www.highland.gov.uk/
energyefficientscotland

The Highland Council
Comhairle na Gàidhealtachd

EES:ABS 2023/24 – Case Study 2

Fort William, Highland

Installation of Room in Roof Insulation, Air Source Heat Pump and Solar Photovoltaic Panels with Battery Storage

Table of Contents

1. Introduction

This report details the project to improve the energy performance of a three-bedroom semi-detached house in Fort William, in the western Scottish Highlands. The aim was to demonstrate effective methods and materials to enhance thermal efficiency, reducing energy consumption and costs for the homeowner. It provides an overview of the property's energy performance before and after the upgrades, highlighting the tangible benefits for both the property and its occupants.

2. The Site

The property is a three-bedroom semi-detached house built in the 1970s, located on the shores of Loch Linnhe in Fort William. Due to its geographic position, the property is exposed to challenging weather conditions, particularly in the winter, with high levels of rainfall and snowfall. The house consists of solid walls with a pitched slate roof and has two windows each on the front and rear elevations. The loft space is converted into a usable bedroom with a coom ceiling, and the existing heating system relied on an oil-fired boiler. The windows throughout the property are PVC double-glazed.

3. Pre-intervention Performance

Before the installation of the energy efficiency measures, the property had an Energy Performance Certificate (EPC) rating of E46, indicating low energy efficiency, and an environmental impact rating of E39, reflecting the property's high carbon emissions and significant environmental footprint. These ratings identified the need for substantial upgrades to reduce energy consumption and improve environmental sustainability. The full pre-installation EPC report is available in Appendix 1.

4. Implemented Improvements

The implemented improvements at the property were designed to target areas of significant energy loss and optimise the building's overall energy performance. By combining advanced insulation techniques with modern heating systems and renewable energy solutions, the project aimed to create a holistic approach to energy efficiency. Each intervention was carefully selected to address the specific needs of the property, taking into consideration the local climate, building structure, and existing energy systems. These improvements work synergistically to reduce energy consumption, enhance thermal comfort, and significantly lower the property's environmental impact. The following sections detail each measure implemented.

4.1 Room in Roof Insulation

One of the primary improvements was the installation of a SWIP Room in Roof Insulation System. This system utilises rigid polyisocyanurate modified polyurethane foam board insulation, pre-bonded to plasterboard. These boards were mechanically fixed through the existing plasterboard into the timber rafters on the sloping sections of the roof and vertical stud walls. Board information can be seen in figure 1 below.

Table 1 Nominal characteristics

Characteristic (unit)	Value
Length (mm)	2400
Width (mm)	1200
Thickness (mm)	25 to 165 (in 5 mm increments)
Minimum compressive strength* at 10% compression (kPa)	150
Edge profile	Square, tongue-and-groove, rebated

Figure 1 – SWIP Board Characteristics

This method ensures that heated air does not escape through the roof, significantly improving thermal retention within the loft space, the U-value potential improvement can be seen in figure 2. After installation, all skirting boards were refitted and sealed with intumescent and acoustic sealant. The new walls were then taped, filled, sanded, and painted white, seamlessly integrating the insulation into the home.

Table 3 Upgrading retained thermal elements

Element[1]	(a) Threshold U-value W/(m²·K)[8]	(b) Improved U-value W/(m²·K)[8]
Wall – cavity insulation[2]	0.70	0.55
Wall – external or internal insulation[3]	0.70	0.30
Floor[4,5]	0.70	0.25
Pitched roof – insulation at ceiling level	0.35	0.16
Pitched roof – insulation between rafters[6]	0.35	0.18
Flat roof or roof with integral insulation[7]	0.35	0.18

1 'Roof' includes the roof parts of dormer windows and 'wall' includes the wall parts (cheeks) of dormer windows.

2 This applies only in the case of a wall suitable for the installation of cavity insulation. Where this is not the case, it should be treated as 'wall – external or internal insulation'.

3 A lesser provision may be appropriate where meeting such a standard would result in a reduction of more than 5% in the internal floor area of the room bounded by the wall.

4 The U-value of the floor of an extension can be calculated using the exposed perimeter and floor area of the whole enlarged building.

5 A lesser provision may be appropriate where meeting such a standard would create significant problems in relation to adjoining floor levels.

6 A lesser provision may be appropriate where meeting such a standard would create limitations on head room. In such cases, the depth of the insulation plus any required air gap should be at least to the depth of the rafters, and the thermal performance of the chosen insulant should be such as to achieve the best practicable U-value.

7 A lesser provision may be appropriate if there are particular problems associated with the load-bearing capacity of the frame or the upstand height.

8 Area-weighted average values.

Figure 2 – U value improvements

4.2 Air Source Heat Pump

To enhance the property's heating system, a Grant Aerona HPID10R32 Air Source Heat Pump (ASHP) was installed alongside a 201L Pre-Plumbed Hot Water Cylinder. The ASHP was positioned in the rear garden, and the system provides a reliable, consistent heat source through newly installed radiators and pipework. A programmable thermostat was added to ensure the heating system operates efficiently, switching on only when needed to minimise energy waste and reduce running costs.

Prior to installation, the property's insulation was upgraded to the highest possible standard to prevent heat loss. Heat loss calculations were carried out for each room, ensuring that the radiators were correctly sized to cover the room's heat loss and maintain target temperatures. This approach ensures optimal heat distribution throughout the house, improving both comfort and energy efficiency.

4.3 Solar Photovoltaic Panels and Battery Storage

In addition to improving the heating system, a solar photovoltaic (PV) system was installed to further reduce the property's reliance on grid-supplied electricity. Solar panels provide renewable, pollution-free energy, helping to reduce both carbon emissions and energy bills. On this project, an 8 panel PV array was fitted due to roof space limitations, with an installed capacity of 3.36 kWp, producing approximately 2,000 kWh of energy annually.

To maximise the effectiveness of the solar panels, a battery storage system was integrated, allowing any surplus energy generated during the day to be stored and used later when demand is higher, such as in the evening. This system reduces the need to draw electricity from the grid, particularly during peak hours, providing immediate savings on energy bills. The solar PV system and battery installation were completed efficiently within one day, although more complex projects may require additional time.

Figure 3 – PV panels on property

Figure 4 – Systems social contributions

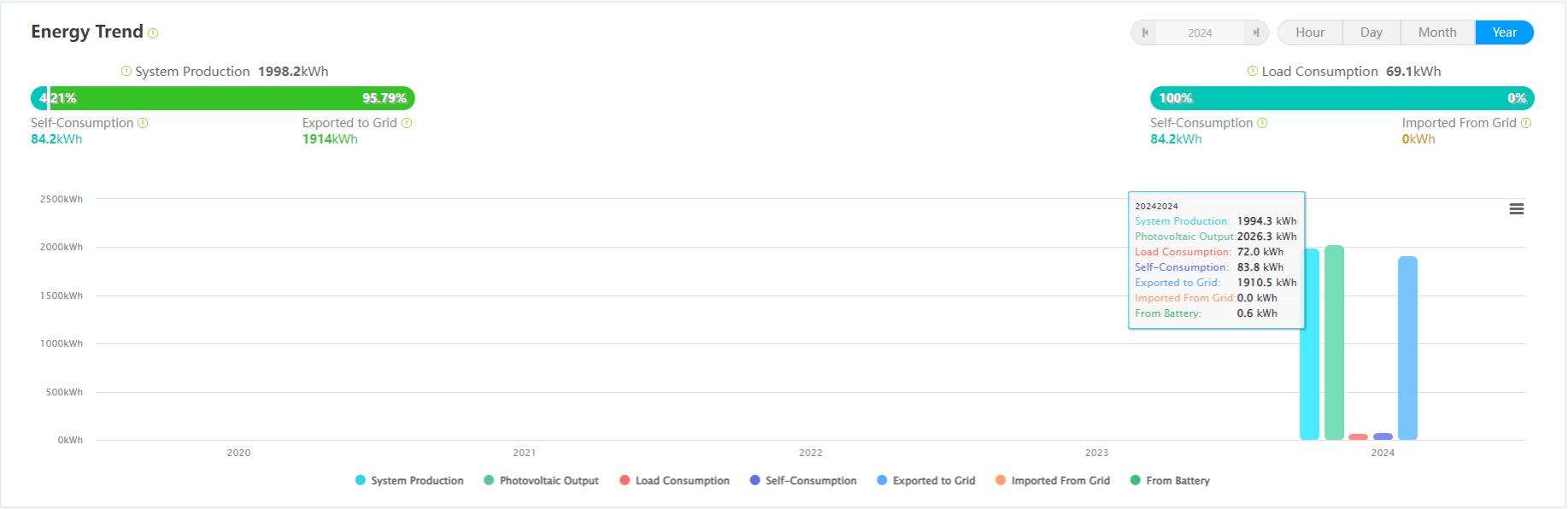


Figure 5 – Energy Trend of system.

5. Post-Intervention Performance

Following the implementation of the energy efficiency improvements, the property's energy performance improved significantly. The Energy Performance Certificate (EPC) rating increased from E46 to B87 for energy efficiency, and the environmental impact rating improved from E39 to B88. These ratings reflect a substantial reduction in both energy consumption and carbon emissions, making the property highly energy efficient and significantly lowering its environmental footprint. The full post-installation EPC report can be found in Appendix 2.

6. Conclusion

The energy efficiency upgrades implemented at the property in Fort William showcase a range of effective methods for improving the energy performance of a semi-detached house. The combination of room in roof insulation, an air source heat pump, and solar photovoltaic panels with battery storage has not only enhanced the overall comfort of the property but also reduced energy consumption and carbon emissions.

Appendix 1 Pre Energy Performance Certificate Extract

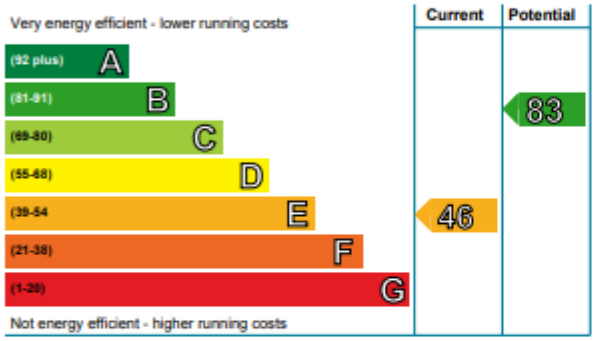
Dwelling type:	Semi-detached house	**Reference number:**	[redacted]
Date of assessment:	20 November 2023	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	08 December 2023	**Approved Organisation:**	Elmhurst
Total floor area:	93 m²	**Main heating and fuel:**	Boiler and radiators, oil
Primary Energy Indicator:	288 kWh/m²/year		

You can use this document to:

- **Compare current ratings of properties to see which are more energy efficient and environmentally friendly**
- **Find out how to save energy and money and also reduce CO_2 emissions by improving your home**

Estimated energy costs for your home for 3 years*	**£5,850**	See your recommendations report for more information
Over 3 years you could save*	**£2,745**	

* based upon the cost of energy for heating, hot water, lighting and ventilation, calculated using standard assumptions

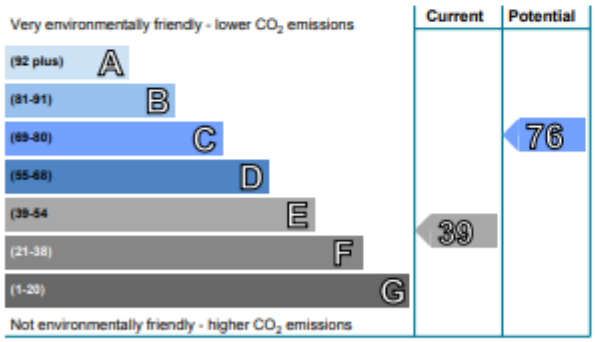


Energy Efficiency Rating

This graph shows the current efficiency of your home, taking into account both energy efficiency and fuel costs. The higher this rating, the lower your fuel bills are likely to be.

Your current rating is **band E (46)**. The average rating for EPCs in Scotland is **band D (61).**

The potential rating shows the effect of undertaking all of the improvement measures listed within your recommendations report.



Environmental Impact (CO_2) Rating

This graph shows the effect of your home on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating, the less impact it has on the environment.

Your current rating is **band E (39)**. The average rating for EPCs in Scotland is **band D (59).**

The potential rating shows the effect of undertaking all of the improvement measures listed within your recommendations report.

Top actions you can take to save money and make your home more efficient

Recommended measures	Indicative cost	Typical savings over 3 years
1 Room-in-roof insulation	£1,500 - £2,700	£1023.00
2 Cavity wall insulation	£500 - £1,500	£360.00
3 Floor insulation (suspended floor)	£800 - £1,200	£423.00

Summary of the energy performance related features of this home

This table sets out the results of the survey which lists the current energy-related features of this home. Each element is assessed by the national calculation methodology; 1 star = very poor (least efficient), 2 stars = poor, 3 stars = average, 4 stars = good and 5 stars = very good (most efficient). The assessment does not take into consideration the condition of an element and how well it is working. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology, based on age and type of construction.

Element	Description	Energy Efficiency	Environmental
Walls	Cavity wall, as built, no insulation (assumed) Timber frame, as built, partial insulation (assumed)	★★☆☆☆ ★★★☆☆	★★☆☆☆ ★★★☆☆
Roof	Pitched, 300 mm loft insulation Roof room(s), ceiling insulated	★★★★★ ★★★☆☆	★★★★★ ★★★☆☆
Floor	Suspended, no insulation (assumed)	—	—
Windows	Fully double glazed	★★★★☆	★★★★☆
Main heating	Boiler and radiators, oil	★★★☆☆	★★★☆☆
Main heating controls	Programmer, TRVs and bypass	★★★☆☆	★★★☆☆
Secondary heating	Room heaters, dual fuel (mineral and wood)	—	—
Hot water	From main system, no cylinder thermostat	★★☆☆☆	★★☆☆☆
Lighting	Low energy lighting in all fixed outlets	★★★★★	★★★★★

The energy efficiency rating of your home

Your Energy Efficiency Rating is calculated using the standard UK methodology, RdSAP. This calculates energy used for heating, hot water, lighting and ventilation and then applies fuel costs to that energy use to give an overall rating for your home. The rating is given on a scale of 1 to 100. Other than the cost of fuel for electrical appliances and for cooking, a building with a rating of 100 would cost almost nothing to run.

As we all use our homes in different ways, the energy rating is calculated using standard occupancy assumptions which may be different from the way you use it. The rating also uses national weather information to allow comparison between buildings in different parts of Scotland. However, to make information more relevant to your home, local weather data is used to calculate your energy use, CO_2 emissions, running costs and the savings possible from making improvements.

The impact of your home on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in our homes produces over a quarter of the UK's carbon dioxide emissions. Different fuels produce different amounts of carbon dioxide for every kilowatt hour (kWh) of energy used. The Environmental Impact Rating of your home is calculated by applying these 'carbon factors' for the fuels you use to your overall energy use.

The calculated emissions for your home are 75 kg $CO_2/m^2/yr$.

The average Scottish household produces about 6 tonnes of carbon dioxide every year. Based on this assessment, heating and lighting this home currently produces approximately 7.0 tonnes of carbon dioxide every year. Adopting recommendations in this report can reduce emissions and protect the environment. If you were to install all of these recommendations this could reduce emissions by 4.4 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

Appendix 2 Post Energy Performance Certificate Extract

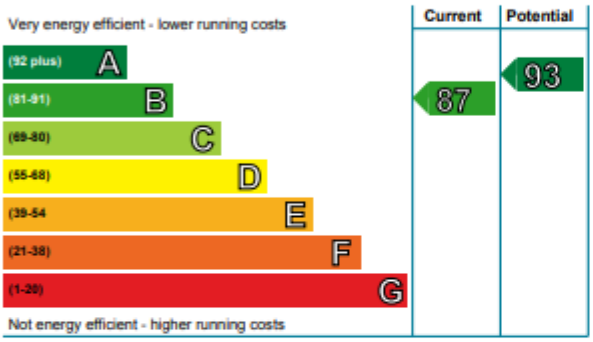
Dwelling type:	Semi-detached house	**Reference number:**	[redacted]
Date of assessment:	01 February 2024	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	23 February 2024	**Approved Organisation:**	Elmhurst
Total floor area:	93 m²	**Main heating and fuel:**	Air source heat pump, radiators, electric
Primary Energy Indicator:	87 kWh/m²/year		

You can use this document to:

- **Compare current ratings of properties to see which are more energy efficient and environmentally friendly**
- **Find out how to save energy and money and also reduce CO_2 emissions by improving your home**

Estimated energy costs for your home for 3 years*	**£4,593**	See your recommendations report for more information
Over 3 years you could save*	**£909**	

* based upon the cost of energy for heating, hot water, lighting and ventilation, calculated using standard assumptions

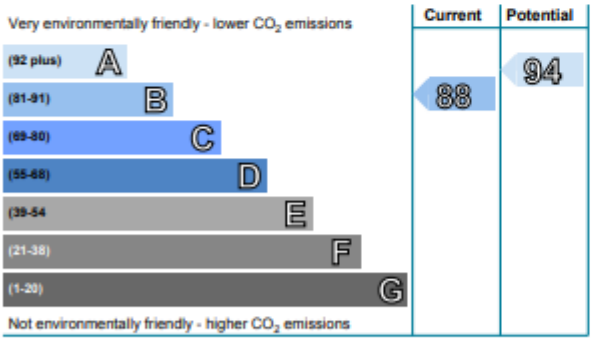


Energy Efficiency Rating

This graph shows the current efficiency of your home, taking into account both energy efficiency and fuel costs. The higher this rating, the lower your fuel bills are likely to be.

Your current rating is **band B (87)**. The average rating for EPCs in Scotland is **band D (61).**

The potential rating shows the effect of undertaking all of the improvement measures listed within your recommendations report.



Environmental Impact (CO_2) Rating

This graph shows the effect of your home on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating, the less impact it has on the environment.

Your current rating is **band B (88)**. The average rating for EPCs in Scotland is **band D (59).**

The potential rating shows the effect of undertaking all of the improvement measures listed within your recommendations report.

Top actions you can take to save money and make your home more efficient

Recommended measures	Indicative cost	Typical savings over 3 years
1 Floor insulation (suspended floor)	£800 - £1,200	£327.00
2 Heating controls (zone control)	£350 - £450	£171.00
3 Solar water heating	£4,000 - £6,000	£414.00

Summary of the energy performance related features of this home

This table sets out the results of the survey which lists the current energy-related features of this home. Each element is assessed by the national calculation methodology; 1 star = very poor (least efficient), 2 stars = poor, 3 stars = average, 4 stars = good and 5 stars = very good (most efficient). The assessment does not take into consideration the condition of an element and how well it is working. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology, based on age and type of construction.

Element	Description	Energy Efficiency	Environmental
Walls	Cavity wall, filled cavity Timber frame, as built, partial insulation (assumed)	★★★☆☆ ★★★☆☆	★★★☆☆ ★★★☆☆
Roof	Pitched, 300 mm loft insulation Roof room(s), insulated	★★★★★ ★★★★☆	★★★★★ ★★★★☆
Floor	Suspended, no insulation (assumed)	—	—
Windows	Fully double glazed	★★★★☆	★★★★☆
Main heating	Air source heat pump, radiators, electric	★★★★☆	★★★★★
Main heating controls	Programmer, TRVs and bypass	★★★☆☆	★★★☆☆
Secondary heating	Room heaters, dual fuel (mineral and wood)	—	—
Hot water	From main system	★★★☆☆	★★★★☆
Lighting	Low energy lighting in all fixed outlets	★★★★★	★★★★★

The energy efficiency rating of your home

Your Energy Efficiency Rating is calculated using the standard UK methodology, RdSAP. This calculates energy used for heating, hot water, lighting and ventilation and then applies fuel costs to that energy use to give an overall rating for your home. The rating is given on a scale of 1 to 100. Other than the cost of fuel for electrical appliances and for cooking, a building with a rating of 100 would cost almost nothing to run.

As we all use our homes in different ways, the energy rating is calculated using standard occupancy assumptions which may be different from the way you use it. The rating also uses national weather information to allow comparison between buildings in different parts of Scotland. However, to make information more relevant to your home, local weather data is used to calculate your energy use, CO_2 emissions, running costs and the savings possible from making improvements.

The impact of your home on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in our homes produces over a quarter of the UK's carbon dioxide emissions. Different fuels produce different amounts of carbon dioxide for every kilowatt hour (kWh) of energy used. The Environmental Impact Rating of your home is calculated by applying these 'carbon factors' for the fuels you use to your overall energy use.

The calculated emissions for your home are 15 kg $CO_2/m^2/yr$.

The average Scottish household produces about 6 tonnes of carbon dioxide every year. Based on this assessment, heating and lighting this home currently produces approximately 1.4 tonnes of carbon dioxide every year. Adopting recommendations in this report can reduce emissions and protect the environment. If you were to install all of these recommendations this could reduce emissions by 0.5 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.