



As mentioned above, the energy consumption pattern, with the highest energy requirement in the middle of the day, fits well with electricity from solar cells. The chosen renewable energy task was to install 380 m^2 with solar cells divided into the façade directed to the south-west and south-east. Theoretical calculations have been done to estimated power contributions from BIPV installations[3]. These calculations

[3] When installing an BIPV installation it is important that the inverter for the solar cells is placed in cool environments, and on non-flammable material. Furthermore, air gap behind the solar cells normally should be 100 mm, but the climate in Bodø dictates that it might be possible to reduce the gap size

show that building integrated solar panels will contribute with about 4,2 % of annual energy consumption or 37 255 kWh pr. year. The simulation showed that shadow from nearby buildings reduces production by about 25%. The calculations are shown in table 4. The estimated annual production figures were made before BIPV supplier was chosen. As the supplier later calculated solar production capacity of BIPV installations they reduced production peak substantially.

Table 4: Theoretical calculations of projected BIPV installations

	Facade east	Facade west
Area solar panels	146 m^2	228 m^2
Energy production	730 kWh/kWp	675 kWh/kWp
Number of solar modules	101	148
Installed effect	27 kWp	43 kWp
Annual production	37 255	
Share of annual energy consumption	4,2 %	

One of the essential calculations in the planning process to upgrade the Rehabilitations building has been to estimate needed power use after implemented energy efficientcy tasks. Table 5 shows calculated power from grid, heating needs from district heating and own power production from BIPV installations. The central number is a net energy requirement. An energy efficient of 126 kwh/m^2 is far below national building requirement of TEK 17, which for nursing homes allows 195 kwh/m2 and is also beyond passive house standard of 131 kWh/m^2

Table 5: Calculation of power use after implementation of energy efficiency tasks

Calculated power use after task implemented		
Power from grid	338398 kwh	47,3 kwh/m^2
District heating	542609 kwh	75,8 kwh/m^2
Sola power own prod.	-37255 kwh	-5,2 kwh/m^2
Net delivery of power	843752 kwh	**117,8 kwh/m^2**

6.0 Life Cycle Cost evaluation

Before decision to implement deep retrofit and BIPV installation Life Cycle Cost (LCC) was calculated. The LCC analysis calculates the present value of investment costs and all costs for management, operation, maintenance and replacement during the useful life. This also includes the BIPV installations.

The methods used for the LCC calculations are based on Norwegian Standard NS 3454:2013 – "Life cycle costs for buildings, principles and classification." (Norconsult report 2020) This is based on the present value method. By doing the LCC calculations the following main assumptions are made:

1. A risk-free interest rate of 2.0% p.a. and a risk premium of 2.0% p.a. is used, which represents a discount rate of 4% p.a.
2. Electricity price is set to 0.8 NOK/kWh. This electricity price represents the lowest value in a sensitivity analysis. Furthermore, energy prices are considered to have a low increase. Calculations also assume a reduced production as solar cells lose effect over the years. The assessment is considered to provide realistic overall earnings over time. Price of district heating is set to 0,75 NOK/kwh
3. Façade plates outer than BIPV modules are reused of existing panels. It is assumed that when reused, the facade panels will be painted before reassembly and that they will need one coat of paint after 20 years. The LCC calculations show price difference in investment and maintenance.

The table below lists building elements included in cost calculations in addition to the lifetime of these elements. Excluded from cost calculations are rig, service, dismantle and exchange of windows and wind barriers.

Tabel 6: Building elements included in LCC analysis and the lifetime of each element.

Analysis	**Included cost**	**Lifetime**
BIPV	Module Inverter Connections to Ignition distributor Assembly	30 years
Insulation of old constructions Exchanges of windows	Insulation Studding Assembly Windows Assembly	40 years 30 Years
Existing wall plates New wall plates	Dismantle of existing wall plates Painting and mounting Dismantle of existing wall plates Material cost Mounting of new wall plates	40 Years

As shown in table 7, the current values of building elements involved in energy efficient tasks are positive. This indicates that neither additional insulation, exchange of windows, replacement of façade plates nor BIPV installations have proven profitable (Norconsult report 2020).

Tabel 7: Estimated LCC calculation

LCC-Calculations	Investment cost	Yearly savings	Current value
BIPV	Nkr. 1 967 700	Nkr. -24 760	Nkr. 1 539 549
Additional Insulation	Nkr. 2 159 872	Nkr. -78 421	Nkr. 607 708
Windows	Nkr. 2 858 432	Nkr. -74 494	Nkr. 1 633 337
Reuse of existing facade plates	Nkr. 1 745 016	Nkr. 0	Nkr. 1 745 016
TOTAL	Nkr. 8 731 020	Nkr. -177 675	Nkr. 5 525 610

7.0 Life Cycle Assessment analysis

To evaluate the effect of energy efficiency tasks implemented, one also made a Life Cycle Assessment analysis of the Rehabilitation Building. As this project has a high environmental and climate profile, it was essential to calculate emission data.

The purpose of LCA calculations was thus to quantify greenhouse gas emissions measured in CO_2 equivalents (CO_2e) from material use in deep retrofit and renewable energy tasks. For BIPV, retrofitting and replacing windows, the savings represent saved energy. For the facade panels, savings represent savings in reuse of existing panels compared to new facade panels.

Methodological greenhouse gas calculation is in line with NS 3720 for greenhouse gas calculation for buildings (Norconsult report 2020). NS 3720 establishes a common life cycle model for buildings shown in table 8.

Tabel 8: LCA Model

Production stage			Implementation stage		User stage								End of life			
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	C1	C2	C3	C4
Raw materials	Transport	Production	Transport	Build Mounting	Use	Maintenance	Repair	Replacement	Renovation	Power use	Water use	Transport	Demolition	Transport	Waste disposal	Disposal
X	X	X	X			X		X								

Depending on the purpose of the LCA calculation, we can decide to include or exclude life cycle stages or describe these scenarios where project-specific information is missing. The table above shows the stages involved in the Life Cycle Assessment. For the Rehabilitations building we include material actual in used and we include emissions from new material made use of (Norconsult report 2020).

Calculating emissions for electricity we use a convert factor of 132 g/kWh[4]. For district heating, the convert factor is set to 18g/kwh.

Tabel 9: LCA calculations and estimated CO_2 emissions after energy efficiency task

LCA-calcu0lations in ton CO_2e	**Emissions from task implemented (tonCO_2e)**	**Reduction in emissions pr year (tonCO_2e)**	**Emissions after end of life (tonCO_2e)**
BIPV	103,26	4,91	-44,05
Additional insulation	17,85	1,88	-57,43
Windows	103,37	1,68	53,08
Reuse of existing facade plates	2,39	0,00	2,39
TOTAL	226,86	8,47	-46,02

The main picture of the LCA analysis as shown in table 8 is that the energy efficiency task has a substantial contribution to reducing CO_2 emissions with an estimated total reduction of 46,02 tonCO_2e. Solar BIPV installations and additional insulations is main contributor to this result, while replacing windows don't have a positive emissions balance between energy savings and material use. This is also confirmed by LCA data estimating when the different tasks arrive emissions neutrality. As shown in table 9 post-insulations tasks reach emission neutrality after 10 years and BIPV after 23 years.

Table 10: Energy efficient tasks and how many years to reach emission neutrality

	Savings pr. Year (kgCO_2e)	**Emission material (kgCO_2e)**	**Neutral emission effect (years)**	**End of life (Years)**
Additional insulation	1,88	17,85	10	40
BIPV	4910,4	103257,3	23	30
Windows	1,68	103,34	61,5	30

The choice to keep and reuse exiting façade and upgrade them has minor emissions consequences according to the LCA analysis as shown in table 10.

[4] A Norwegian ZEB Definition Guideline (Sintef). The ZEB Centre has chosen an average CO_2e factor of 132g CO_2e/kWh for electricity in the operational phase of the building's lifetime of sixty years. This value is significantly lower than the EU average of 242 g CO_2e/kWh in 2023, indicating a lower-carbon electricity supply, and suggests the grid mix includes a substantial amount of low-carbon energy sources.

Table 11: Estimated emission from reuse of existing facade plates

	Emission (kg CO_2/m^2	**Emission material ($tonCO_2e$)**
Reuse of existing facade plates	0,33	2,39

8.0 Methods and monitoring parameters.

Bodø Municipality has invested in an energy monitoring system (EOS), a digital tool that contributes with an overview of energy use. This software program is called E-save and is developed by the IT firm Esave AS located in Rognan. E-save is a central online monitoring and management tool used to optimize energy consumption of the municipal building stock. Energy data is monitored pr. hour or pr. week and energy use of different energy carriers such as solar, geothermal, district heating, and electricity from grid can be measured. Centralised monitoring makes it easy to detect deviations from the norm and make it possible to find the reason why a single building suddenly uses more electricity than normal or that a building uses more electricity than another similar building.

The main purpose of using E-Save is to reduce energy consumption to a minimum in the buildings. This is done as E-Save makes it possible to optimise and upgrade the performance of heat, ventilation, light etc.

To monitor, register and systematise energy data from our pilot Rehabilitation building we use this E-Save tool. E-Save has different visualisation options, which make it possible to show:

- An energy/temperature diagram measuring kwh/m^2/week. The diagram shows if energy use is on budget or shows energy subobtimalisation/technical defects.
- A bar diagram showing energy use/production pr. energy carrier used for the actual building.
- Accumulated graph showing energy use during the year.

The parameters we are monitoring:

- Total power use kwh/m^2 pr. Year. (Jan. 2023 to Dec. 2025)
- Total solar power production pr. Week (Jan. 2023 to Dec. 2025)
- Deviation from optimal solar conditions
- Total production from district heating (Jan. 2023 to Dec 2025)
- Total heating needs
- Condition for peak solar productions
- Calculate climate effect on energy use.
- Measure energy efficient task taking technology into use steering light, ventilations.
- Cost calculations and pay off for energy technology investment.

- Obtainment climate and energy goals

9.0 Conclusions: Results and summing up data

We have monitored energy data for the Rehabilitations building systematically for the three years period January 2023 to December 2025. BIPV installations were installed and started to produce energy to the building week 10 2023. To create a full year of data, we estimated electricity production for the first nine weeks of 2023. This estimate is calculated as average BIPV energy data from equivalent periods for 2024 and 2025 and added to productions data for 2023. As shown in table 12, this is only a minor correction as solar production is low for this period.

Table 12: Estimation of production data from BIPV installation first 9 weeks of 2023

	BIPV production kwh/m^2/week	BIPV production kwh
2024 week 1 – week 9	0,072	513,2
2025 week 1 – week 9	0,065	463,9
Average	0,068	488,55

For the monitoring period of four years table 12 shows the amount of electricity produced by BIPV facades. Compared with the calculated baseline the production has not reached expected level. Numbers are approximately 40% less than estimated and reach in 2024 a production of 21277 kWh compared with estimated baseline 37255 kWh. The contribution of kWh/m^2 is about 3 kWh.

Table 13: Production from BIPV façade elements

	Baseline	2023	2024	2025
Sola production	37255	20571,15	21277,2	19194,7
Sola use kWh/m2	5,203	2,872	2,969	2,68
Sola % of total energy use	4,2 %	2,07 %	2,19 %	2,12 %
Emissions tonCO2e 132	4,91666	2,71544	2,80859	2,5337

The reason for lower power production from BIPV façade installations than expected we find when we examine the patten for peak production as shown in table 14.

Table 14: Periods with peak production from BIPV installations

	Week	Peak kWh	Temperature
2023	12: 20-26 March	891	-2,59
	13: 27 March-2April	1024	-2,51
	18: 1-7 May	895	3,53
	26: 26 June-2 July	1105	16,76
	30: 24 July-30 July	1022	15,84
2024	16: 15-21 April	1212	2,16
	17: 22-28 April	1073	4,46
	18: 29 April-5 May	920	8,13
	21: 20-26 May	1204	12,91
	24: 10-16 June	1025	13,84
	29: 15-21 June	960	19,49
2025	17: 21-27 April	905	2,3
	29: 14-20 July	1294	19,71
	30: 21-27 July	910	18,71
	35: 25-31 July	925	13,66

The figures 3 and 4 below shows the BIPV production 2023 and 2024 per hour and the weekly production in 2024. It shows solar production happens approximately between week 6 and 43, where the significant production is from week 10 to 41. The production per hour is quite high from early in March, and the maximum production does not get much higher throughout the summer. Looking at accumulated production per week, the production however is higher in the summer months, which is reasonable with longer days and generally more sun.

Figure 3: BIPV production 2023 and 2024 per hour

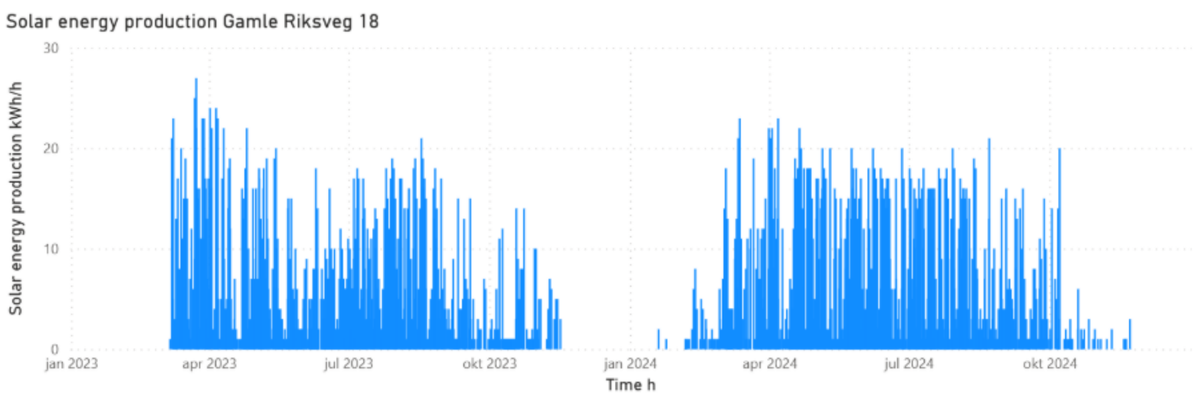
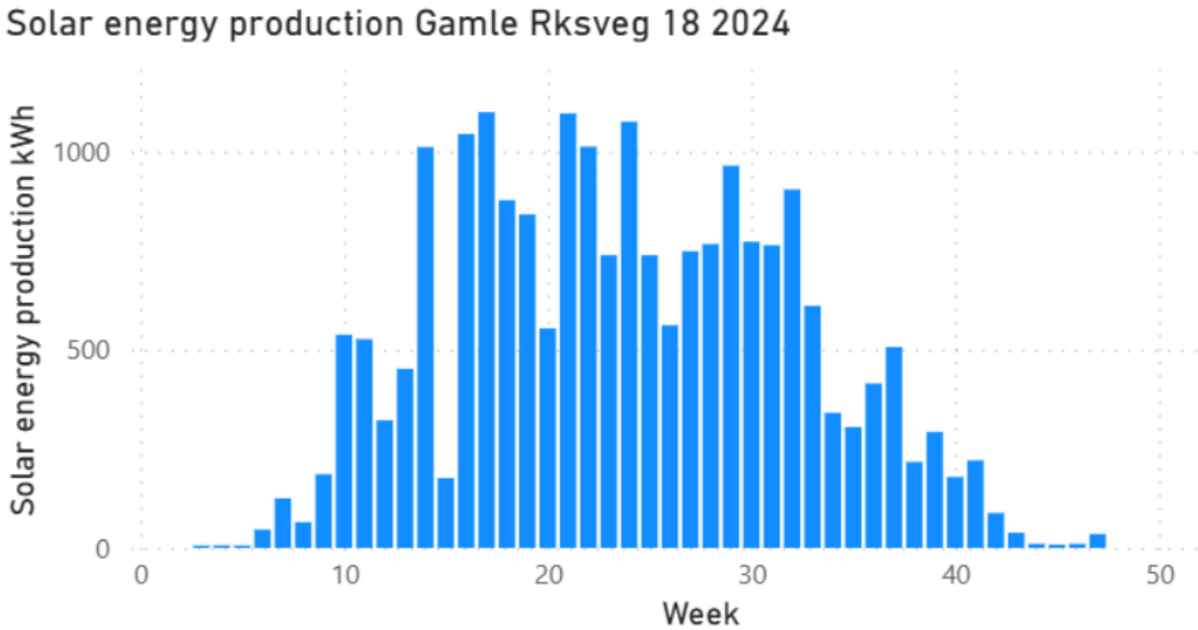


Figure 4: Solar energy production per week for 2024

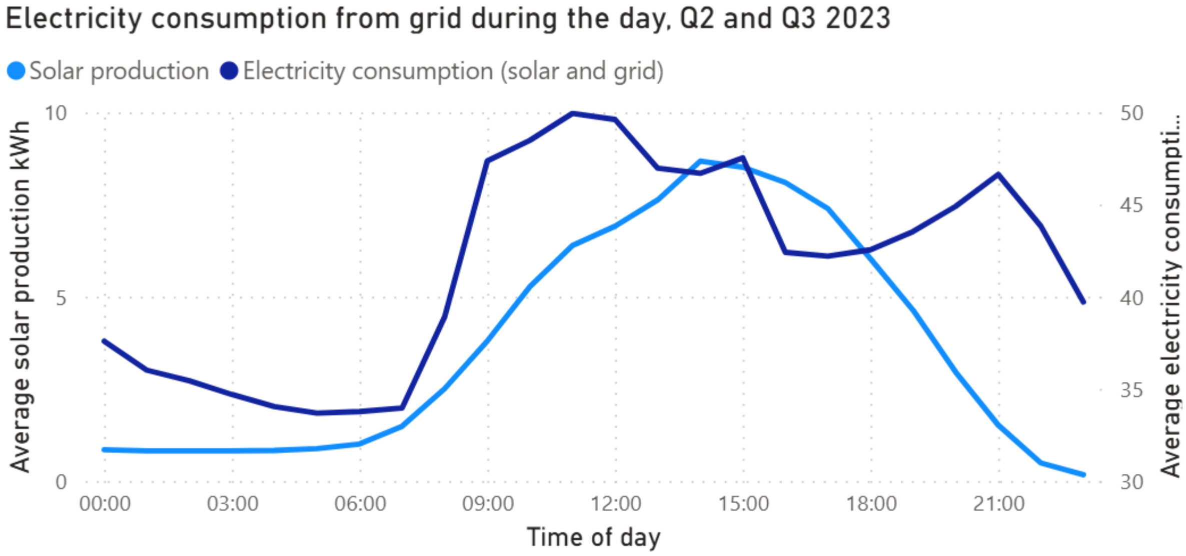


Power production patten shows that solar has its peak production in the period from April to May and in July. This is concurrent with the fact that BIPV installations are most efficient with horizontal Solar radiation. In arctic Bodø this is the fact in spring period and in the midnight sun month of July. Building integrated PV installations is not that efficient when solar radiation is vertical. Also, at low and even at minus temperature BIPV has high efficiency. Because BIPV panels have max productions with horizontal sun radiation, shadow effects from the neighboring building will cause minor solar production for Rehabilitation building.

The maximum production per hour since the solar panels were installed has been 27 kWh/h, accounting for 39% of theoretical peak capacity. With solar panels divided over the two facades, production is not expected to meet the theoretical peak capacity, considering this a fair, but not high utilization of peak capacity. All the highest production hours are in March and April, between 13-16 in the afternoon.

Looking at how production is divided during the day, we have looked at the average production per day in the second and third quarters of 2024. It shows that production rises from around 6.00 and stays at high production around 10-18, with peak production around 15.00. The figures below show peak production during the day (blue line), with the average electricity consumption pattern for the same period as a reference (purple line) (not using the same scale). Peak consumption happens some hours earlier than peak production, but overall, the patterns go quite well, with significant production in a large part of the consumption period.

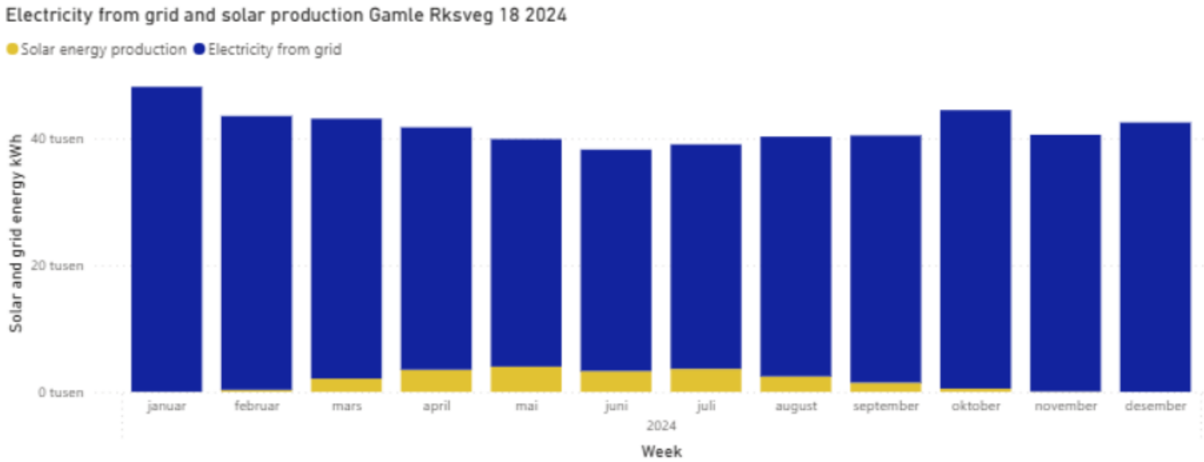
Figure 5: Comparison between patterns for solar production and electricity consumption



When looking at solar production compared with the electricity consumption in the building, we see that solar energy makes up a small share of the total electricity use from March to September. The electricity use is the lowest at the time when solar production is highest, but the variation in electricity consumption is low throughout the year. The low electricity variation is due to the use of district heating, which has much higher peaks in the winter.

Electricity and solar production data show that in 2023-2024 the BIPV produced more energy than is needed in the building for a total of 12 hours during the two years, with a maximum of 9 kWh higher production and an accumulated export of 24,6 kWh. Power export to the grid can be complicated and not profitable. The 12 hours of export is, however, a low number.

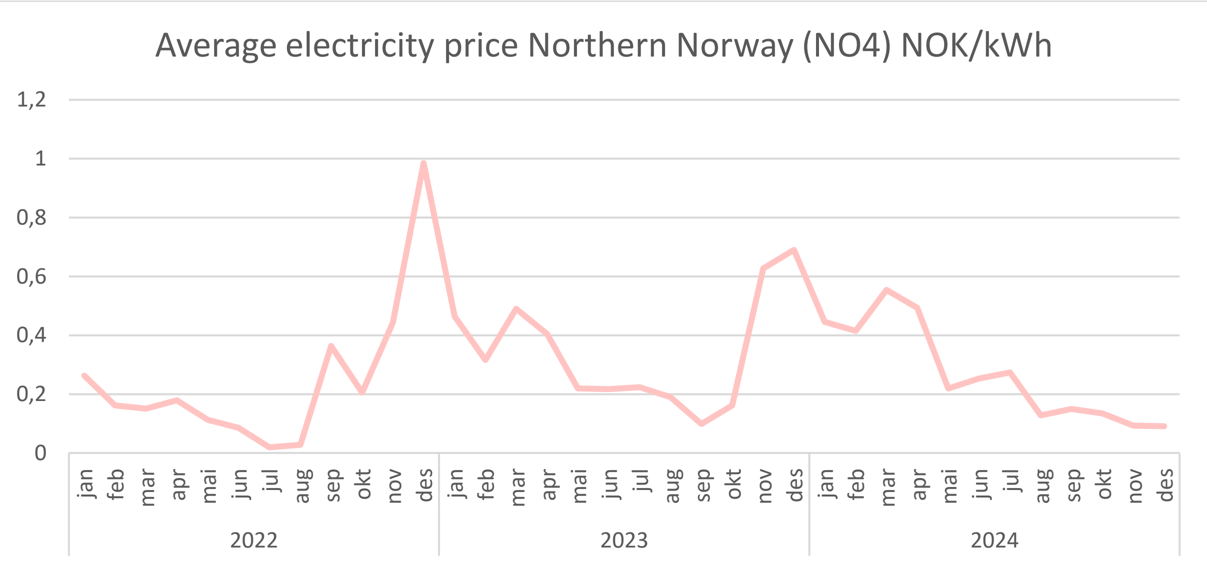
Figure 6 Monthly solar production as part of electricity consumption from grid 2024



Combining the solar production data with electricity prices in Northern Norway for the same period, it is possible to get an impression of the economy of the solar production.

The actual electricity price is more complicated than just the price to the power company itself, and a larger share comes on top to the grid company. The pattern is, however, similar. Electricity prices are typically high in late fall and winter, and can stay quite high in March and April, before decreasing towards the end of the summer. Solar production early in the year can therefore have economic benefits over later energy production. Taking this into account, the choice of façade mounted solar panels has the benefit of catching the spring sun efficiently, even though it may have lower efficiency as the sun goes higher on the sky during the summer.

Figure 7: Average electricity price Northern Norway between 2022 to 2024



Even with the modest solar production produced at Rehabilitation building, the contribution to reducing CO_2 emissions still is substantial. As shown in table 13, reduction is calculated to approximately 2.8 tonCO_2e.

Installing BIPV façade elements was part of deep retrofitting and other energy efficient tasks. In total energy efficient tasks have demonstrated great results in obtaining reduction in CO_2 emissions. Table 15 shows power use before and after energy efficient tasks and power use divided between power from grid to electricity use and district heating for heating purposes.

Baseline data are calculated as average energy use for the period 2019-2021 and to calculate emissions for electricity and district heating, we use a convert factor of 132 g/kWh for electricity and 18g/kWh for district heating. We present these calculations in table 15 and table 16.

Reduction in total energy use from grid and district heating compared with baseline numbers for total energy use shows for 2023 a reduction of 25.6% and for 2024 27,3%. The equivalent reduction in CO_2e compared with baseline is 16% for the year 2023 and 4% for 2024. The reason for a lesser reduction in CO_2e in 2024 is the change in power use with a large increase in electricity use from grid and a considerable decrease in district heating. This change in pattern is due to the installation of a new heath recovery ventilations system in mid-2023. Heath recovery increases power needs but reduces heating needs from district heating. Another reason for the rise in electricity needs is deliberate decisions to exchange the car fleet from fossil to electric cars. Charging for electrical cars is included in power production numbers from grid. For the year 2025 the reduction in CO_2 emissions is back to 12.4%.

Table 15: Development of energy efficiency and calculated emissions compared with baseline

	Power from grid (kwh)	District heating	Total energy use	Energy use kWh/m^2	Emission based on energy use (tonCO_2e)
Baseline	466080,38	871400,45	1337480,6	186,80	77,2078
2023	414840,00	560237,00	995 159,5	139,02	64,84 equals 16% reduction
2024	499776,90	451731,00	972 784,6	135,88	74,10 equals 4% reduction
2025	453203,80	434464,00	887 667,8	123,98	67,64 equals 12,4% reduction

Table 16: Average total energy use before implemented energy efficiency tasks

	Power from grid kWh	District heating kWh	Total energy use kWh
2019	463850,96	732372,00	1196222,96
2020	481910,57	901189,19	1383099,76
2021	452479,61	980640,15	1433119,07
Average	466080,38	871400,45	1337480,60

Table 17: Average total emission from energy use before implemented energy efficiency tasks

	Emission from electricity (tonCO_2e)	Emissions from district heating ton	Total emissions from energy used (tonCO_2e)
2019	61,2283	13,1827	74,411
2020	63,6122	16,2214	79,8336
2021	59,7273	17,6515	77,3788
Average	61,5226	15,6852	77,2078

Do we now compare the theoretical calculation for energy savings made with actual energy savings we realise that the actual savings are far higher than expected as shown in table 18. This will also influence the cost calculations made.

Table 18: Differences between theoretically calculated energy and real energy consumption data

	Theoretical calculations expected data	Real numbers 2024 data
Energy use before energy task	1074912 kWh	1337480,60
Energy use after energy task	881007 kWh	972784,60
Energy savings	193905 kWh	364696,00
Energy savings %	18 %	27,27 %

The difference in energy use between theoretical calculations and real numbers is 170791 kWh. A simplify calculation using the kWh price of Nkr. 0,8 contributes to additional cost savings of Nkr. 136.632 pr. year. Taking this into account to the Life Cycle Cost analysis we find that the energy efficient task implemented for Rehabilitations building at least will be cost neutral. The same argument also is valid as a comment to the Life Circle Assessment. As we see in LCA model table 8, power use at the user stage isn't included. As our monitoring data recognise the reduction in energy use is substantially higher than expected. This indicates that CO_2 emissions will reach a higher level than the theoretical calculations to justify. Estimated this energy data shows that approximately half of energy use is derived from grid and half from district heating. Additional savings in CO_2 emission pr year then amount to 12,8093 tonCO_2e compared to theoretical LCA calculations.

Table 19: Difference between energy efficiency in theoretical and real energy consumption data

	Theoretical calculation	**2023**	**2024**	**2025**
Energy use kwh/m^2	123,1	139,0	135,9	123,9
Solar production kwh/m^2	5,2	2,9	3,0	2,7
Energy standard	117,9	136,1	132,9	121,2

One of the most impressive achievements of the Rehabilitations pilot is the building after a deep retrofit combined with installing BIPV façade has improved its energy standard to passive houser standard. For 2025 energy use kwh/m^2 was reduced to 123,9 kwh/m^2 as shown in table 18.

Appendix 1:

Building Energy Rating (BER)

ADVISORY REPORT

Energy use in our homes is responsible for more than a quarter of Ireland's total CO emissions. Reducing energy use will save you money and is good for the environme This report provides advice on improving your Building Energy Rating, reducing your energy usage and costs, while improving the comfort and condition of your home.

Report Date: 13/09/2020

Assessor: Matthew Dilworth

Address: MACRONEY LOWER KILWORTH CO. CORK

Eircode: P61 P825

BER: 111167698

MPRN: 10007452811

About this Advisory Report

Energy use in our homes is responsible for almost a quarter of Ireland's total CO2 emissions. Reducing energy use will save you money and is good for the environment. This report provides advice on improving your BER, reducing your energy usage and costs, while improving the comfort of your home. The improvement measures recommended in this report are not mandatory and can be completed at your own discretion. Some improvements may require the use of suitably qualified installers or professional advice. All works should be completed to the relevant health and safety standards. Where applicable, works should be completed to the relevant Building Regulations. In this report an associated cost and impact are provided for the recommendations specific to your home. Costs and impacts are divided into categories and these are defined as follows:

Low Cost are improvements that are expected to cost less than 100 euro to complete.

Medium Cost are improvements that are expected to cost 100 euro to 1,000 euro to complete.

High Cost are improvements that are expected to cost more than 1,000 euro to complete. The above costs are guidelines only and actual costs will vary depending on house size, work specification and market conditions.

Low Impact are measures that will make a small improvement in energy efficiency.

Medium Impact are measures that will make a medium improvement in energy efficiency.

High Impact are measures that will make a large improvement in energy efficiency. Implementing any improvement measure will reduce your energy consumption. When implementing improvements it is sensible to prioritise those with a low cost and a high impact first. The money saved by reducing energy usage can help to pay for theimprovement measures. Moreover apart from increasing the comfort and costs the measures could increase the value of your home and reduce its environmental impact.

Ventilation

Operational Advice on Ventilation Care should always be taken to ensure a sufficient level of ventilation to maintain fresh air levels in each room and to remove moisture, water vapour and pollutants. For health and safety reasons it is important to ensure an adequate air supply to combustion appliances e.g. gas, oil or solid fuel. Signs of inadequate ventilation are persistent condensation and mould growth. If such problems exist, they should be addressed first, since reducing ventilation may make the problem worse. In a typical home 20% of all heat loss is through ventilation and draughts. Energy consumption can be improved while maintaining adequate ventilation. If draught sealing is damaged at any time make sure to replace it. When draughtproofing or making houses more airtight, it is important to maintain recommended ventilation standards. Radon concentrations can increase in existing houses as a result of greater airtightness. Further information on Radon is available from the Radiological Protection Institute of Ireland in their publication "Radon in Homes". This guide can be downloaded from www.rpii.ie.

Suspended Wooden Floor

This dwelling has a solid floor.

No specific action is advised.

Draught Stripping

This dwelling has 100% draught stripping.

No specific action is advised.

Ventilation System

This dwelling has balanced whole house mechanical ventilation, with heat recovery. Regular, professional servicing of your Mechanical Ventilation and Heat Recovery System is required to ensure that filters and grilles are clean and that the system is functioning correctly. The fans and heat exchangers also need to be cleaned regularly.

Building Elements

Floors

General Operational Advice on Floors Floors can be a source of significant heat loss and dampness in a dwelling. For example heat loss through the ground floor of a two storey house typically accounts for about 10% of total heat loss. For a single storey house this figure is about 15%. However, if a house is well insulated everywhere except for the ground floor, this percentage will be higher. A U-Value is a measure of the heat loss through the fabric of the building. The lower the U-Value the better and the higher the U-Value the greater the heat loss. Floors with a U-Value greater than 0.25 could be improved in a number of ways. A relatively simple way to reduce heat loss through a ground floor is to lay a carpet with foam backing or a foam underlay ensuring that both carpet andunderlay are laid wall to wall. Sealing of gaps in the ground floor will help to reduce draughts. Modern insulation methods for new houses may also be implemented in existing houses. In some cases this would be disruptive and costly, but if work needs to be done on the floor anyway, this is a good time to consider an insulation upgrade. For further details please refer to publication 'A Detailed Guide to Insulating Your Home' available on www.seai.ie

Roofs

General Operational Advice on Roofs Proper insulation will help retain valuable heat and improve overall comfort levels. If insulation is disturbed or damaged at any time, e.g. in attic space, make sure to restore or replace it. Heat loss through an un-insulated roof of a typical house can account for up to 30% of the total heat loss. Installing insulation will reduce this heat loss, and hence reduce the energy demand of the dwelling. A U-Value is the measure of the heat loss through the fabric of the building. The lower the U-Value the better and the higher the U-Value the greater the heat loss. Modern pitched roofs or habitable roof spaces that are insulated between the rafters, have a U-Value less than or equal to 0.2. Modern flat and pitched roofs that are insulated at ceiling level, have a U-Value less than or equal to 0.16. Blanket insulation, rigid board insulation or expanding foam may be used to achieve the required insulation level. Loose beads may also be used for roofs insulated on the ceiling. Installing roof insulation generally involves a considerable amount of work. The attic/roof space must have adequate ventilation to prevent dampness. This is achieved by leaving a continuous air gap along the eaves at each side. Electric cables should not be buried under insulation. Leave clearance for recessed lights to avoid them overheating. For further details please refer to publication ' A Detailed Guide to Insulating Your Home' available on www.seai.ie All pitched roofs insulated on the ceiling in this dwelling have a U-Value of less than or equal to 0.16. These roofs have reasonable insulation qualities. No specific action is advised.

Walls

Heat loss through the walls can account for up to 30% of the total heat loss. This can typically be reduced by two-thirds by insulating the walls and so reduce the energy demand of the dwelling. A U-Value is a measure of the heat loss through the building fabric. The lower the U-Value the better and the higher the U-Value the greater the heat loss. Walls with a U-Value greater than 0.27 could be improved. Insulation may be installed as cavity fill. This is where the gap between the inner and outer layers of external walls is filled with an insulating material. If cavity insulation is not applicable or is not technically possible, insulation may be installed internally or externally. Internal insulation involves a layer of insulation being fixed to the inside surface of external walls, and a suitable fire resistant finish being incorporated or applied. External solid wall insulation is the application of an insulant and a weather-protective finish to the outside of the wall. For further details please refer to publication 'A Detailed Guide to Insulating Your Home' available on www.seai.ie

Windows

Glass allows heat to escape more readily than most other building materials. For this reason, it is important that the windows are as energy efficient as possible. Windows can account for around 15% of the heat loss in your home. Installing energy efficient windows such as low-E double glazing helps to retain heat and improves comfort through elimination of cold window surfaces and associated downdraughts and condensation. The use of shutters, lined curtains and blinds can improve heat retention at night and further reduce downdraughts. A U-Value is a measure of the heat loss through the building fabric. The lower the U-Value the better and the higher the U-Value the greater the heat loss. Windows with a heat loss greater than the current building standards (i.e. have a U-Value greater than 2) could be improved. The best benefits are achieved through replacing single glazed windows with low-E double glazing or triple glazing. Note that single glazing can also be improved by adding secondary glazing (installing a secondary window and frame on the room side of the existing window).

Doors

Heat is lost from dwellings through doors which often have relatively poor thermal insulation compared to other elements of the building. Installing insulated doors will reduce this heat loss, and also generally reduce draughts through air gaps at the frames. Replacement doors, whether glazed or half glazed, should have insulated cores. A U-Value is a measure of the heat loss through the fabric of the building. The lower the U-Value the better and the higher the U-Value the greater the heat loss. Doors with a U-Value greater than 2.0 could be improved. For further details please refer to publication 'A Detailed Guide to Insulating Your Home' available on www.seai.ie

Hot Water

General Operational Advice on Hot Water. Ensure that the hot water cylinder insulation is not disturbed or damaged. Incomplete insulation increases heat loss and costs money.

Lighting

General Operational Advice on Lighting Compact Fluorescent Lamps (CFLs) use 20% of the energy used by typical incandescent bulbs to give the same amount of light. A 22 Watt CFL has the same light output as a 100 Watt incandescent. LED (Light-emitting diode) lights use less than 10% of the energy required for corresponding tungsten lights. Low energy lighting will give highest savings in rooms that are most often used.

Space Heating

General Operational Advice on Space Heating A reduction of 1oC on your thermostat can reduce annual space heating costs by 10% or more. An automatic timer switch or programmer allows you to schedule the heating duty on the hot water and heating system and to turn the system on and off as required. Use this facility to limit the running time for the heating system to fit your specific needs and you will save money.Room thermostats nomally turn the boiler and heating circulation pump off when the room temperature has reached the desired level. A room thermostat is normally located in a living area or circulations area (hall or landing). Guide temperature settings are 20oC for a living room and 16 - 18oC for circulation areas. However, the most appropriate setting depends on location of the thermostat and the heating system design. Choose the lowest setting that gives acceptable comfort conditions. Finding the setting to suit you may take some experimentation. Thermostatic Radiator Valves (TRVs) can be set to suit the heating requirements of the room(s) in question. For further details please refer to "A Detailed Guide to Home Heating Systems" available on www.seai.ie **Dist. System losses and gains (control category)** There are good heating system controls in this dwelling. No specific action advised.

Main Heating System

General Operational Advice on Main Heating System You should have your boiler professionally serviced at least once per year. A clean and serviced appliance will operate more economically and will have a longer service life.

Efficiency of Main Heating System (Electricity)

General Operational Advice on Efficiency of Electric Heating Systems. Electric storage heaters are more cost effective if you use electricity supplied at a cheaper night-time rate. Checking your tariff with your electricity supplier could save you money.

Efficiency of main heating system (Electricity)

This dwelling has an electric main heating system with a heat pump. You should have your heat pump professionally serviced at least once per year. A clean and serviced appliance will operate more economically and will have a longer service life.

General Advice on Energy Use in Your Home

The way we use energy in our homes can reduce energy consumption. Some simple everyday measures will save money, improve comfort and reduce your impact on the environment. Some of these are outlined below.

Appliances:

New kitchen appliances carry an energy rating label which rates energy efficiency on a scale of A to G. When buying new appliances look for A rated products which are more energy efficient and cost less to run. Do not under or overload appliances, such as dishwashers and washing machines. For washing machines, a 40ºC rather than a 60ºC wash cycle cuts electricity use by approximately a third. (Modern washing powders and detergents can work equally effectively at lower temperatures.) Defrost your freezer regularly to save energy and extend the operating life. Equipment on standby uses up to 20% of the energy it would use when fully on. When an appliance is not in use, turn it off fully.

Lighting:

Avail of natural daylight whenever possible and avoid leaving electric lights switched on in unoccupied rooms. All lighting lamps carry an energy label similar to that on appliances (i.e. an A to G label) so always choose the most efficient to suit your particular needs.

Useful Links and Sources of Further Information

Useful energy saving tips are available on www.change.ie (Tel. 1890 242643) and www.powerofone.ie. For specific queries on BER please contact SEAI on 1890734237 or by email info@ber.seai.ie. There are many useful documents available on The Sustainable Energy Authority of Ireland's (SEAI) website www.seai.ie The most recent Technical Guidance Documents for the Building Regulations and other supporting documents are available from the Department of Environment, Heritage and Local Government website www.environ.ie on the link to Building Standards (Tel. 1890 202021). Some of these documents are listed below. Technical Guidance Document Part L Conservation of Fuel and Energy - Dwellings; Technical Guidance Document Part J Heat Producing Appliances; Technical Guidance Document Part F Ventilation. When performing building works it is important to take the correct health and safety measures. Useful health and safety information on ventilation, radon and combustion devices can be found on the Carbon Monoxide safety website: www.carbonmonoxide.ie Tel. 1850797979 and The Radiological Protect Institute of Ireland website www.rpii.ie/radon Tel. 01 269 77 66. Please consider the environment before printing this document.

Appendix 2

HYBES KilworthMarch 2024

Overview

6kW of Solar PV

•3kW South Facing Ground Mounted

•3kW East/West Facing Roof Mounted

Battery Storage

•4.8 kWh

Space & Water Heating

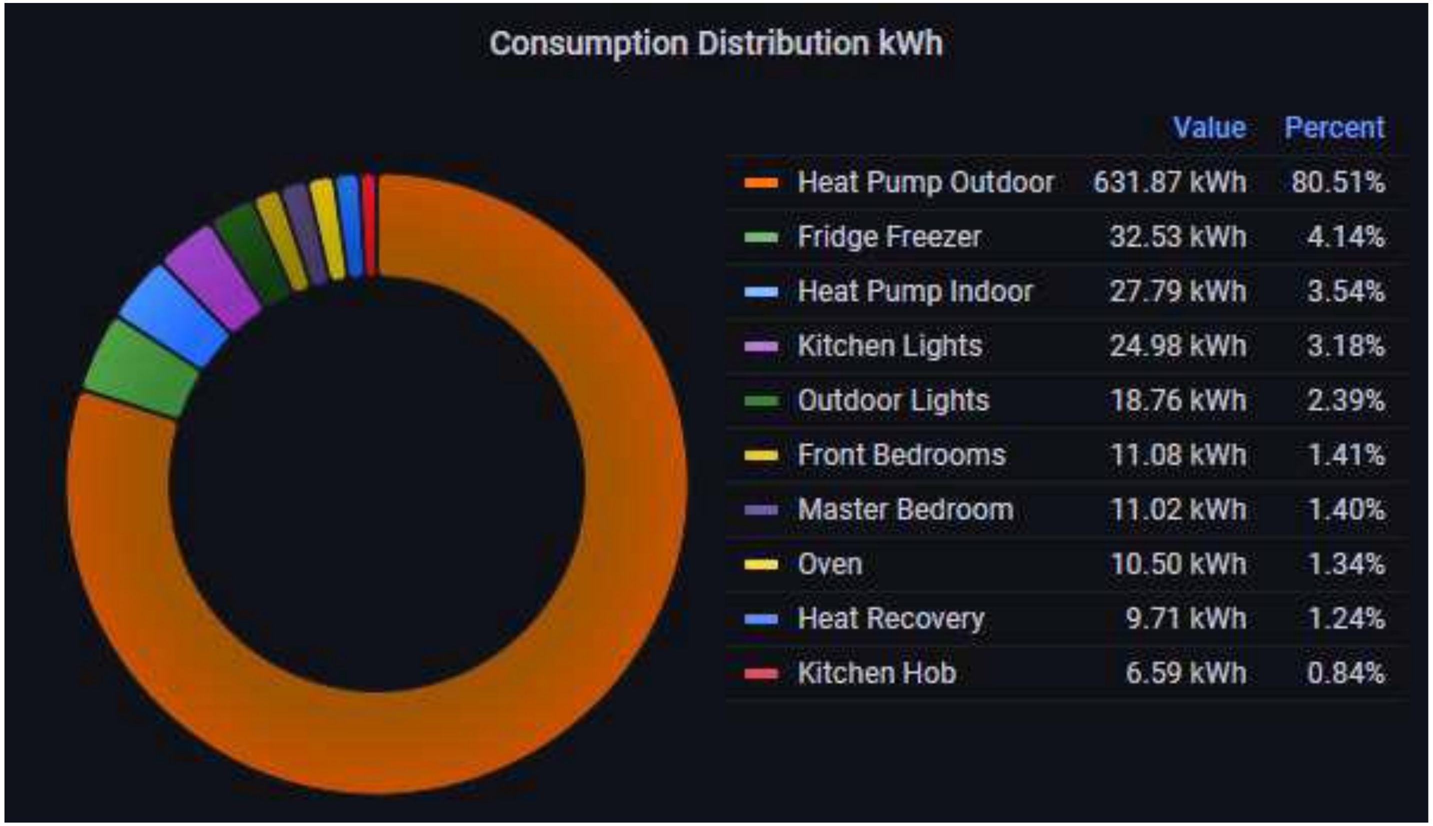
•3kW ASHP

A2 BER

Wattrics Energy Monitoring

Interreg
Co-funded by the European Union
Northern Periphery and Arctic

House Consumption Breakdown
January 2024



Interreg
Co-funded by the European Union
Northern Periphery and Arctic

Solar Potential

Potential earnings from this type of system is 4,914 kWh or €1,474/year at current electricity rates and 100% self-consumption. Additional is saves 1,300 kg CO2/year

Battery Energy Storage currently keeping self-consumption very high, this will be monitored further over the summer.

Month	Solar Radiation (kWh / m2/ day)	AC Energy kWh
January	0.69	100
February	1.46	199
March	2.30	353
April	3.84	569
May	4.88	729
June	4.82	692
July	4.59	678
August	4.23	625
September	3.21	463
October	1.91	287
November	1.02	146
December	0.52	73
Annual	2.79	4,914

ASHP January 2024

Typical daily consumption profile for the ASHP in January shown below, lots of consumption happening during off peak.

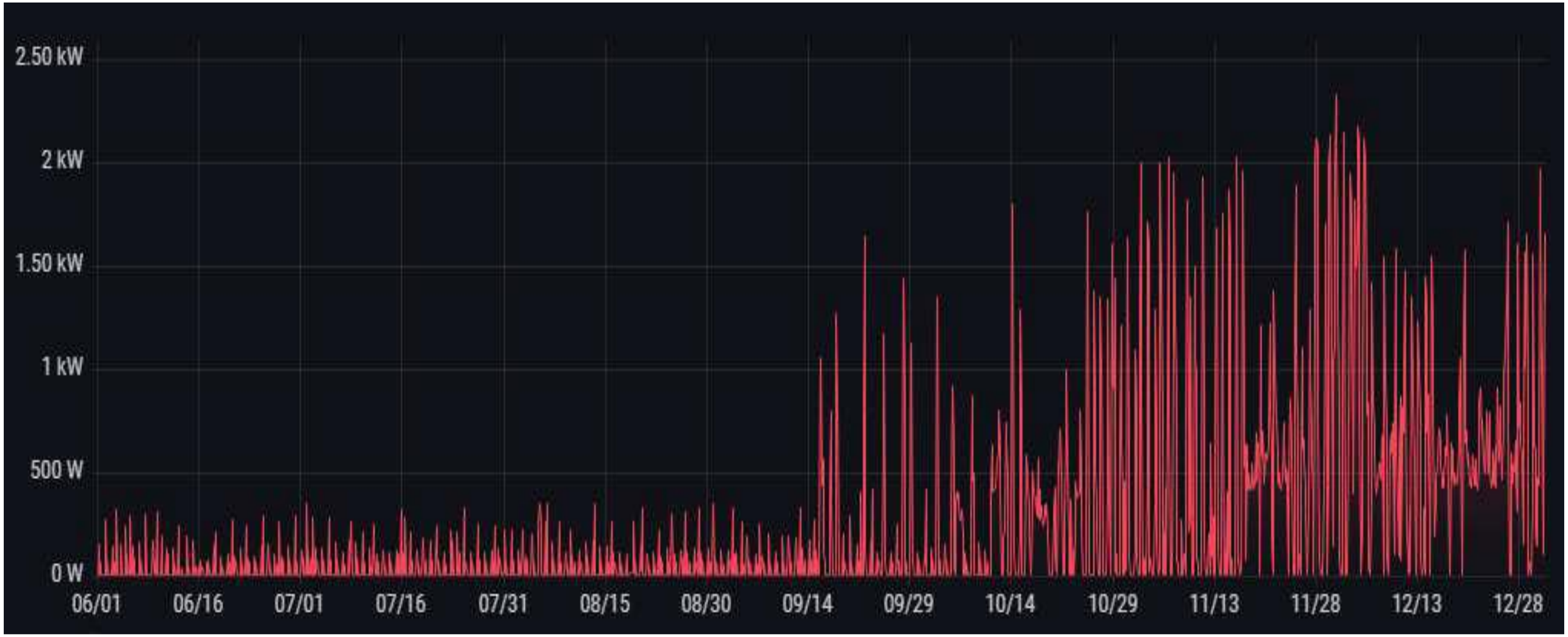
January consumption was 631 kWh.

ASHP Q3 & Q4 2023

Space heating energy demand only began in late September.

Annual kWh consumption less than 2,300 kWh. A typical Irish home is 11-16,000 kWh.

Saving 2,900 kg of C02/year


2.50 kW
2 kW
1.50 kW
1 kW
500 W
0 W
06/01
06/16
07/01
07/16
07/31
08/15
08/30
09/14
09/29
10/14
10/29
11/13
11/28
12/13
12/28