Building Typology Brochure
Ireland

A detailed study on the energy performance of typical Irish dwellings

August 2014












EPISCOPE

Co-funded by the Intelligent Energy Europe Programme of the European Union

www.building-typology.eu

Disclaimer

The sole responsibility for the content of this brochure lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the EACI nor the European Commission are responsible for any use that may be made of the information contained therein.

Co-funded by the Intelligent Energy Europe Programme of the European Union

Table of Contents Page

Co-funded by the Intelligent Energy Europe Programme of the European Union

Acknowledgements

The authors would like to thank the many stakeholders and experts who contributed to the Irish TABULA project.

Members of the Irish TABULA National Advisory Group:

Sean Armstrong, Department of Environment, Community & Local Government
Matt Carroll, Dublin City Council
Joseph Curtin, Institute for International and European Affairs
Sarah Cassidy, Dun Laoghaire Rathdown County Council
Ann Golden, South Dublin County Council
Tom Halpin, Sustainable Energy Authority of Ireland
Sean Mooney, Electric Ireland
St. John O'Connor, Department of Communications, Energy & Natural Resources
Charles Roarty, Energy Action
Sue Scott, ESRI
Duncan Stewart, Earth Horizon Productions
Fintan Smyth, Gyproc and Isover Ireland
Simon McGuinness, Dublin Institute of Technology
Dermot Byrne, Retrofit Energy Ireland Limited
Paddy Sweeney, Retrofit Energy Ireland Limited

Providers of additional research resources and support:

Keith Beirne, Codex Energy
Michael Cunningham, Researcher
Shay Kavanagh, Sustainable Energy Authority of Ireland
Garrett Kelly, Energy Consultant
Jamie Lacey, Researcher

The Irish TABULA project was part-funded by the Intelligent Energy Europe programme. It was kindly co-funded in Ireland by:

Dublin City Council
Electric Ireland
Sustainable Energy Authority of Ireland

Research Report written by:

Marcin Badurek
Michael Hanratty
Bill Sheldrick
Dara Stewart
(In-house Consultants, IHER Energy Services)

Introduction

The aim of the Intelligent Energy Europe (IEE) TABULA project (2009-2012) was to create a building typology in each of the member states participating in the project. In the case of Ireland, the building typology identified the most common residential building types and provided relevant building energy information for each type that would be of use to home owners and building professionals alike.

Information on TABULA was then made available to energy consultants and the general public via two key channels, namely through (1) the TABULA building typology webtool www.building-typology.eu and (2) brochures for each participating country giving an overview of the energy performance of typical buildings and the possible energy savings by refurbishment measures. The webtool analysis is based on a common EU methodology defined for the TABULA project whereas the energy analysis within the brochures was based on the Irish national Building Energy Rating (BER) method known as Dwelling Energy Assessment Procedure (DEAP). (BER is more often referred to as EPC or energy performance certificate in Europe).

The Irish TABULA building typology brochure was first published in May 2012. As a follow-on to TABULA, the IEE EPISCOPE project (2013-2016) is conducting further typology-based research focusing on the monitoring of building refurbishment levels. Within EPISCOPE, the 17 partners are also tasked with adding new build and NZEB design dwellings to their typologies in the case of existing TABULA project partners. (New partners will develop full typologies from scratch.)

This document contains the updated Irish building typology including new build design dwellings complying with the Building Regulations 2011 (Technical Guidance Document L) and the proposed NZEB standard outlined in "Towards Nearly Zero Energy Buildings in Ireland - Planning for 2020 and Beyond", Dept. of the Environment, Community and Local Government, November 2012). In total there are 3 new build types and 31 existing dwelling types in this latest TABULA brochure. Individual double-sided A4 brochures are available separately for each building type. The upgrade measures and costs analysis of all 31 existing dwelling types have also been revised in this latest 2014 edition. In the case of the upgrade measures, these changes are evident in table 3 and table 4.

Creation of the Irish Building Typology

34 typical Irish house & apartment types identified by the Irish TABULA project team are included in the Irish TABULA brochure. The typical existing Irish residential buildings were selected primarily by assessing the ranges of construction types and age bands with the Irish national Building Energy Rating method (DEAP) and examining data sources such as the Irish Census and the Sustainable Energy Authority of Ireland's (SEAI's) national BER database.

Within the Irish TABULA project, 10 distinct Irish construction age bands were identified based on distinct construction types prior to building regulations in 1976 and then step changes to building regulations that would significantly affect the energy performance of dwellings. Draft Building Regulations were first introduced in Ireland in 1976 and there were revisions in 1981 (draft also), leading to full Building Regulations in 1991 with subsequent revisions in 1997, 2002, 2005, 2008 and 2011. Allowing for the transition interval between the commencement date for new regulations and the completion of the construction process, dwelling built two years after the introduction of the new regulations are considered to meet the new regulations. (This approach is consistent with the DEAP method).

The 10 construction age bands selected for the Irish TABULA typology are shown in Table 1.

Co-funded by the Intelligent Energy Europe Programme of the European Union

Table 1: Irish Construction Age Bands

Construction Year Class	Code
1800-1899	1
1900-1929	2
1930-1949	3
1950-1966	4
1967-1977	5
1978-1982	6
1983-1993	7
1994-2004	8
2005-2010	9
2010-onwards	10

The 34 Irish dwelling types are spread across these 10 age bands. They include both detached, semi-detached and terraced houses plus one pre 1977 apartment. They also include a range of building wall types including stone, mass concrete, solid brick, hollow block, cavity and timber frame with insulation levels varying from none to NZEB standards.

Table 2 shows the reduction in energy demand required by the Irish Building Regulations when compared to a reference dwelling defined in the 2005 Building Regulations Technical Guidance Document L (Appendix C).

Table 2: TGD Part L Revisions since 2005

Part L (Average Dwelling)	2005	2008	2011	2016
% Improvement	Baseline	40%	60%	70%
Primary Energy Consumption (kWh/ m2/a)	150	90	60	45
CO2 Emission Rate (kgCO2/m2/a)	30	18	12	10
BER	B3	B1	A3	A2
MPEPC	-	0.6	0.4	0.302
MPCPC	-	0.69	0.46	0.305

The 70% improvement in energy demand proposed for 2016 will set the Nearly Zero Energy Building standard for new dwellings in Ireland in accordance with the common general framework set out in Annex 1 of Directive 2010/31/EU on the Energy Performance of Buildings (Recast). For a typical dwelling, this will equate to an A2 rating with a primary energy value of 45 kWh/m2/annum and an energy performance co-efficient (EPC) and carbon performance co-efficient (CPC) not exceeding 0.302 and 0.305 respectively.

Co-funded by the Intelligent Energy Europe Programme of the European Union

Construction Details

The individual brochures for the 34 dwelling types are shown in this document. For each building type, sectional drawings and sketches are provided to illustrate many of the typical wall and roof constructions for both the original state and the refurbished state. These sectional drawings and sketches should provide homeowners, in particular, with some basic information relating to their dwelling that will enable them engage fully with potential refurbishment projects. They will also guide designers of new buildings.

For example the roof and wall construction for type 8, a mass concrete terraced house, are shown in figures 1 and 2 below.

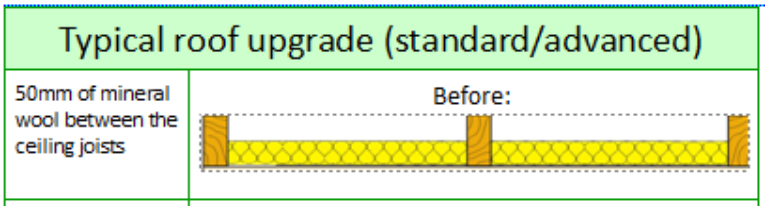


Figure 1

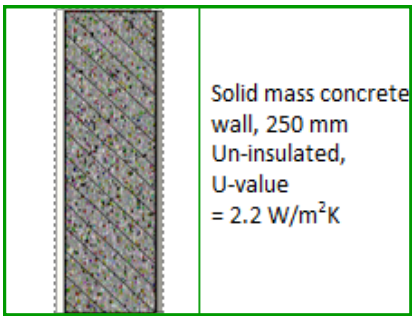


Figure 2

Characteristics of Typical Irish Buildings

When determining the energy related characteristics of a house built in the 1930s for example, the challenge for the project team was to estimate what would be the typical energy performance of such a building. When it was constructed, it would have had single glazed windows, no wall, roof or floor insulation and no central heating. When the TABULA project started in 2009, there was very limited information available to the project team on the levels of refurbishment of Irish buildings.

The Irish National Survey of Housing Quality report (2001-2002) published by the Economic & Social Research Institute (ESRI), based on a survey of 40,000 Irish dwellings, is the most comprehensive report available on Irish dwellings and contains much useful information. However, it did not contain sufficiently detailed information for adaptation into TABULA.

Thus, the Irish TABULA team used its extensive surveying experience of Irish dwellings to draw conclusions on how to determine the current state of typical older buildings. In determining the energy characteristics of older dwellings, the approach adopted was to assume that all older dwellings would have had modest energy upgrades only in keeping with general societal modifications to dwellings. For example, it was assumed that a house built in the 1940s would have had roughly 50mm of roof insulation installed during the 1970s say and that it would have had an oil or gas central heating system with minimal heating controls installed at the same time. This approach was adopted for all pre 1977 typical Irish buildings.

The existing conditions for all building types are listed in each of the individual brochures.

Co-funded by the Intelligent Energy Europe Programme of the European Union

Refurbishment Analysis for each Existing Dwelling Type

As well as indentifying these national house types, two stages of refurbishment of each existing dwelling type are examined in TABULA. Data on the 2 stages of retrofit , i.e. standard and advanced, are contained in each of the first 31 brochures.

Each member state involved in TABULA was given the freedom to define its own refurbishment measures.

The first stage of refurbishment (standard level) for Irish dwellings is broadly based on the SEAI Better Energy Homes (BEH) standard for roof and wall insulation and heating system upgrades. The Standard refurbishment also includes measures which are not part of the SEAI BEH standard but which would be recommended for comprehensive refurbishment of existing buildings, namely the replacement of un-insulated wooden floors, the replacement of windows and the provision of spray foam cylinder insulation. The Standard refurbishment measures are listed in Table 3 below.

Table 3: Standard Level Refurbishment

Standard Level Measures	Upgrade Standards
Roof U-Value	0.13W/m^2K
Flat roofs	0.22 W/m^2K
Wall U-Value	0.27 W/m^2K - 0.48 W/m^2K*
Wooden Floor (replace)	0.25 W/m^2K
Window U-Value	1.4 W/m^2K**
Doors (PVC)	2.0 W/m^2K
Space heat generator efficiency	90% gas, 90% oil, 89.5% Condensing Wood Pellet Boiler
Water heat generator efficiency	90% gas, 90% oil, 89.5% Condensing Wood Pellet Boiler
Heating controls	Full zone control
Cylinder Insulation	50mm, spray foam
*Ultimately, the aim is to achieve a U-Value of 0.27W/m^2K. As there is no one size fits all solution, various factors will determine which insulation method would be best suited, hence the U-value may vary.	
**A target U-value of 1.4W/m^2K may be achieved by either a high performance double glazed unit or triple glazed unit.	

The second stage of refurbishment is for a more advanced level of refurbishment. The measures for the Advanced level refurbishment are detailed in table 4. The U values for flat roofs, walls and windows have been reduced broadly to match the backstop or area-weighted average values within the 2011 building regulations standards (Technical Guidance Document Part L) and renewable technologies are included for water heating and space heating. (Obviously, the range of renewable technologies available is far wider than those included in table 3 and different solutions would be recommended for individual houses.)

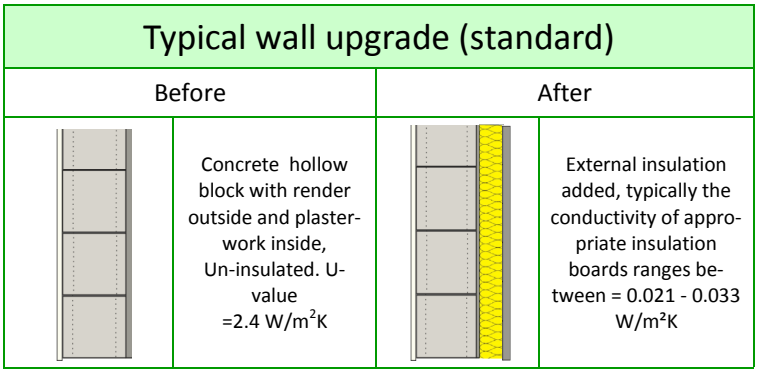
Co-funded by the Intelligent Energy Europe Programme of the European Union

Table 4: Advanced Level Refurbishment

Advanced Level Measures	Upgrade Standards
Roof U-Value	0.13 W/m²K
Flat roof	0.22 W/m²K
Wall U-Value	0.15 W/m²K - 0.27W/m²K
Wooden Floor (replace)	0.25 W/m²K
Window U-Value	0.9 W/m²K
Doors (PVC)	1.5 W/m²K
Space heat generator efficiency	Ground Source Heat Pump: 400% min Air to Water Heat pump: 380% min Air to Air Heat Pump: 270% min
Water heat generator efficiency	Ground Source Heat Pump: 400% min Air to Water Heat pump: 380% min Air to Air Heat Pump: 270% min
Solar thermal (2m² to 4m²)	40% contribution of total energy (10% electric immersion)
Heating controls	Full zone control
Cylinder Insulation	Increased Capacity Cylinder* with 50mm spray foam
Mechanical Heat Recovery Ventilation	92% minimum efficiency, AP<5 m3/hr/m²**
Demand Control Extract Ventilation	Specific Fan Power (SFP) min 0.18W/l/s
Photovoltaic panels	4-8 panels***
*Note the cylinder capacity is increased, typically 1/3 of the cylinder volume is dedicated to storage of solar heated water	
** The success of a MVHR depends on the air tightness of the dwelling. For the purposes of this study, it is assumed that an advanced upgrade will involve the application of an air tightness membrane therefore the value of 5 ACH will be assigned.	
*** Photovoltaic panels specified have a peak output of 240W. This value is based upon the panel being fixed at a 30˚ pitch facing south with no obstructions.	

The impact of the refurbishment measures are shown in each of the individual dwelling brochures in terms of reductions in primary energy use, carbon dioxide emissions and the corresponding BER grade (i.e. A to G rating band). The impact of each individual measure is shown separately to demonstrate the expected results from partial upgrades.
An example for upgrading a hollow block wall is shown in figure 3 below.

Figure 3: Building Fabric (Wall) Upgrade Step



Co-funded by the Intelligent Energy Europe Programme of the European Union

For each dwelling type, the cost of the recommended measures is shown as well the associated payback periods. The cost of measures are full costs and do not include any possible grants that may be available. The costs used are average industry costs gathered from a survey of market prices in 2014 (see details in Appendix A). It was decided to use payback periods and not to include actual yearly running costs as the former can vary with regular energy price movements and make the brochure appear less relevant. The payback information can give a better impression of the value for money aspect of particular refurbishment measures.

The relevant table showing estimated costs and payback time for a sample house is shown in table 5 below.

Table 5: Estimated costs & payback example

Estimated costs and payback time**		
Measure	Estimated costs	Payback (y)
Step 1	€ 750	3.4
Step 2	€ 5,800	15.6
Step 3	€ 6,650	32.9
Step 4	€ 11,100	28.9
Total:	**€ 24,300**	**20.6**

Note that in the case of dwelling type 15, the pre 1977 apartment, a different approach was adopted for refurbishment analysis. Two variants on the main heating system were used, namely a gas boiler and an electric storage heating system. Standard refurbishment details for both heating systems are contained in the brochure for this dwelling type only.

It is worth noting that all running costs and payback periods are based on energy use predicted by the DEAP calculation. Research data from other TABULA partners indicates that, for older and poorly (say G) rated house types, actual energy consumption is typically 50% of that predicted by BER calculation methods. Thus, the payback periods may be longer than estimated.

Additionally, with regard to the installation of photovoltaic panels in the advanced level measures, the electricity produced from the panels is subtracted from the energy demand of the dwelling in the DEAP calculation method.

Summary of BER Calculation Results for Existing Buildings

The improvement in BER scores for the first 31 dwelling types is shown in Table 6.

Standard measures improve the BER scores to a range between C2 and B1. The advanced measures improved the BER ratings to a range between B2 and A2.

Co-funded by the Intelligent Energy Europe Programme of the European Union

Table 6: BER Results Summary

No.	Age Band:	House type	Current State	Standard Measures	Advanced Measures
1	1800-1899	SFH.01.Gen	G	B3	B1
2	1800-1899	TH.01.Gen	G	B3	B2
3	1800-1899	TH.01.325SB	E2	B1	A3
4	1800-1899	SFH.01.325SB	F	B2	B1
5	1900-1929	SFH.02.Gen	G	C2	B1
6	1900-1929	TH.02.Gen	G	B2	B1
7	1900-1929	TH.02.325SB	G	C1	B1
8	1930-1949	SFH.03.Gen	G	C1	B2
9	1930-1949	TH.03.Gen	G	C1	B2
10	1950-1966	SFH.04.Gen	G	B3	B1
11	1950-1966	TH.04.Gen	G	B2	A3
12	1950-1966	TH.04.HBlockHBF	G	B2	A3
13	1967-1977	SFH.05.Gen	G	B3	A3
14	1967-1977	TH.05.Gen	G	B2	A3
15	1950-1966	AB.04.Gen	G	B1	B2
16	1978-1982	SFH.06.Gen	E2	B3	A3
17	1978-1982	TH.06.Gen	E1	B2	A3
18	1978-1982	SFH.06.HBlock	E1	B2	A3
19	1978-1982	TH.06.HBlock	E1	B2	A3
20	1983-2004	SFH.07.Gen	D2	B3	B1
21	1983-2004	TH.07.Gen	D2	B3	A3
22	1983-2004	SFH.07.Hblock	D1	B3	A3
23	1983-2004	TH.07.Hblock	D1	B3	A3
24	1983-2004	SFH.08.Gen	D2	C1	A3
25	1983-2004	TH.08.Gen	C2	B2	A2
26	1983-2004	SFH.08.Tframe	C3	C1	B1
27	1983-2004	TH.08.Gen	C3	B3	A3
28	2005-2010	SFH.09.Gen	C1	B2	A3
29	2005-2010	TH.09.Gen	B3	B2	A3
30	2005-2010	SFH.09.Tframe	C1	B1	A3
31	2005-2010	TH.09.Tframe	B2	B2	A3

Co-funded by the Intelligent Energy Europe Programme of the European Union

Comparison of TABULA BER Calculations to average BER Rating Values on SEAI NAS

SEAI provided data from the National Administration System in October 2011 on the 225,000 BER (EPC) certificates that had been published for existing dwellings at that stage. This enabled a comparison to be made between the TABULA-based primary energy values (in kWh/m2/year) for each of the 29 house types within the Irish building typology (2012 version) and the average primary energy values (in kWh/m2/year) for those same house types extracted from the Irish BER (EPC) database. (The pre 1977 apartment is not included in the table below). Table 7 shows the primary energy values for the 29 Irish house types created for TABULA along with the average primary energy value for each of these 29 house types derived from the EPC database in October 2011.

Table 7: TABULA & EPC Primary Energy Comparisons

TABULA House type	TABULA Typical Primary Energy-Value (kWh/m2/a)	EPC Average Primary Energy Value (kWh/m2/a)	Variation	Variation as % of TABULA typical Primary Energy Value
SFH.05.Gen	483.85	365.91	117.94	24%
Th.05.Gen	489.08	314.14	174.94	36%
SFH.01.Gen	618.18	440.14	178.04	29%
TH.01.Gen	607.41	410.36	197.05	32%
SFH.02.Gen	634.04	443.34	190.70	30%
TH.02 Gen	463.56	390.24	73.32	16%
SFH.01.325SB	453.53	383.00	70.53	16%
TH.02.325SB	631.70	381.47	250.23	40%
SFH.03.Gen	656.59	507.00	149.59	23%
TH.03.Gen	398.14	364.00	34.14	9%
SFH.04.Gen	549.40	398.18	151.22	28%
TH.04.Gen	499.43	333.92	165.51	33%
TH.04.HBlockHBF	456.75	333.92	165.51	33%
SFH.06.Gen	365.73	237.96	127.77	35%
TH.06.Gen	317.67	262.15	55.52	17%
SFH.06.Hblock	321.72	258.70	63.02	20%
TH.06.Hblock	346.16	270.13	76.03	22%
SFH.07.Gen	302.52	271.60	30.92	10%
TH.07.Gen	293.97	260.88	33.09	11%
SFH.07.Hblock	250.87	232.27	18.60	7%
TH.07.Hblock	265.12	267.16	-2.04	-1%
SFH.08.Gen	292.27	244.87	47.40	16%
TH.08.Gen	179.55	227.11	-47.56	-26%
SFH.08.Tframe	214.70	265.98	-51.28	-24%
TH.08.Tframe	203.99	220.44	-16.45	-8%
SFH.09.Gen	171.12	162.20	8.92	5%
TH.09.Gen	149.74	167.26	-17.52	-12%
SFH.09.Tframe	162.37	147.36	15.01	9%
TH.09.Tframe	123.21	154.26	-31.05	-25%

Co-funded by the Intelligent Energy Europe Programme of the European Union

It is notable that for the pre 1977 house types, the average primary energy values from the NAS database were about 30% lower than the values for the TABULA house type.

This difference is due to several factors including:

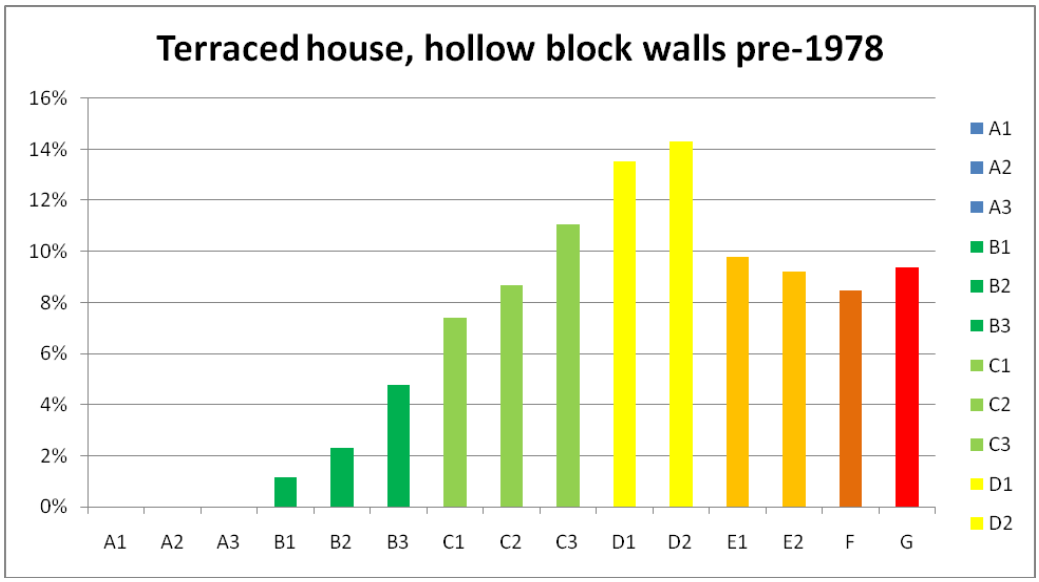
* the EPC database includes EPCs for many dwellings that have been retrofitted with energy upgrades. (In order to avail of grants from the Government for refurbishment works, post works EPCs are required.) Thus, many of the EPCs for the old dwellings will have better primary energy values than typical buildings of this age would have.
* each TABULA house type is based on a selected fuel type. The EPC average includes all fuel types.

For the years 2007-2011, approximately 180,000 Irish dwellings have had refurbishment measures installed under SEAI's energy efficiency programmes. Approximately 50% of these dwellings will have had EPCs published based on the post works primary energy values.

The chart in figure 4 shows the range of published BER scores from the SEAI National Administration System (NAS) for a Type 12 house, a pre 1978 terraced hollow block wall house. It is interesting to note that many of these dwellings have B, C and D ratings indicating that these properties will have already had some refurbishment measures carried under the current energy efficiency schemes. It is notable that there is a spike in published BER certificates at the D1, D2 grades and a falling off thereafter. It is also interesting to note that within the brochure for type 12, that the standard refurbishment of the building fabric brings the TABULA dwelling from a G to a C3 rating.

This pattern showing a spike of published BER numbers at D1, D2 was consistent for all pre 1977 dwelling types.

Figure 4: Analysis of Type 12 BER Scores from NAS, October 2011



Co-funded by the Intelligent Energy Europe Programme of the European Union

Variants for TGD Part L 2011 and NZEB Building Types

For new building types, the brochures have been structured to show several design options that will enable compliance with TGD Part L 2011 and the proposed NZEB standards. For these house types in particular, three variants have been developed to demonstrate a range of design solutions meeting these standards.

The first 2011 Part L variant uses backstop U values and has a high level of renewable technologies whereas the third variant uses ambitious U values and air permeability levels and a low level of renewable technologies. The second variant provides a midway design solution. The aim of these variants is to show that a range of solutions are available to designers when striving to comply with the Part L 2011 standards. Indeed, the 2011 Building Regulations are structured so that compliance is not achieved by meeting the backstop U values and minimum renewable contribution alone. Further extra measures are required to reduce the energy demand and that responsibility rests with the designer of the dwelling. The range of measures shown in the Part L 2011 variants provide just three design options. Of course, building designers can select many different design options using different U values, air permeability levels and combinations of heating systems, renewable technologies and onsite energy generation to achieve compliance with the 2011 Building Regulations.

In the case of the proposed NZEB standard, a technical guidance document has not yet been published indicating backstop U values. However, as the EPC and CPC levels have been set for the NZEB standard, three similar NZEB variants are set out in TABULA. The first NZEB variant uses higher U values and has a high level of renewable technologies whereas the third variant uses ambitious U values and air permeability levels and a low level of renewable technologies. The second variant provides a midway design solution. The three variants shown give an indication of the types of design combinations that will be needed to meet the proposed NZEB standard. Of course, designers will be free to consider a wider range of solutions in order to meet the proposed NZEB standard.

Observations

The development of this suite of brochures of typical Irish dwellings will hopefully act as a useful information source for both Irish householders and building professionals.

The National Energy Efficiency Action Plan 2009 -2020 (NEEAP) includes the aim to retrofit 1 million residential buildings in Ireland with energy efficient measures by 2020. The Stage 1 and Stage 2 refurbishment measures outlined in the TABULA brochures broadly cover the spectrum of works needed for the Irish housing stock.

The Irish TABULA project hopes that this brochure will make a positive contribution to the long term goal of retrofitting 1 million Irish dwellings by making the subject more accessible and more easily understood by a wider audience, most particularly, the Irish homeowners. Also, for new buildings, the brochure provides useful reference data for designers and builders relating to the 2011 Building Regulations and the proposed NZEB standard as required by the Recast Energy Performance of Buildings Directive.

Co-funded by the Intelligent Energy Europe Programme of the European Union

1. Detached House, stone walls, pre 1900

Description:

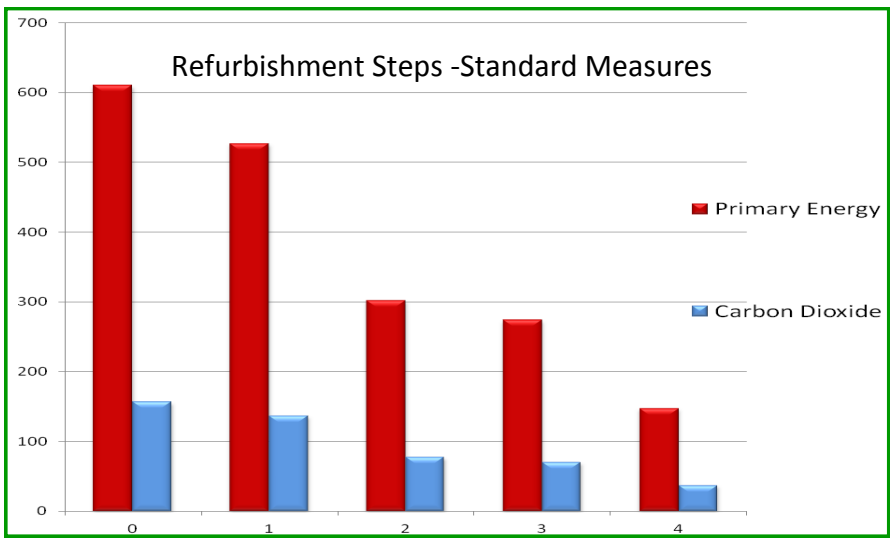
Stone wall construction was common in rural Ireland up until the 1930s. Wall depth typically ranged from 300-400mm. The type of stone and method of construction utilised will determine the most suitable insulation solution.

Building elements :		Insulation	U - value
Walls	Solid stone	None	2.1
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Solid	none	0.65
Windows	Single glazed, wooden frame	N/A	4.8
Doors	Solid timber	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated	Heating oil (kerosene)	65%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Un insulated, no cylinder thermostat.		
Controls	Programmer only		

Refurbishment steps — standard				Prim. energy kWh/m²/yr	Carbon Dioxide kgCO₂/m²/yr	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**609** (actual state)	**156** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	527	137	G
2	**Wall insulation**	Add	Application of 100-120mm external insulation or dry -line with 62.5-72.5mm thermal laminate board	0.27	302	77	E1
3	**Windows and Doors**	Replace	Double glazed, low-e windows, argon filled, 16mm gap. Insulated wooden/PVC doors.	1.4 / 2.0	274	70	D2
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separate heating zones with time and thermostatic control, independent water heating . Hot water cylinder factory insulated (50 mm spray foam). Existing secondary heating system has been removed and replaced by a solid fuel burner (75% efficient)		**147**	**37**	**B3**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

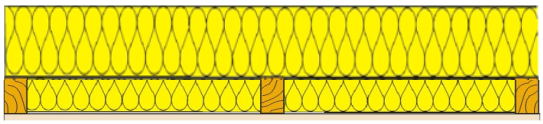
Measure	Estimated costs	Payback (y)
Step 1	€ 1,322	1.6
Step 2	€ 24,779	13.1
Step 3	€ 5,184	22.0
Step 4	€ 4,370	4.0
Total:	**€ 35,656**	**8.8**

Standard upgrade summary

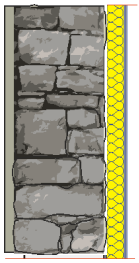
Consumption of primary energy reduced by:	**462 kWh/m²/y**
Emission of carbon dioxide reduced by:	**119 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK.	After: 

Typical wall upgrade (standard/advanced)

Before		After	
	Solid stone wall, uninsulated U-value = 2.1 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

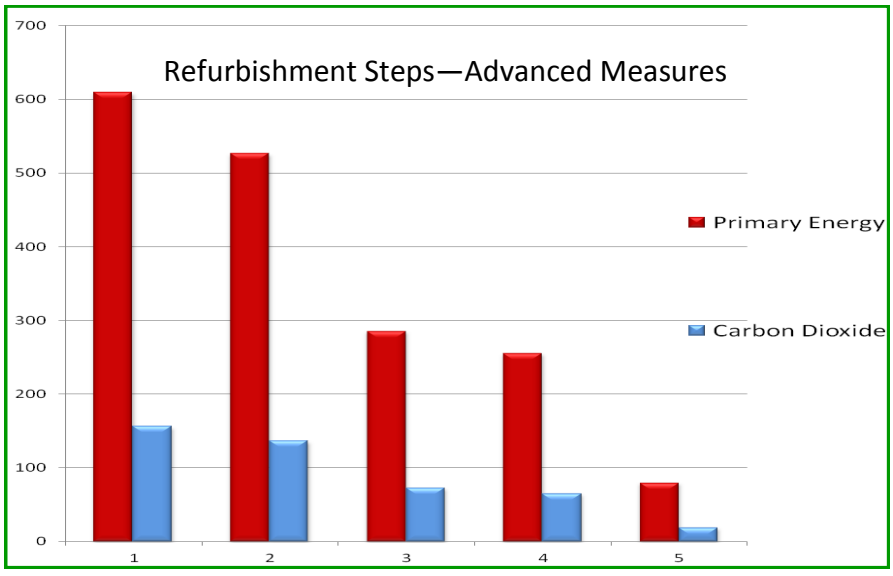
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Ground source heat pump
Efficiency:	90%	400%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**609** (actual state)	**156** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist and installation of required roof vents	0.13	527	137	G
2	**Wall insulation**	Add	Application of 150-200mm of external wall insulation	0.15	286	73	D2
4	**Windows and Doors**	Replace	Triple glazed, argon filled, 16mm gap, low-e coated window units and Insulated wooden/PVC doors.	0.9 / 1.5	256	65	D1
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Ground source heat pump 400% efficient, two separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery.4 photovoltaic panels have been installed on the southern aspect of the property.		**80**	**19**	**B1**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,322	1.6
Step 2	€ 29,564	14.6
Step 3	€ 6,075	24.5
Step 4	€ 25,515	17.1
Total:	**€ 62,477**	**13.6**

Advanced upgrade summary

Consumption of primary energy reduced by:	**529 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**137 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

2. End of terrace house, stone walls, pre 1900

Building elements :		Insulation	U - value
Walls	Solid stone	None	2.1
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Solid floor Suspended floor	None None	0.73 0.8
Windows	Single glazed, wooden frame	N/A	4.8
Doors	Solid timber	none	3.0

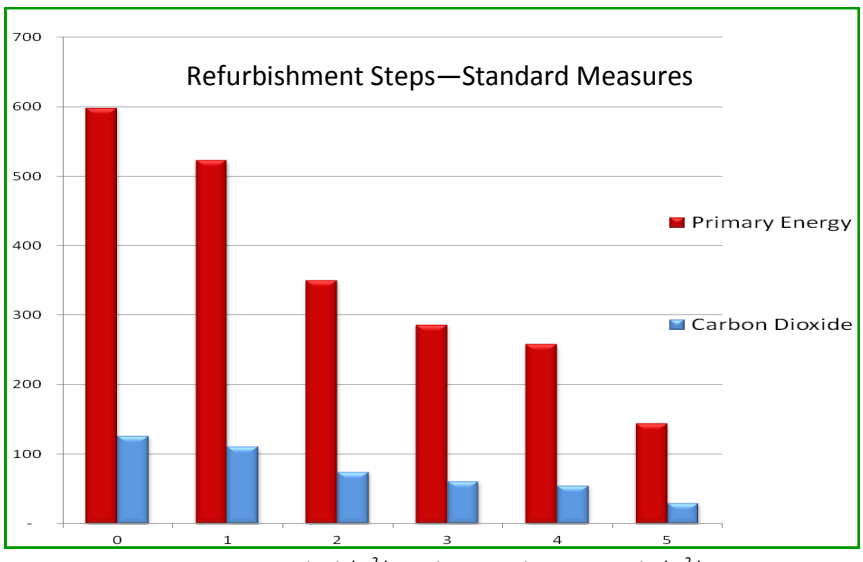
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un insulated	Mains gas	65%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Un-insulated, no cylinder thermostat.		
Controls	Programmer only		

Description:

Stone walls were common up to the 1930s in rural towns. Walls can be 300-400mm thick. These thicker walls have good thermal mass properties and help retain heat. The type of stone will influence the insulation options.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**598** (actual state)	**126** (actual state)	**G**
1	**Roof insulation and WHS package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	522	110	G
2	**Wall insulation**	Add	Application of 100-120mm external insulation or dry-line with 62.5-72.5mm thermal laminate board	0.27	350	74	E2
3	**Flat roof insulation**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	286	60	D2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap PVC/Timber, Insulated solid door	1.4 / 2.0	258	54	D1
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and replaced by a solid fuel burner (75% efficient)		**144**	**29**	**B3**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

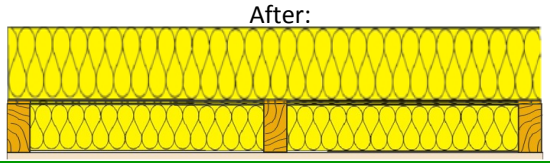
Measure	Estimated costs	Payback (y)
Step 1	€ 1,176	2.0
Step 2	€ 15,971	17.0
Step 3	€ 1,447	4.1
Step 4	€ 5,315	34.2
Step 5	€ 5,520	7.9
Total:	**€ 29,439**	**10.7**

Standard upgrade summary

Consumption of primary energy reduced by:	**454 kWh/m²/y**
Carbon dioxide reduced by:	**97 kg CO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014. 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard/advanced)

Before		After	
	Solid stone wall, uninsulated U-value = 2.1 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

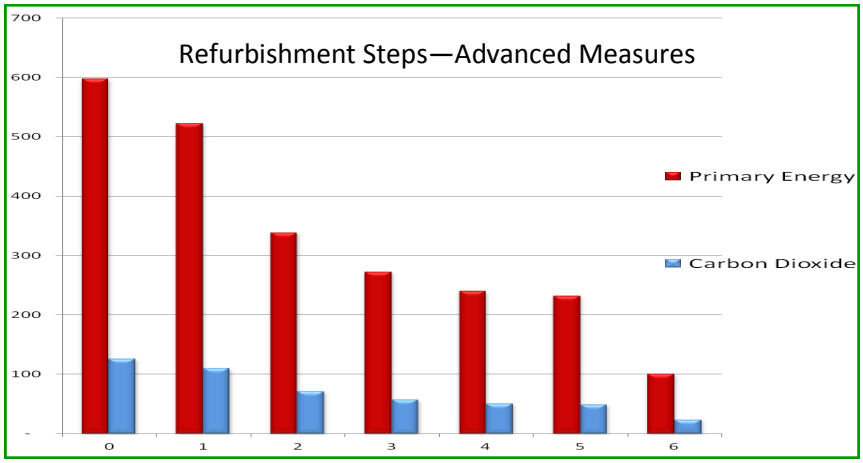
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler with solid fuel burner as SHS	Air source heat pump, SHS removed and chimneys have been sealed
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	DCV

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**598** (actual state)	**126** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist and installation of required roof vents	0.13	522	110	G
2	**Wall insulation**	Add	Application of 150-200mm of external wall insulation	0.15	339	71	E1
3	**Flat roof**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	272	57	D2
4	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, 16mm gap, argon filled, low-e windows	0.9/1.5	240	50	D1
5	**Suspended floor**	Replace	Suspended floor replaced, insulation boards added between the floor joists, 70-100mm	0.25	233	49	D1
	Systems upgrade:						
6	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Demand Control Ventilation (DCV) installed. 4 photovoltaic panels have been installed on the southern aspect of the property.		**101**	**24**	**B2**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,176	2.0
Step 2	€ 19,102	18.9
Step 3	€ 1,447	4.0
Step 4	€ 5,799	33.2
Step 5	€ 368	8.6
Step 6	€ 19,163	32.0
Total:	**€ 47,055**	**13.0**

Advanced upgrade summary

Primary energy reduced by:	**497 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**102 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

3 Terraced house, solid brick wall, Pre 1900

Description:

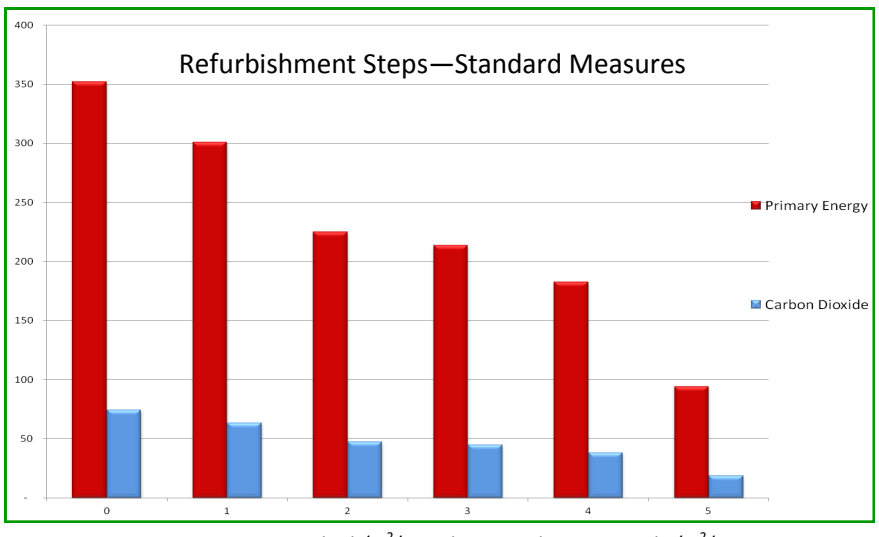
Typical brick terrace house found in Dublin, Cork, Limerick etc from late 1800s up to 1930s. These 3 storey dwellings often have a parapet wall to the front which disguises the pitched roofs behind. In order to retain the aesthetic of the streetscape, an internal insulation solution would be ideal.

Building elements :		Insulation	U - value
Walls	Solid brick, 325 mm Solid Brick 225 mm	None Dry lined	1.64 1.41
Roofs	Front pitched, insulation between joists Rear pitched roof	100mm None	0.4 2.3
Floors	Solid floor (basement)	None	0.61
Windows	Single glazed, wooden frame Double glazed, PVC frame	N/A N/A	4.8 2.7
Doors	Solid timber	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated	Mains gas	65%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Insulated with 25mm lagging jacket, no cylinder thermostat.		
Controls	Programmer only		

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**352** (actual state)	**74** (actual state)	**E2**
1	**Roof insulation and standard package***	Add	300 mm of mineral wool between and over the ceiling joists	0.13	301	64	E1
2	**Wall insulation**	Add	Dry line/internally insulate with 72.5-82.5mm thermal laminate board	0.27	225	47	D1
3	**Flat roof**	Add	Thermal laminate (82.5mm) board fixed to underside of flat roof and rafters of un-insulated pitched roof.	0.22	214	45	C3
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Door is retained due to concerns over architectural heritage. Sash windows frame is retained while single glazing is replaced for efficient double glazed unit	1.4 / 2.0	183	38	C2
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Secondary heating system is replaced by a solid fuel burner (75% efficient)		**95**	**19**	**B1**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

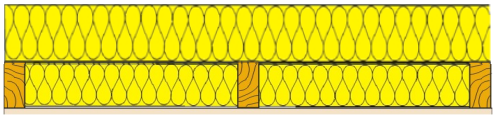
Measure	Estimated costs	Payback (y)
Step 1	€ 820	1.2
Step 2	€ 11,468	13.3
Step 3	€ 305	2.4
Step 4	€ 12,283	35.2
Step 5	€ 5,970	5.4
Total:	**€ 30,846**	**9.8**

Standard upgrade summary

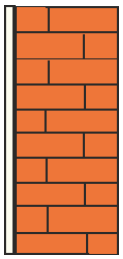
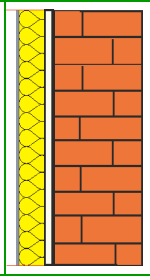
Primary energy reduced by:	**257 kWh/m²/y**
Carbon dioxide reduced by:	**55 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard/advanced)

Before		After	
	Solid brick wall 325 mm, un-insulated, U-value = 2.1 W/m^{2}K		Thermal laminate boards applied via mechanical fixing or adhesive, typically conductivity of boards ranges between = 0.021 - 0.025 W/mK

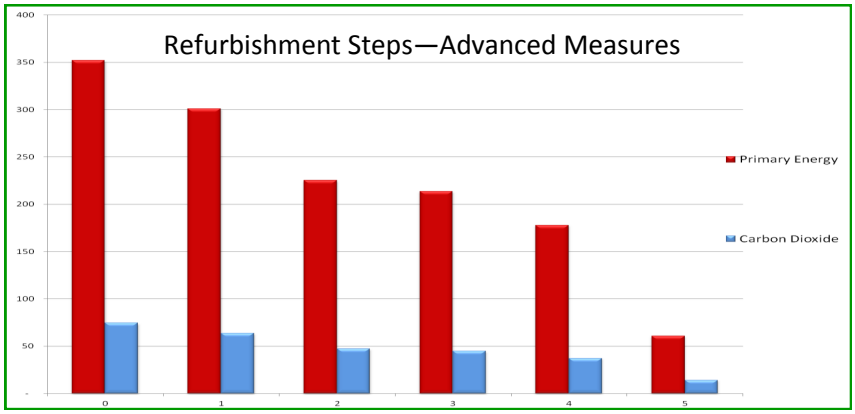
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	DCV

Refurbishment steps — standard

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**352** (actual state)	**74** (actual state)	**E2**
1	**Roof insulation and standard package***	Add	300 mm of mineral wool between and over the ceiling joists	0.13	301	64	E1
2	**Wall insulation**	Add	Dry line/internally insulate with 72.5-82.5mm thermal laminate board	0.27	225	47	D1
3	**Flat roof**	Add	Thermal laminate (82.5mm) board fixed to underside of flat roof and rafters of un-insulated pitched roof.	0.22	214	45	C3
4	**Windows and Doors**	Replace	Triple glazed, low-e windows, air filled, 16mm gap Door is retained due to concerns over architectural heritage. Sash windows frame is retained while single glazing is replaced for efficient double glazed unit	0.9 / 1.5	178	37	C2
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Demand Control Ventilation (DCV). Secondary heating system is removed and replaced with a solid fuel burner (75% efficient) and chimneys are sealed. 3 photovoltaic panels have been installed on the southern aspect		**60**	**14**	**A3**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 820	1.2
Step 2	€ 11,468	12.9
Step 3	€ 305	2.4
Step 4	€ 13,914	34.8
Step 5	€ 19,465	13.6
Total:	**€ 45,972**	**14.0**

Advanced upgrade summary

Primary energy reduced by:	**292 kWh/m^2/y**
Carbon dioxide reduced by:	**60 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

4. Detached house, solid brick walls, 1900

Description:

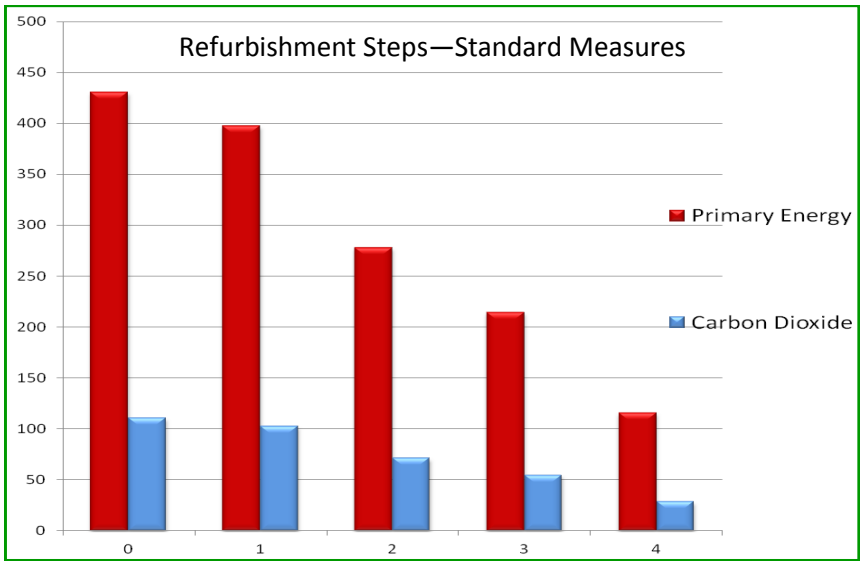
Larger detached solid brick house typically found in larger towns and cities from 1900s to 1940s. Normally brick to front and block walls to side and rear. Internal dry-lining suitable for front with external wall insulation to side and rear.

Building elements :		Insulation	U - value
Walls	Solid brick, 325 mm	none	1.64
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Solid floor	none	0.73
Windows	Single glazed, metal frame	N/A	5.7
Doors	Solid wood	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un insulated	Heating oil	65%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Insulated with lagging jacket 125mm, no cylinder thermostat.		
Controls	Programmer only		

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**431** (actual state)	**111** (actual state)	**F**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	397	103	F
2	**Wall insulation**	Add	Dry line/internally insulate with 62.5-72.5mm thermal laminate board	0.27	278	71	D2
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated wooden/PVC doors.	1.4 / 2.0	214	55	C3
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separate heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Chimney sealed		**116**	**28**	**B2**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

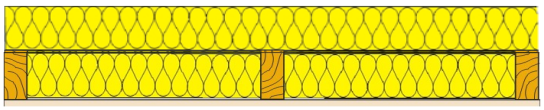
Measure	Estimated costs	Payback (y)
Step 1	€ 1,908	3.6
Step 2	€ 17,145	10.1
Step 3	€ 16,375	18.1
Step 4	€ 4,520	3.3
Total:	**€ 39,948**	**8.9**

Standard upgrade summary

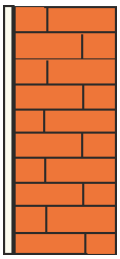
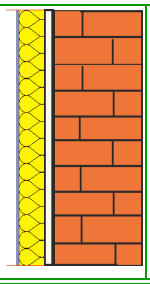
Primary energy reduced by:	**315 kWh/m²/y**
Carbon dioxide reduced by:	**83 kg CO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard/advanced)

Before		After	
	Solid brick wall 325 mm, un-insulated, U-value = 2.1 W/m^{2}K		Thermal laminate boards applied via mechanical fixing or adhesive, typically conductivity of boards ranges between = 0.021 - 0.025 W/mK

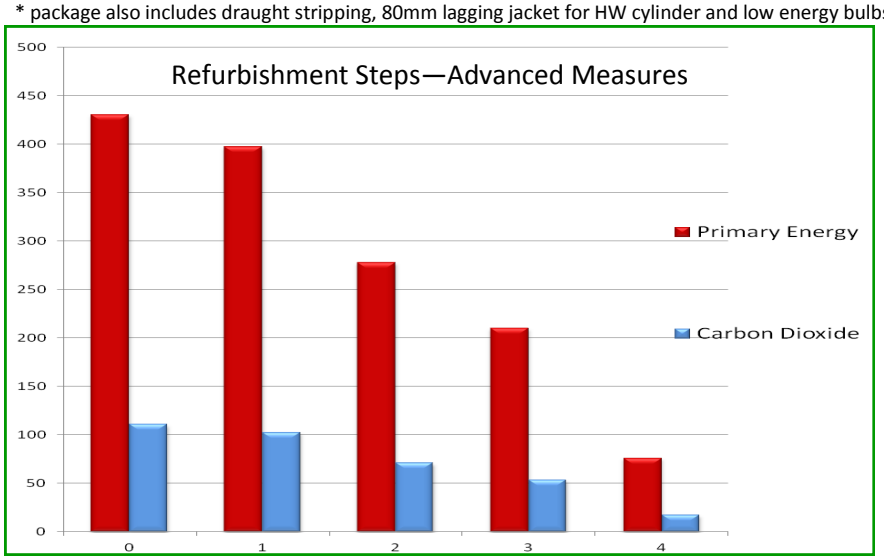
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Ground source heat pump
Efficiency:	90%	400%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**431** (actual state)	**111** (actual state)	**F**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist and installation of required roof vents	0.13	397	103	F
2	**Wall insulation**	Add	Dry line/internally insulate with 62.5-72.5mm thermal laminate board	0.27	278	71	D2
3	**Windows and Doors**	Replace	Triple glazed, 16mm gap argon filled, low-e windows Insulated PVC/wooden doors.	0.9 / 1.5	210	53	C3
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace & Add	Ground source heat pump 400% efficient, two separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). 5 photovoltaic panels installed on the southern aspect of the property.		**76**	**17**	**B1**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,908	3.6
Step 2	€ 16,740	9.9
Step 3	€ 18,440	19.2
Step 4	€ 15,153	8.4
Total:	**€ 52,241**	**10.6**

Advanced upgrade summary

Primary energy reduced by:	**355 kWh/m^2/y**
Carbon dioxide reduced by:	**94 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

5. Bungalow, solid brick walls, 1900-1929

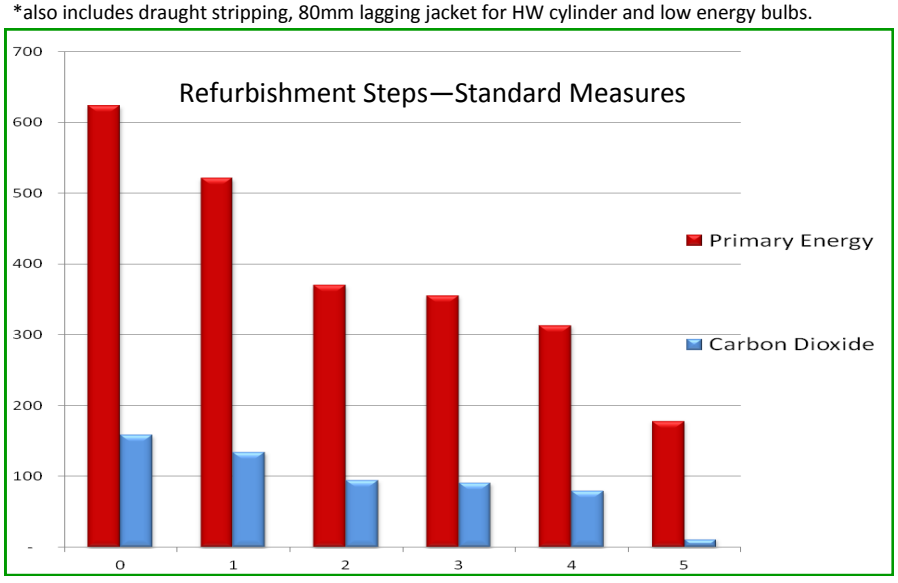
Building elements :		Insulation	U - value
Walls	Solid brick, 225 mm	None	2.1
Roofs	Pitched, insulation between joists Flat roof over the kitchen	50 mm none	0.68 2.3
Floors	Solid floor	none	0.84
Windows	Single glazed, wooden frame	N/A	4.8
Doors	Solid timber doors half glazed back doors	None None	3.0 3.9
Heating systems characteristics:		**Fuel**	**Efficiency**
Primary	Central heating boiler, pipe work un-insulated	Heating oil	65%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Un-insulated, no cylinder thermostat.		
Controls	Programmer only		

Description:

One-off bungalow with un-insulated solid brick walls. Most likely found in outer parts of towns and in rural areas. Often extended to rear. Ideally suited for external wall insulation.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**624** (actual state)	**159** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	521	134	G
2	**Wall insulation**	Add	Application of 100-120mm external insulation or dry-line with 62.5-72.5mm thermal laminate board	0.27	370	95	E2
3	**Flat roof insulation**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	355	91	E2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap PVC/Timber doors, insulated	1.4 / 2.0	313	80	E1
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing wood pellet boiler (89.5% efficiency) two separate heating zones with time and thermostatic control, independent water heating .Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and replaced by a solid fuel burner (75% efficient)		**178**	**12**	**C1**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

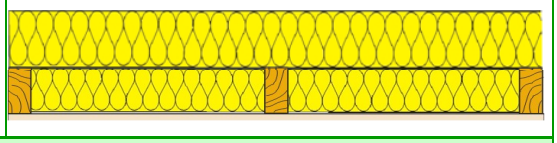
Measure	Estimated costs	Payback (y)
Step 1	€ 1,606	2.0
Step 2	€ 17,087	17.4
Step 3	€ 338	3.4
Step 4	€ 7,417	27.2
Step 5	€ 9,682	8.4
Total:	**€ 36,130**	**11.0**

Standard upgrade summary

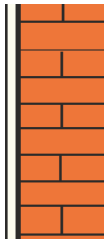
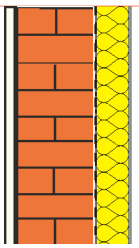
Primary energy reduced by:	**446 kWh/m²/y**
Carbon dioxide reduced by:	**147 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard/advanced)

Before		After	
	Solid brick wall 225 mm, un-insulated, U-value = 2.1 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

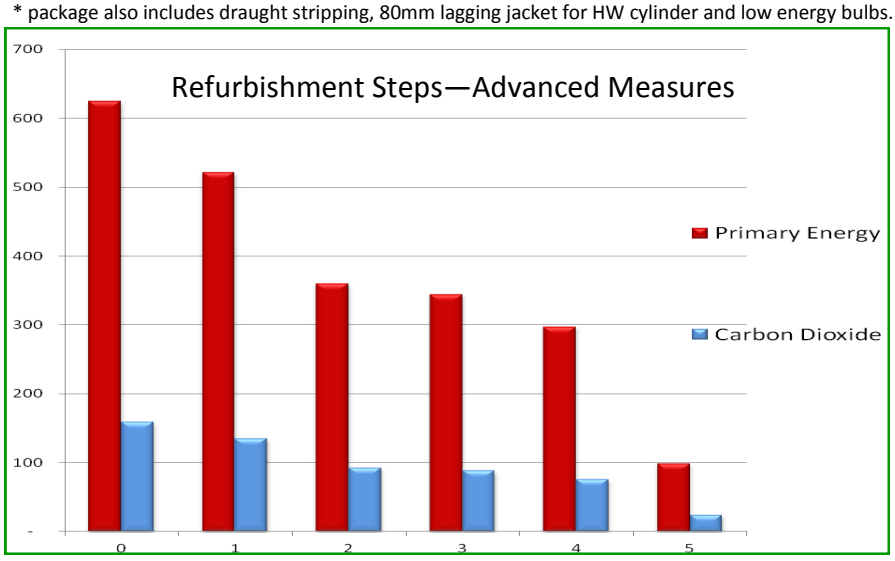
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Condensing wood pellet boiler	Air source heat pump
Efficiency:	89.5%	380%
Fuel:	Wood pellet (Bulk)	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**624** (actual state)	**159** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist and installation of required roof vents	0.13	521	134	G
2	**Wall insulation**	Add	Application of 150-200mm of external wall insulation	0.15	359	92	E2
3	**Flat roof**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	344	88	E2
4	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, 16mm gap, argon filled, low-e windows	2.0 / 1.3	297	75	D2
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Ground source heat pump 400% efficient, separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of DHW with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). Solid fuel burner (75% efficient). 4 photovoltaic panels installed on the southern aspect of the property		**99**	**24**	**B1**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,606	2.0
Step 2	€ 20,019	19.0
Step 3	€ 338	3.4
Step 4	€ 8,169	26.6
Step 5	€ 25,515	19.7
Total:	**€ 55,646**	**19.7**

Advanced upgrade summary

Primary energy reduced by:	**525 kWh/m^2/y**
Carbon dioxide reduced by:	**135 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

6. End of terrace, solid brick walls, 1900-1929

Description:

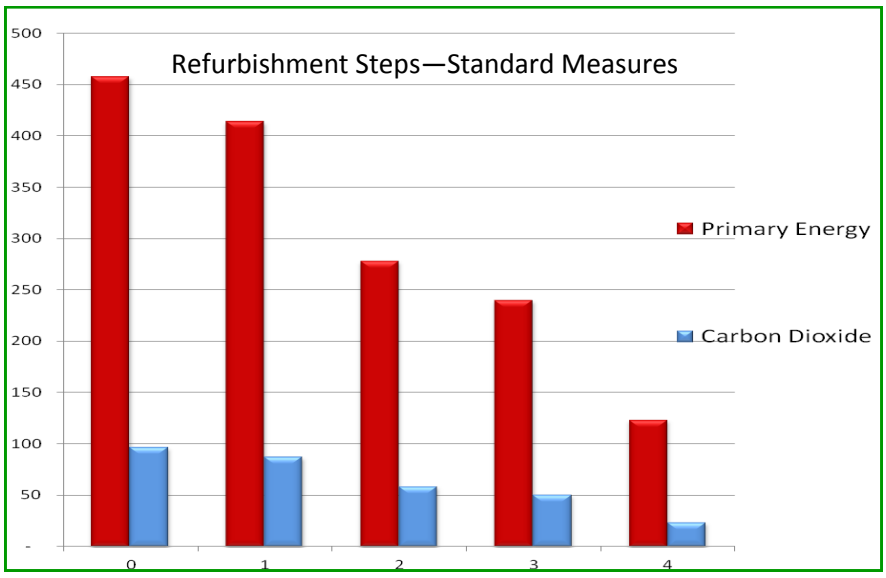
Solid brick fronted house with solid block walls to side and rear. Very common in older parts of Dublin, Limerick, Cork, etc. Built in the early 1900s and up to the 1940s. Suspended timber floors fitted in most of the property.

Building elements :		Insulation	U - value
Walls	Solid brick, 225 mm, partially semi-exposed	none none	2.1 1.38
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Suspended timber floor Solid floor	none none	0.69 0.79
Windows	Single glazed, wooden frame Single glazed, metal frame	N/A N/A	4.8 5.7
Doors	Solid wooden Wooden, half glazed	None none	3 3.9

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated	Mains gas	65%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Insulated with lagging jacket 25mm, no cylinder thermostat.		
Controls	Programmer only		

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U -values	**458** (actual state)	**97** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	414	87	F
2	**Wall insulation**	Add	Dry line/internally insulate with 72.5-82.5mm thermal laminate board.	0.27	278	59	D2
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap PVC/Timber frame doors.	1.4 / 2.0	240	50	D1
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Secondary heating system is removed and chimney is sealed.		**123**	**23**	**B2**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

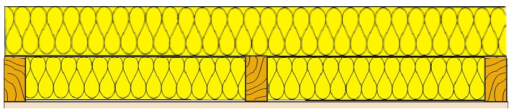
Measure	Estimated costs	Payback (y)
Step 1	€ 2,128	4.7
Step 2	€ 10,294	9.3
Step 3	€ 9,022	28.9
Step 4	€ 4,520	4.4
Total:	**€ 25,963**	**9**

Standard upgrade summary

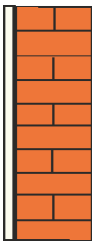
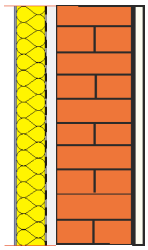
Primary energy reduced by:	**335kWh/m²/y**
Carbon dioxide reduced by:	**74 kg CO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard/advanced)

Before		After	
	Solid brick wall 225 mm, un-insulated, U-value = 2.1 W/m^{2}K		Thermal laminate boards applied via mechanical fixing or adhesive, typically conductivity of boards ranges between = 0.021 - 0.025 W/mK

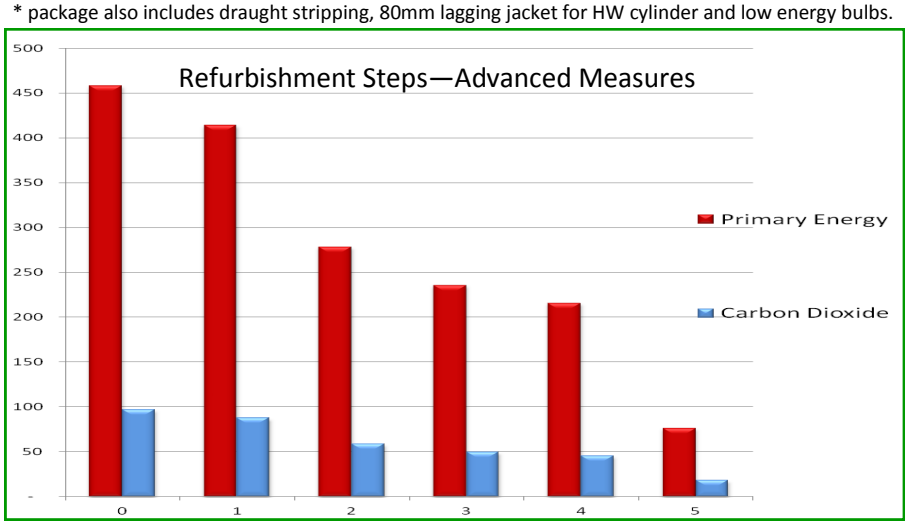
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	DCV

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U -values	**458** (actual state)	**97** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist	0.13	414	87	F
2	**Wall insulation**	Add	Dry line/internally insulate with 72.5-82.5mm thermal laminate board.	0.27	278	59	D2
3	**Windows and Doors**	Add	Triple glazed, argon filled, low-e windows , 16mm gap. Insulated PVC/wooden doors,	0.9 / 1.5	236	49	D1
4	**Suspended floor**	Add	Insulate the suspended wooden floor with 70-100mm rigid insulation boards	0.25	216	45	C3
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Demand Control Ventilation (DCV). Solid fuel burner (75% efficient). 4 photovoltaic panels installed on the southern aspect of the property	**76**	**18**	**B1**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 2,128	4.7
Step 2	€ 10,294	9.3
Step 3	€ 9,929	28.6
Step 4	€ 1,290	7.9
Step 5	€ 18,425	17.9
Total:	**€ 42,066**	**13.6**

Advanced upgrade summary

Primary energy reduced by:	**382 kWh/m^2/y**
Carbon dioxide reduced by:	**79 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

7. Terraced house, solid brick wall, 1900-1929

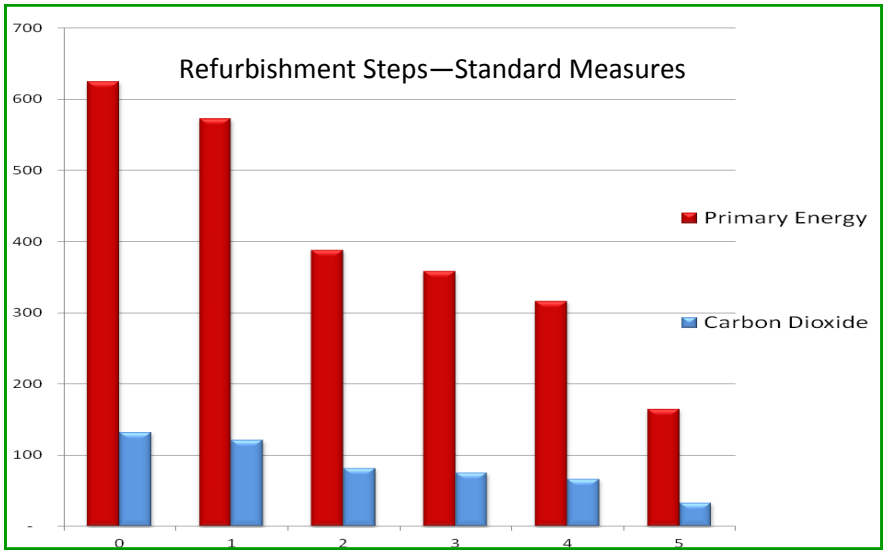
Description:

Typical redbrick house found in Dublin, Cork, Limerick etc from late 1800s up to 1930s. Often includes a flat roof extension to rear. Suited to a mix of internal and external wall insulation. Suspended timber floors are common that can be retrofitted with insulation.

Building elements :		Insulation	U - value
Walls	Solid brick, 325 mm	none	1.64
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Suspended timber floor Solid floor (kitchen)	none none	0.69 0.79
Windows	Single glazed, wooden frame Single glazed, metal frame	N/A N/A	4.8 5.7
Doors	Solid timber	none	3.0
Heating systems characteristics:		**Fuel**	**Efficiency**
Primary	Central heating boiler, pipe work un-insulated	Mains gas	65%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Insulated with 25mm lagging jacket, no cylinder thermostat.		
Controls	Programmer only		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**625** (actual state)	**132** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	573	121	G
2	**Wall insulation**	Add	Dry line/internally insulate with 72.5-82.5mm thermal laminate board	0.27	389	82	F
3	**Flat roof**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	358	75	E2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors	1.4 / 2.0	317	67	E1
Systems upgrade:							
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Secondary heating system is replaced by a solid fuel burner (75% efficient)		**165**	**33**	**C1**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

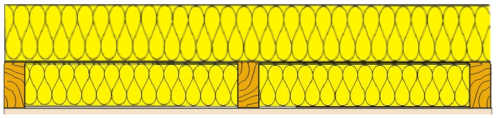
Measure	Estimated costs	Payback (y)
Step 1	€ 1,296	3.8
Step 2	€ 12,770	13.3
Step 3	€ 668	4.2
Step 4	€ 6,412	29.7
Step 5	€ 6,535	7.5
Total:	**€ 27,681**	**10.9**

Standard upgrade summary

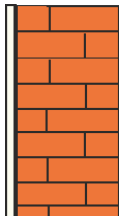
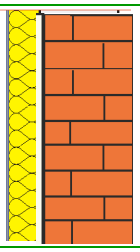
Primary energy reduced by:	**460 kWh/m²/y**
Carbon dioxide reduced by:	**99 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard/advanced)

Before		After	
	Solid brick wall 325 mm, un-insulated, U-value = 2.1 W/m^{2}K		Thermal laminate boards applied via mechanical fixing or adhesive, typically conductivity of boards ranges between = 0.021 - 0.025 W/mK

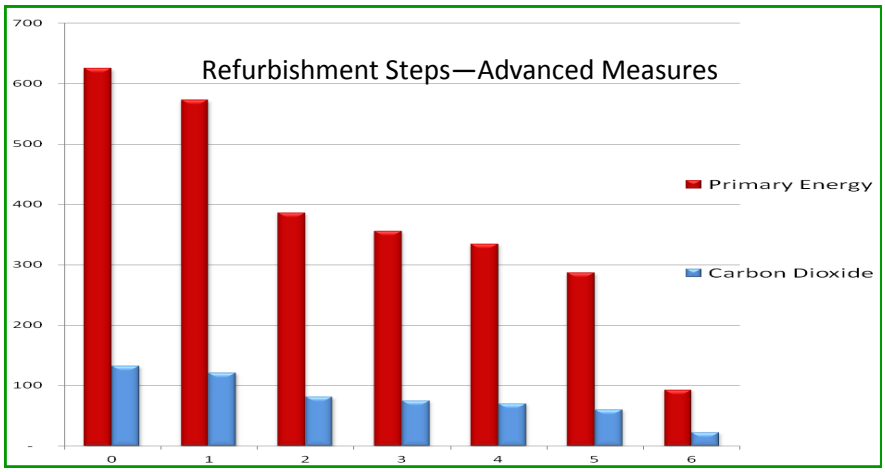
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	DCV

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**625** (actual state)	**132** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	573	121	G
2	**Wall insulation**	Add	**Brick wall:** Dry line/internally insulate with 72.5-82.5mm thermal laminate board. **Block wall:** Externally insulate with 150-200mm rigid insulation board.	0.27 0.15	386	81	F
3	**Flat roof**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	356	75	E2
4	**Suspended floor**	Add	Insulation board between the floor joists, 70-100mm	0.25	334	70	E1
5	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, 16mm gap, argon filled, low-e windows	2.0 / 1.3	287	60	D2
	Systems upgrade:						
6	**Space and water heating system and controls and renewable energy**	Replace& Add	Air source heat pump, 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of DHW with combined HW cylinder. Demand Control Ventilation, Solid fuel burner (75% efficient) replacing secondary heating system, 4 photovoltaic panels installed on the southern aspect		**93**	**22**	**B1**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,296	3.8
Step 2	€ 12,,835	13.2
Step 3	€ 668	4.2
Step 4	€ 926	8.3
Step 5	€ 7,041	28.7
Step 6	€ 18,425	19.8
Total:	**€ 41,191**	**14.9**

Advanced upgrade summary

Primary energy reduced by:	**532 kWh/m^2/y**
Carbon dioxide reduced by:	**110 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

8. Detached bungalow, mass concrete, 1930-1949

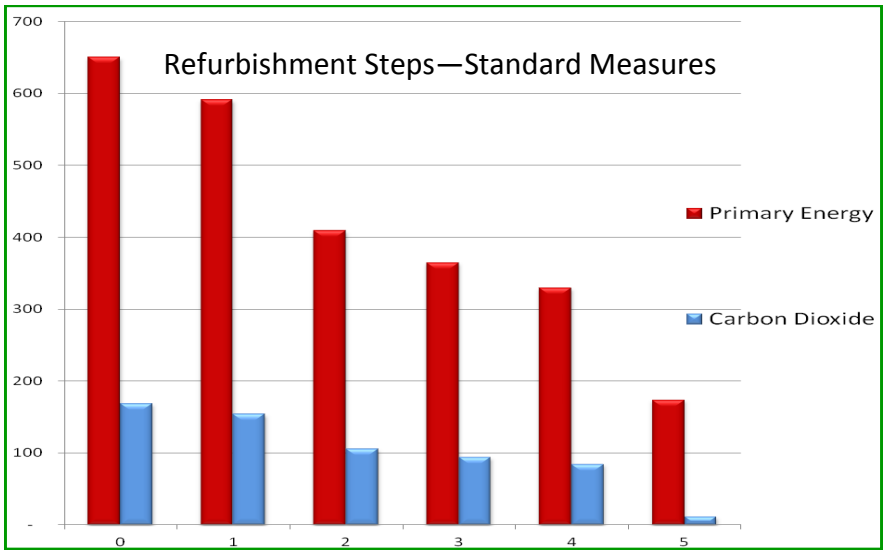
Building elements :		Insulation	U - value
Walls	Solid mass concrete	none	2.2
Roofs	Pitched, insulation between joists Flat roof (kitchen)	50 mm none	0.68 2.3
Floors	Solid floor	none	0.84
Windows	Single glazed, wooden frame	N/A	4.8
Doors	Solid timber (back door)	none	3.0
Heating systems characteristics:		**Fuel**	**Efficiency**
Primary	Central heating boiler, pipe work un-insulated	Heating oil	65%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Insulated with loose jacket, 25mm, no cylinder thermostat		
Controls	Programmer only		

Description:

This house type very common in rural areas and towns in 1940s and 1950s. Mass concrete walls have good thermal mass and is suited for external insulation. Flat roof often in kitchen annex.

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**650** (actual state)	**169** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	592	154	G
2	**Wall insulation**	Add	Application of 70-100mm external insulation or internally with 62.5-82.5mmmm thermal laminate board	0.27	409	106	F
3	**Flat roof**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	365	94	E2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors	1.4/2.0	330	85	E1
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing wood pellet boiler (89.5% efficiency) two separate heating zones with time and thermostatic control, independent water heating .Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and replaced by a solid fuel burner (75% efficient)		**174**	**12**	**C1**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

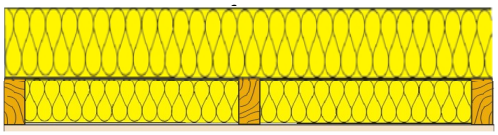
Measure	Estimated costs	Payback (y)
Step 1	€ 1,965	3.7
Step 2	€ 20,736	13.7
Step 3	€ 1,105	3.0
Step 4	€ 6,642	22.6
Step 5	€ 11,091	6.5
Total:	**€ 41,539**	**9.4**

Standard upgrade summary**

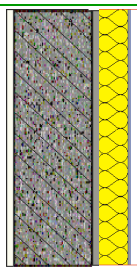
Primary energy reduced by:	**476 kWh/m²/y**
Carbon dioxide reduced by:	**157 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	

Typical wall upgrade (standard/advanced)

Before		After	
	Solid mass concrete wall, 250 mm Un-insulated, U-value = 2.2 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/m^{2}K

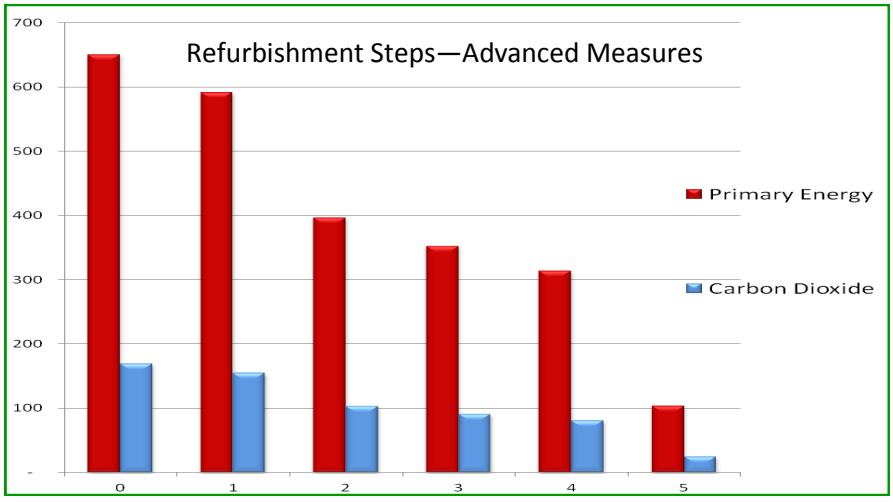
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Condensing wood pellet boiler	Ground source heat pump
Efficiency:	89.5%	400%
Fuel:	Wood pellet (Bulk)	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**650** (actual state)	**169** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	592	154	G
2	**Wall insulation**	Add	Application of 150-200mm external insulation	0.15	397	103	F
3	**Flat roof**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	352	91	E2
4	**Windows and Doors**	Replace	Insulated PVC/wooden doors Triple glazed, 16mm gap, argon filled, low-e windows	0.9 / 1.5	314	81	E1
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Ground source heat pump, 400% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). Solid fuel burner (75% efficient) replacing existing secondary heating system , 4 photovoltaic panels installed on the southern aspect		**104**	**25**	**B2**

* package also includes draughts tripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,965	3.7
Step 2	€ 24,397	15.1
Step 3	€ 1,105	3.0
Step 4	€ 7,426	23.4
Step 5	€ 26,924	15.6
Total:	**€ 61,817**	**13.5**

Advanced upgrade summary**

Primary energy reduced by:	**546 kWh/m^2/y**
Carbon dioxide reduced by:	**144 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

9. Terraced house, mass concrete, 1930-1949

Description:

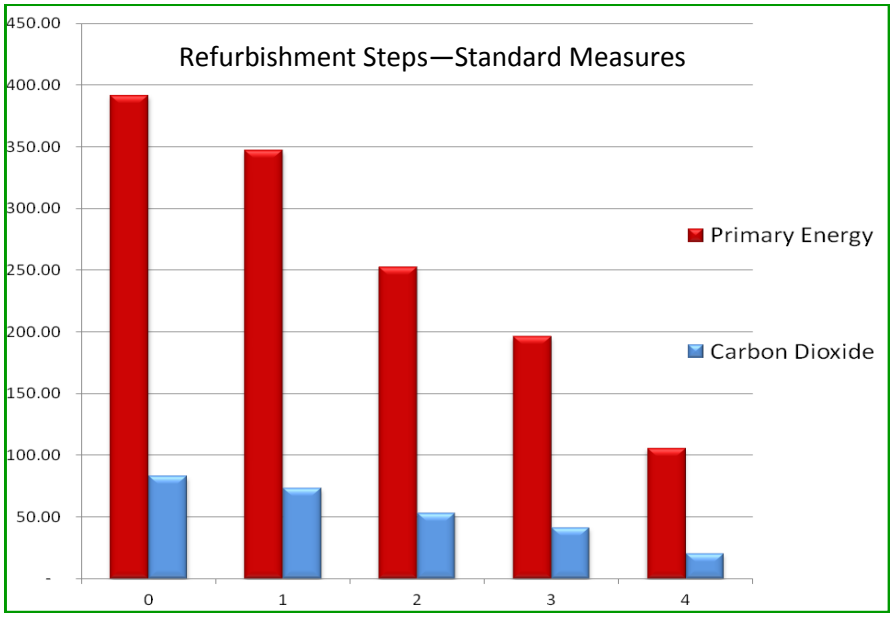
Terraced house, very common in Dublin's 1930s and 1940s housing stock. Originally built by Dublin Corporation with mass concrete walls and solid floors. This house type is an ideal candidate for external wall insulation as space is limited internally.

Building elements :		Insulation	U - value
Walls	Solid mass concrete	none	2.2
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Solid floor	none	0.61
Windows	Single glazed, metal frame	N/A	5.7
Doors	Solid wooden	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated	Mains gas	65%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Insulated with loose jacket, 25mm, no cylinder thermostat		
Controls	Programmer only		

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**392** (actual state)	**83** (actual state)	**F**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	347	73	E2
2	**Wall insulation**	Add	Application of 70-100mm external insulation	0.27	252	53	D1
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors	1.4 / 2.0	196	41	C2
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and chimney sealed.		**106**	**20**	**B2**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

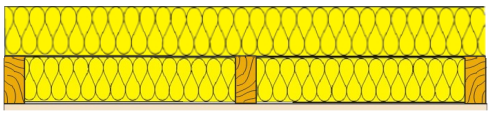
Measure	Estimated costs	Payback (y)
Step 1	€ 911	3.2
Step 2	€ 7,862	16.8
Step 3	€ 1,735	6.2
Step 4	€ 4,520	8.8
Total:	**€ 15,028**	**9.7**

Standard upgrade summary

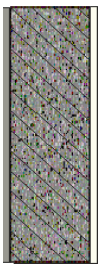
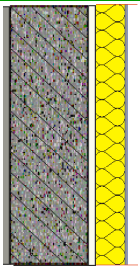
Primary energy reduced by:	**286 kWh/m²/y**
Carbon dioxide reduced by:	**63 kg CO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard/advanced)

Before		After	
	Solid mass concrete wall, 250 mm un-insulated, U-value = 2.2 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

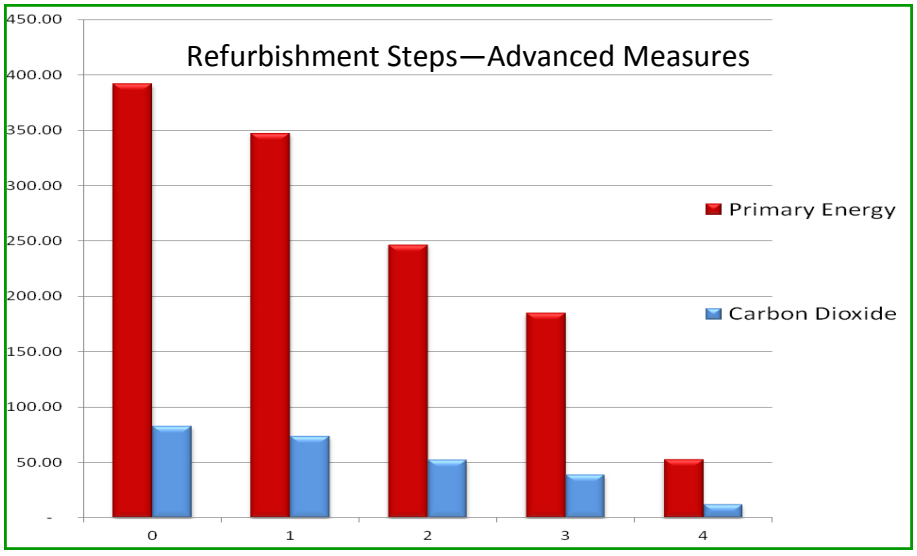
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	DCV

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**392** (actual state)	**83** (actual state)	**F**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	347	73	E2
2	**Wall insulation**	Add	Application of 150-200mm external insulation	0.15	256	52	D1
3	**Windows and Doors**	Replace	Triple glazed, argon filled, 16mm gap low-e coated windows. Insulated PVC/wooden doors.	0.9 / 1.5	185	39	C2
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump, 380% efficient, two separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Demand Control Ventilation (DCV). 4 photovoltaic panels installed on the southern aspect of the property. Chimney sealed		**52**	**12**	**A3**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 911	3.2
Step 2	€ 9,165	18.4
Step 3	€ 7,490	24.7
Step 4	€ 17,425	26.9
Total:	**€ 34,990**	**20.2**

Advanced upgrade summary

Primary energy reduced by:	**340 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**71 kg CO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

10. Bungalow, hollow block, 1950-1966

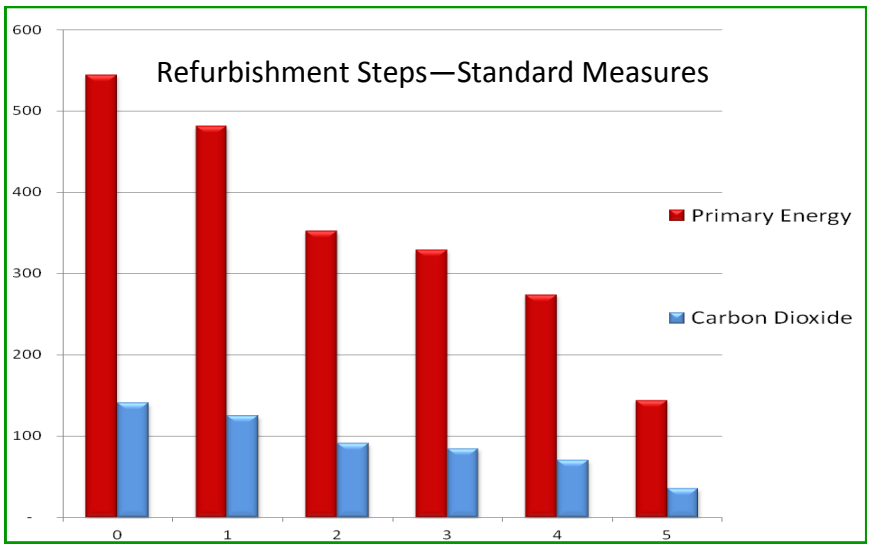
Description:

1950s detached bungalow with un-insulated 9 inch (225mm) hollow block walls, un-insulated suspended timber floors and a standard pitched roof insulated at ceiling level between the attic joists. This house type is located in the Dublin and east coast areas in particular.

Building elements :		Insulation	U - value
Walls	Concrete hollow block	none	2.4
Roofs	Main roof insulated on ceiling Flat roof over the extension	50mm none	0.68 2.3
Floors	Suspended wooden floor, unsealed	none	0.69
Windows	Single glazed, wooden frame Single glazed, metal frame	N/A N/A	4.8 5.7
Doors	Solid timber doors	none	3.0
Heating systems characteristics:		**Fuel**	**Efficiency**
Primary	Central heating boiler, pipe work un-insulated.	Heating oil	65%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated with 25mm thick loose jacket, no thermostat		
Controls	Time clock only		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**544** (actual state)	**140** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists and installation of required roof vents.	0.13	481	125	G
2	**Wall insulation**	Add	Application of 100-150mm external insulation to hollow block wall and extension wall	0.20	352	91	E2
3	**Flat roof insulation**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	329	84	E1
4	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap, Insulated doors.	1.4 / 2.0	274	70	D2
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separate heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Secondary heating system removed and chimney has been sealed.		**144**	**35**	**B3**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

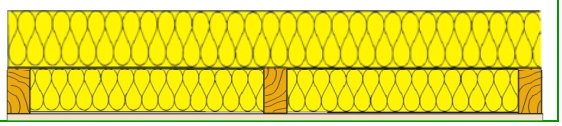
Measure	Estimated costs	Payback (y)
Step 1	€ 2,354	3.1
Step 2	€ 22,034	15.7
Step 3	€ 754	2.8
Step 4	€11,528	19.2
Step 5	€ 5,655	4.1
Total:	**€ 42,325**	**9.6**

Standard upgrade summary

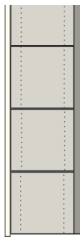
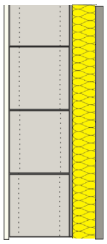
Primary energy reduced by:	**400 kWh/m²/y**
Carbon dioxide reduced by:	**105 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof up-grade includes topping the attic insulation up to 300 mm. Conduc-tivity = 0.04 W/mK	After: 

Typical wall upgrade (standard)

Before		After	
	Concrete hollow block with render outside and plaster-work inside, un-insulated. U-value =2.4 W/m^{2}K		External insulation added, typically the conductivity of appro-priate insulation boards ranges be-tween = 0.021 - 0.033 W/mK

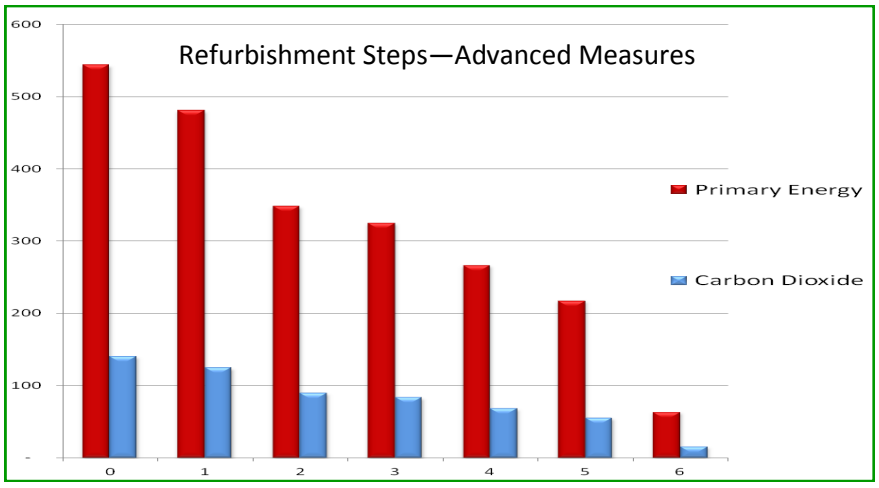
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control, load compensation
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW de-mand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylin-der, factory insulated
HW Controls type:	Time and thermo-static	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**544** (actual state)	**140** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists and installation of required roof vents .	0.13	481	125	G
2	**Wall insulation**	Add	150-200mm external insulation to both wall types	0.15	348	90	E2
3	**Flat roof insulation**	Add	Rigid insulation board fixed to underside of roof or applied over existing roof (warm deck) (100-110mm)	0.20	325	84	E1
4	**Windows and Doors**	Replace	Triple glazed, 16mm gap, argon filled low-e windows, Insulated doors.	0.9/ 1.5	267	68	D2
5	**Floors**	Add	Insulation board between the floor joists, 70-100mm	0.25	218	55	C3
	Systems upgrade:						
6	**Space and water heat-ing system and con-trols and renewable energy**	Replace	Air source heat pump 380% efficient, separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR) 4 photovoltaic panels installed on the southern aspect of the property. Secondary heating system removed. Chimney and vents / flues have been sealed		**64**	**16**	**A3**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 2,354	3.1
Step 2	€ 23,693	16.3
Step 3	€ 754	2.9
Step 4	€ 12,887	20.1
Step 5	€ 3,847	7.1
Step 6	€ 20,101	12.6
Total	**€ 63,636**	**12.15**

Advanced upgrade summary

Consumption of primary energy re-duced by:	**480 kWh/m^2/y**
Carbon dioxide reduced by:	**124 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

11. Semi detached, hollow block walls, 1950-1966

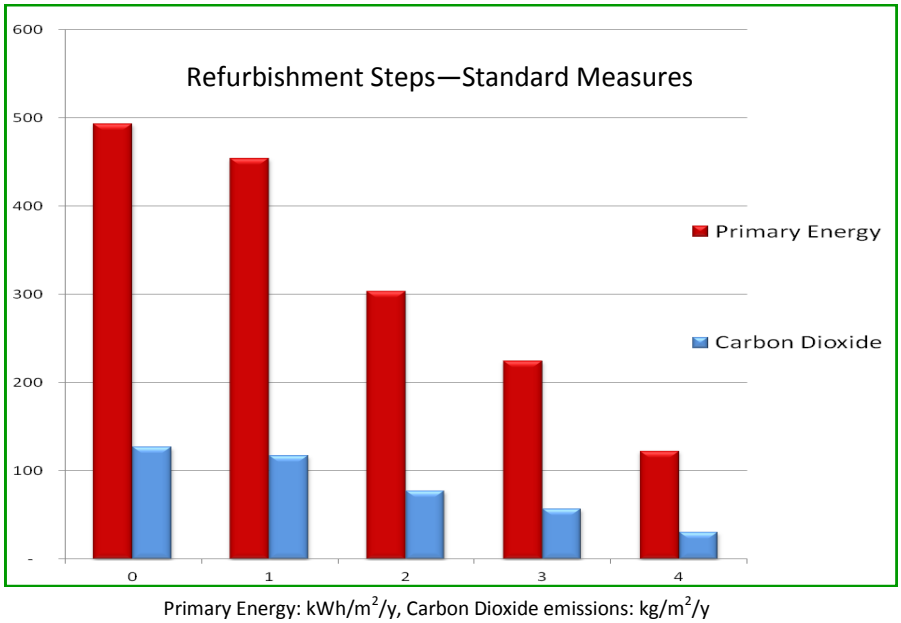
Building elements :		Insulation	U - value
Walls	Hollow block (gable and rear) Cavity wall (front)	none none	2.4 1.78
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Solid	none	0.79
Windows	Single glazed, metal frame	N/A.	5.7
Doors	Single glazed, metal frame	none	5.7
Heating systems characteristics:		**Fuel**	**Efficiency**
Primary	Central heating boiler, pipe work un-insulated	Heating oil	65%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Insulated with lagging jacket 25mm thick, no cylinder thermostat.		
Controls	Programmer only		

Description:

Semi-detached house with a brick-cavity-block front wall and hollow block walls to side & rear. All walls would be un-insulated. This construction was common from the 1950s up to the end of the 1970s in Dublin and along the East Coast but can be found in Cork too.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**494** (actual state)	**127** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	454	117	G
2	**Wall insulation**	Add	Hollow block wall: Internal insulation with 50-62.5mm thermal laminate board. Cavity wall: 60mm loose fill (Bead)	0.27 0.48	304	78	E1
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors.	1.4 / 2.0	225	57	C3
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and replaced by a solid fuel burner (75% efficient). Chimney is sealed and a flue is installed		**123**	**31**	**B2**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

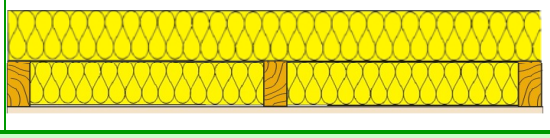
Measure	Estimated costs	Payback (y)
Step 1	€ 1,518	3.6
Step 2	€ 15,055	10.7
Step 3	€ 11,631	15.8
Step 4	€ 6,655	6.7
Total:	**€ 34,859**	**9.8**

Standard upgrade summary

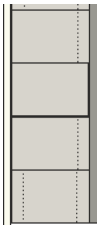
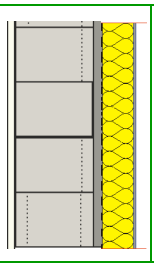
Primary energy reduced by:	**371 kWh/m²/y**
Emission of carbon dioxide reduced by:	**96 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/m²K	After: 

Typical wall upgrade (advanced)

Before		After	
	Concrete hollow block with render outside and plasterwork inside, uninsulated. U-value =2.4 W/m²K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/m²K

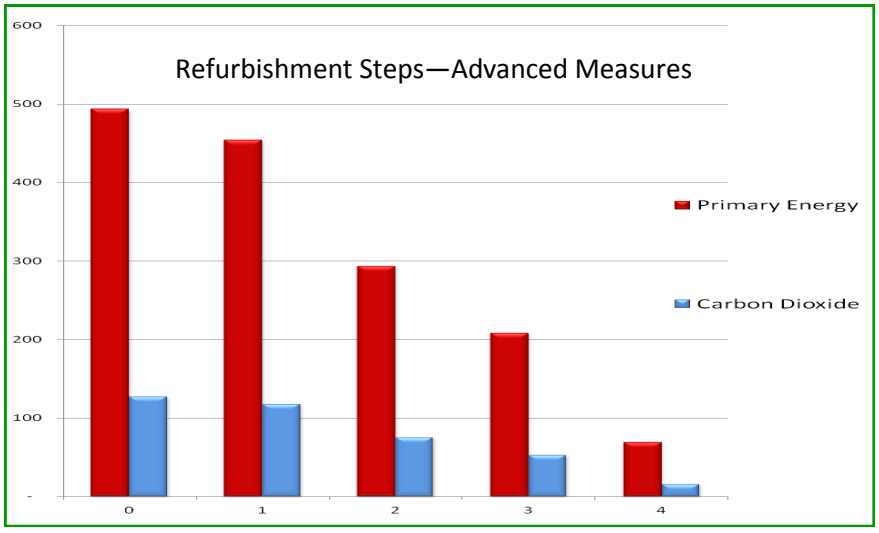
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U -values	**494** (actual state)	**127** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	454	117	G
2	**Wall insulation**	Add	**Hollow block wall**: Internal insulation with 50 - 62.5mm thermal laminate board. **Cavity wall**: 60mm loose fill (with 27-50mm thermal laminate board.	0.15 0.27	294	75	D2
3	**Windows and Doors**	Add	Insulated PVC/wooden doors Triple glazed, 16mm gap, argon filled, low-e windows	0.9 / 1.5	208	58	C3
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). Existing secondary heating system has been removed and replaced by a solid fuel burner (75% efficient). 2 photovoltaic panels have been installed on the southern aspect of the property		**70**	**16**	**A3**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,518	3.6
Step 2	€ 17,757	11.8
Step 3	€ 13,176	16.5
Step 4	€ 19,365	15.7
Total:	**€ 51,816**	**13.1**

Advanced upgrade summary

Consumption of primary energy reduced by:	**424 kWh/m²/y**
Emission of carbon dioxide reduced by:	**111 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

12. Terraced house, hollow block walls 1950-1966

Description:

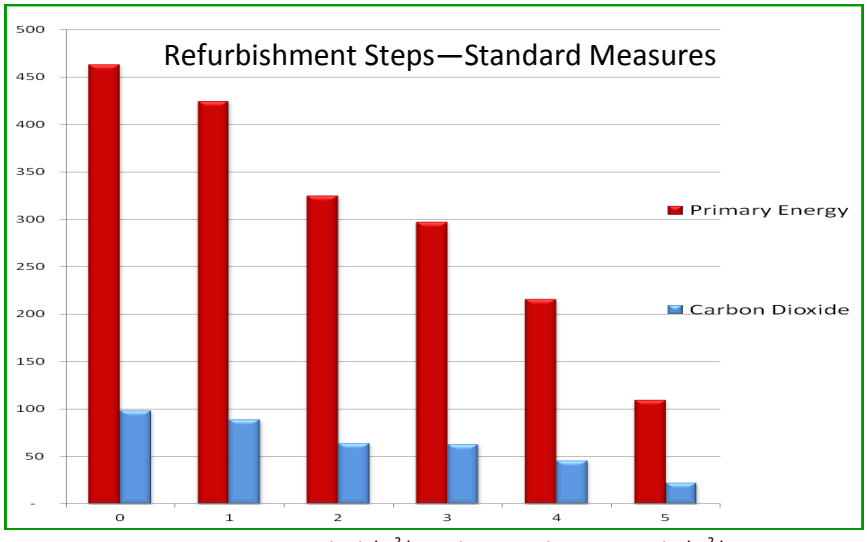
Mid terrace house with half brick front. Very common in Dublin in 1950s and 1960s. Small 50mm cavity behind brick wall with 9 inch (225mm) hollow block walls elsewhere. Un-insulated exposed floor above the garage. Suspended timber floors.

Building elements :		Insulation	U - value
Walls	Hollow block (up front, rear and extension) Cavity wall (lower front)	none none	2.4 1.78
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Suspended floor Exposed floor (over the garage)	none none	0.54 1.2
Windows	Single glazed, metal frame	N/A	5.7
Doors	Single glazed, metal frame	none	5.7

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated	Mains gas	65%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Insulated with lagging jacket 25mm thick, no cylinder thermostat.		
Controls	Programmer only		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**463** (actual state)	**98** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists and installation of required roof vents	0.13	424	89	F
2	**Wall insulation**	Add	**Hollow block wall:** Internal insulation with 50-62.5mm thermal laminate board. **Cavity wall**: 60mm loose fill (Bead)	0.27 0.48	325	64	E1
3	**Flat roof and floor over the garage**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	297	63	D2
4	**Windows and Doors**	Replace	Double glazed, low-e windows and doors, air filled, 16mm gap	1.4 / 2.0	216	45	C3
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. secondary heating system has been removed and replaced by a solid fuel burner (75% efficient). Chimney is sealed and flue is installed	**110**	**22**	**B2**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

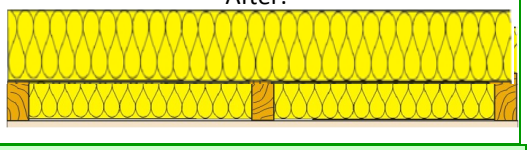
Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,268	3.1
Step 2	€ 10,239	12.6
Step 3	€ 566	2.5
Step 4	€ 14,349	21.6
Step 5	€ 5,670	5.9
Total:	**€ 32,091**	**10.4**

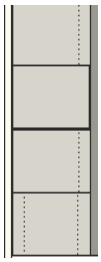
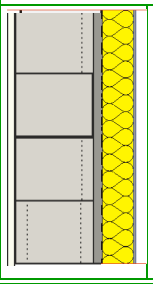
Standard upgrade summary	
Primary energy reduced by:	**353 kWh/m²/y**
Carbon dioxide reduced by:	**76 kg CO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between the ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (advanced)

Before		After	
	Concrete hollow block with render outside and plasterwork inside, uninsulated. U-value = 2.4 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

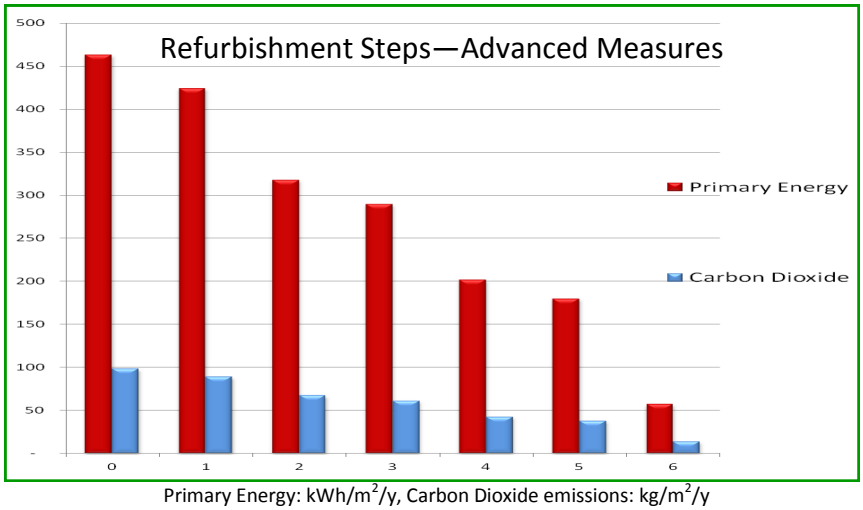
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	DCV

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**463** (actual state)	**98** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist and installation of required roof vents	0.13	424	89	F
2	**Wall insulation**	Add	All walls: external insulation. Thickness 150-200 mm	0.15	317	67	E1
3	**Flat roof and floor over the garage**	Add	Thermal laminate (82.5mm) board fixed to underside or rigid board applied on top of roof (100-150mm)	0.22	290	61	D2
4	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, 16mm gap, argon filled, low-e windows	0.9 / 1.5	202	42	C3
5	**Suspended floor**	Add	Insulation board between the floor joists, 70-100mm	0.25	180	38	C2
	Systems upgrade:						
6	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Demand Control Ventilation (DCV). 4 photovoltaic panels installed on the southern aspect of the property		**57**	**13**	**A3**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,268	3.1
Step 2	€ 12,544	14.4
Step 3	€ 566	2.5
Step 4	€ 16,156	22.4
Step 5	€ 2,031	11.3
Step 6	€ 18, 725	19.6
Total:	**€ 51,290**	**15.3**

Advanced upgrade summary

Primary energy reduced by:	**406 kWh/m^2/y**
Carbon dioxide reduced by:	**85 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

13. Detached Bungalow, cavity walls 1967-1977

Building elements :		Insulation	U - value
Walls	Empty cavity walls	none	1.78
Roofs	Pitched, insulation between joists	50 mm	0.68
Floors	Suspended timber floor	none	0.65
Windows	Single glazed, metal frame	N/A	5.7
Doors	Single glazed, metal frame	N/A	5.7

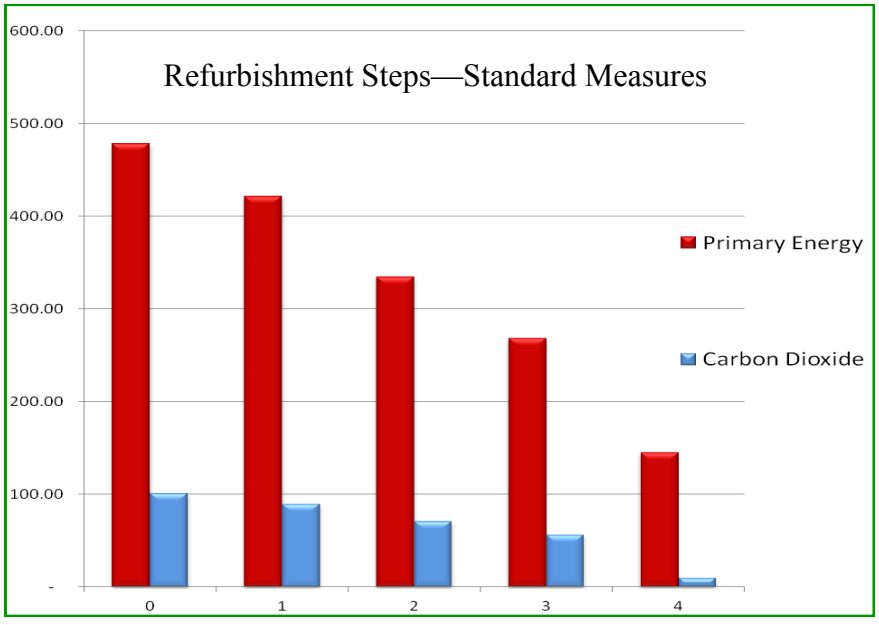
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated	Mains gas	65%
Secondary	Open fire in grate	Solid, smoke-less	30%
Hot water	From primary heating system. Electric immersion used in summer		
Cylinder	No thermostat, insulated with 25mm lagging jacket		
Controls	Time clock only		

Description:

Very common house construction in most of rural Ireland during 1960s and 1970s. Typically, the cavity wall construction has a 100mm empty cavity which can potentially be pumped with insulation beads to improve the thermal performance of the dwellings fabric.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**478** (actual state)	**101** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists and installation of required roof vents	0.13	422	89	F
2	**Wall insulation**	Add	100mm cavity filled with loose cavity fill.	0.29	335	71	E2
3	**Windows and Doors**	Replace	Double glazed,16mm gap, low-e windows, air filled, Insulated Doors	1.4 / 2.0	267	56	D2
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing wood pellet boiler (89.5% efficiency) two separate heating zones with time and thermostatic control, independent water heating .Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been replaced by a solid fuel burner (75% efficient). Chimney sealed and flue installed	**145**	**10**	**B3**

*also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

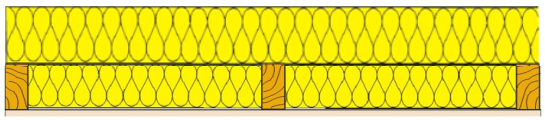
Measure	Estimated costs	Payback (y)
Step 1	€ 3,194	5.7
Step 2	€ 1,757	2.2
Step 3	€ 11,524	19.1
Step 4	€ 9,682	6.5
Total:	**€26,157**	**7.6**

Standard upgrade summary

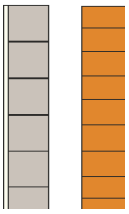
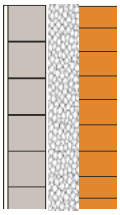
Primary energy reduced by:	**333 kWh/m²/y**
Emission of carbon dioxide reduced by:	**91 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard)

Before		After	
	Empty cavity walls, brick or block -cavity - block. U-value = 1.78 W/m^{2}K		100 mm cavity filled with beads, conductivity = 0.33 W/mK

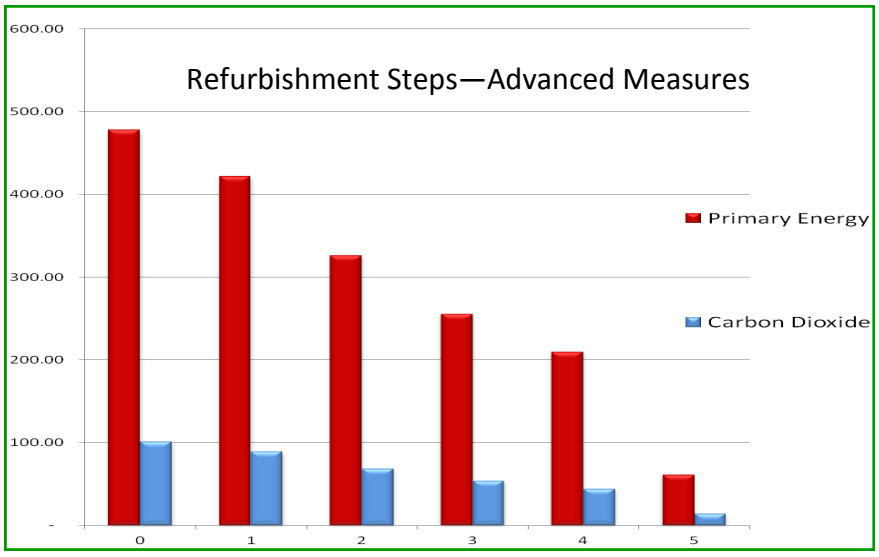
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Ground source heat pump
Efficiency:	90%	400%
Fuel:	Mains gas	Electricity
SH Controls:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**478** (actual state)	**101** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists and installation of required roof vents	0.13	422	89	F
2	**Wall insulation**	Add	Cavity walls filled with beads and external wall insulation (100-150mm) is applied.	0.15	326	69	E1
3	**Windows and Doors**	Replace	Triple glazed, low-e windows, argon filled	0.9 / 1.5	255	54	D1
4	**Floors**	Add	Insulation boards between the floor joists	0.25	210	44	C3
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Ground source heat pump 400% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR).4 photovoltaic panels installed on southern aspect of house. Solid fuel burner installed (75% efficient). Chimney sealed and flue installed		**61**	**14**	**A3**

* package also includes draught stripping, 80mm lagging . jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€3,194	5.7
Step 2	€19,801	22.8
Step 3	€13,055	20.2
Step 4	€3,528	8.5
Step 5	€25,515	18.6
Total:	**€65,092**	**16.9**

Advanced upgrade summary

Consumption of primary energy reduced by:	**417 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**87 kg CO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

14. End of terrace house, cavity walls, 1967-1977

Description:

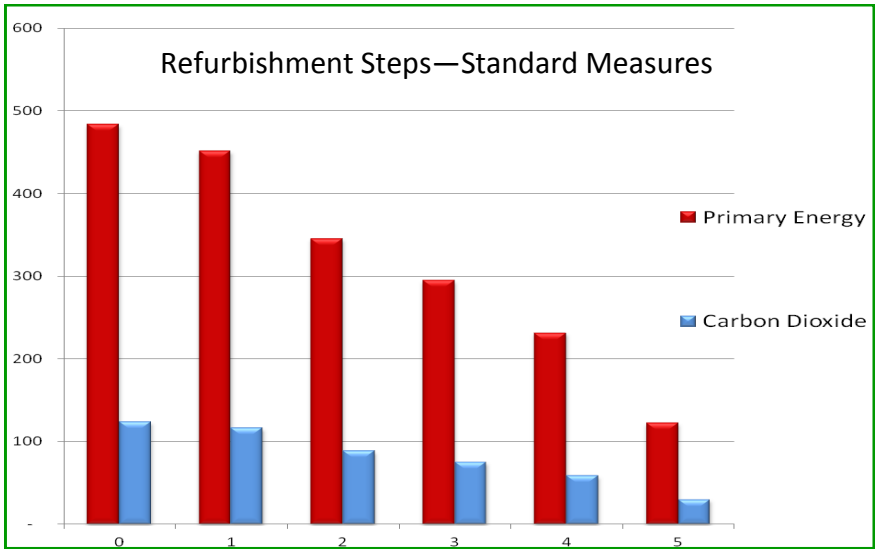
1970s end of terrace/ semi-detached house with 12 inch (300mm) cavity walls containing a 100mm empty cavity. This house type has un-insulated solid floors and a standard pitched roof insulated at ceiling level between the attic joists. Most likely found in north, west & south of Ire-

Building elements :		Insulation	U - value
Walls	300 mm cavity walls	None	1.78
Roofs	Main roof insulated on ceiling Flat roof over the extension	50mm 0	0.68 2.3
Floors	Ground solid concrete floor	None	0.79
Windows	Single glazed, wooden frame	N/A	4.8
Doors	Solid timber doors	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Heating oil	65%
Secondary	Open fire in grate	Solid, smoke-less	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	No thermostat, insulated with 25mm loose jacket.		
Controls	Time clock only		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**483** (actual state)	**124** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists and installation of required roof vents .	0.13	451	116	G
2	**Wall insulation**	Add	100 mm cavity fill (beads)	0.29	345	89	E2
3	**Flat roof insulation**	Add	Rigid insulation board fixed to underside of roof or applied over existing roof (warm deck) (100-110mm)	0.22	295	75	D2
4	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap, PVC/wooden doors, insulated.	1.4 / 2.0	231	59	D1
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and chimney sealed.		**122**	**30**	**B2**

*also includes draughts tripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

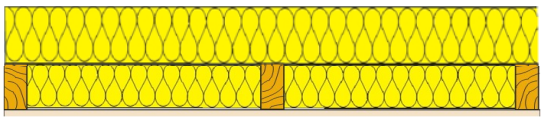
Measure	Estimated costs	Payback (y)
Step 1	€ 958	2.9
Step 2	€ 1,686	1.8
Step 3	€ 1,384	3.0
Step 4	€ 12,172	21.3
Step 5	€ 5,655	5.7
Total:	**€ 21,855**	**6.6**

Standard upgrade summary

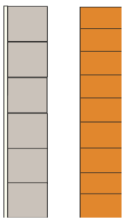
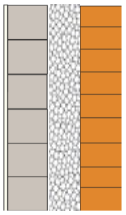
Primary energy reduced by:	**361 kWh/m²/y**
Emission of carbon dioxide reduced by:	**94 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

50mm of mineral wool between ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard)

Before		After	
	Empty cavity walls, outer brick and inner block with plasterwork, un-insulated. U-value = 1.78 W/m^{2}K		Empty cavity filled with the beads through the number of holes drilled in the outer brickwork. Conductivity of beads up to 0.033 W/mK

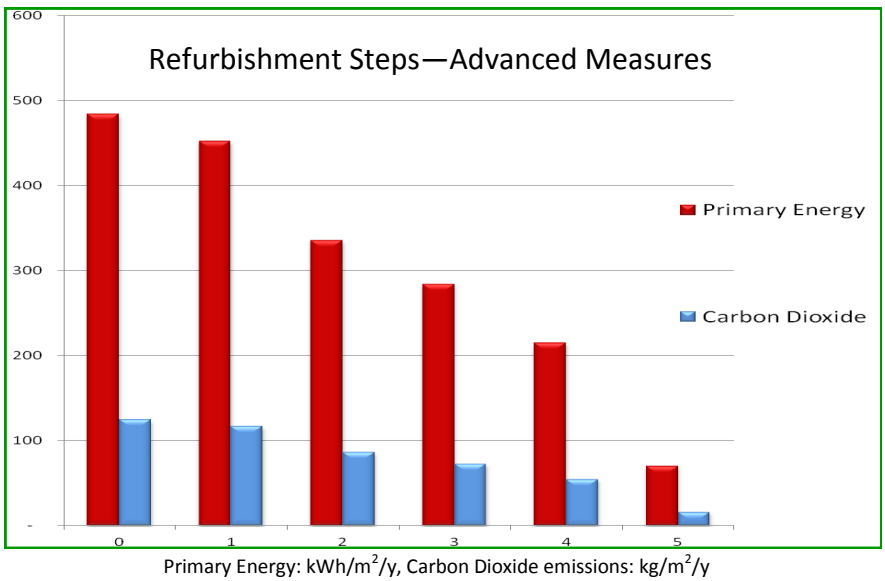
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control, load compensation
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U -values	**483** (actual state)	**124** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists and installation of required roof vents .	0.13	451	116	G
2	**Wall insulation**	Add	Cavity walls filled with beads with combination of external wall insulation (100-150mm)	0.15	335	86	E1
3	**Flat roof insulation**	Add	Rigid insulation board fixed to underside of roof or applied over existing roof (warm deck) (100-150mm)	0.22	284	72	D2
4	**Windows and Doors**	Replace	Triple glazed low-e windows, 16mm gap, argon filled, Insulated PVC or wooden doors.	0.9 / 1.5	215	54	C3
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). 2 photovoltaic panels installed on the southern aspect. Chimney sealed		**70**	**16**	**A3**

* package also includes draught stripping, 80mm lagging jacket for HW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 958	2.9
Step 2	€ 18,200	17.2
Step 3	€ 1,384	3.0
Step 4	€ 13,690	21.8
Step 5	€ 18,365	14.3
Total:	**€ 52,597**	**14.0**

Advanced upgrade summary

Primary energy reduced by:	**413 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**108 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

15. Apartment, solid brick & concrete walls, 1950-1966

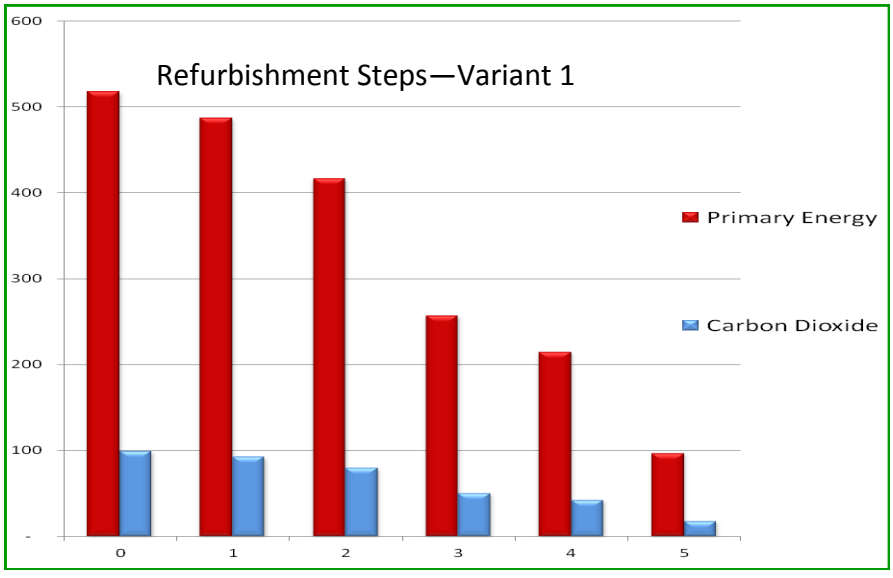
Building elements :		Insulation	U - value
Walls	Front wall and stairwells: mass concrete Rear wall: 325mm solid brick	none none	2.2 1.64
Roofs	Flat roof, concrete slab	none	2.3
Windows	Single glazed, wooden frame	N/A	4.8
Doors	Solid timber	none	3.0

Description:

Top floor flat of 1950s block of flats in Dublin city centre. This flat has both mass concrete walls facing the courtyard with 325mm solid brick walls facing the street. It has a flat concrete roof. External insulation would be the optimum solution if the block was upgraded as a single project.

Heating systems characteristics:		
Feature:	**Variant 1-gas heating**	**Variant 2 -electric heating**
Heating	Gas boiler, 68% efficient	Electric storage heaters
Hot water	From the gas boiler, immersion heater supplementary in summer	Electric immersion heater
Controls	Programmer only	Manual charge control
Cylinder	Insulated with 25 mm lagging jacket	

Refurbishment steps — variant 1 (gas heating)					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**518** (actual state)	**99** (actual state)	**G**
1	**Basic measures**	Add	100% Draught stripping, Replacing all bulbs with CFLs, Installing 80 mm lagging jacket on the cylinder	N/A	487	92	G
2	**Wall insulation**	Add	Dry line/internally insulate with 72.5-82.5mm thermal laminate board.	0.27	417	79	F
3	**Roof insulation**	Add	52.5mm thermal laminate fixed to underside of roof	0.5	257	50	D1
4	**Windows and Doors**	Replace	Triple glazed low-e windows, argon filled, 16mm gap. PVC or wooden doors.	0.9 / 1.5	215	42	C3
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient with room thermostat and TRVs, independent water heating. Hot water cylinder insulated with 50 mm spray foam. 3 photovoltaic panels installed on the southern aspect of the communal flat roof. Demand Control Ventilation (DCV) installed.		**98**	**18**	**B1**



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time*

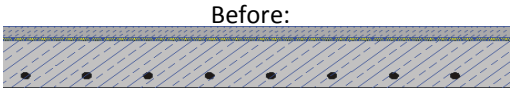
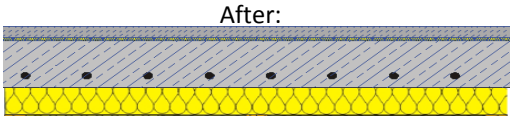
Measure	Estimated costs	Payback (y)
Step 1	€ 219	1.7
Step 2	€ 2,060	9.7
Step 3	€ 2,198	4.6
Step 4	€ 3,709	29.5
Step 5	€ 7,870	17.3
Total:	**€ 16,055**	**11.5**

Standard upgrade summary

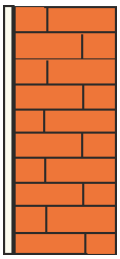
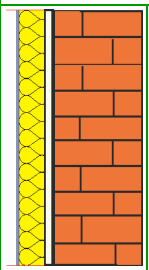
Primary energy reduced by:	**420 kWh/m²/y**
Carbon dioxide reduced by:	**81 kg CO_2/m²/y**

*Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade

Concrete slab, un-insulated	Before: 
Internal drylining boards fixed to the ceiling Conductivity = 0.023 W/mK	After: 

Typical wall upgrade

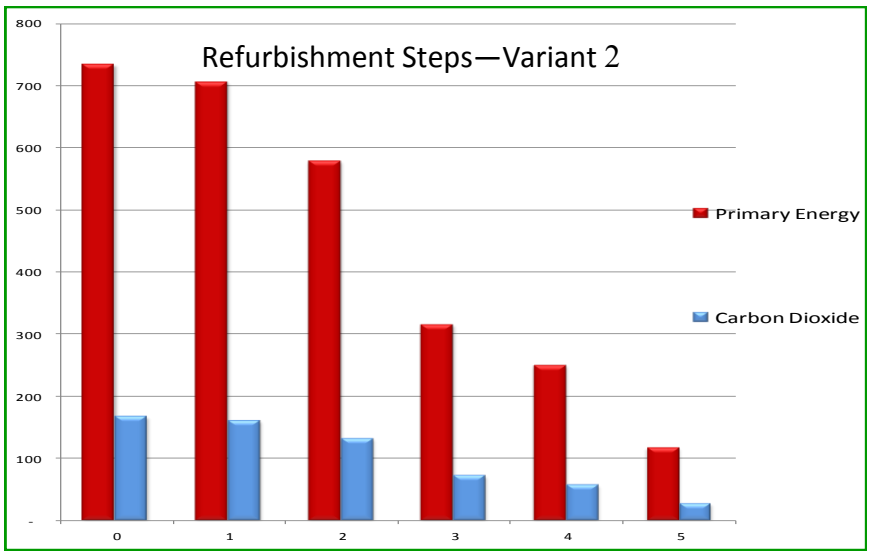
Before		After	
	Solid brick wall 325 mm, un-insulated, U-value = 2.1 W/m^{2}K		Thermal laminate boards applied via mechanical fixing or adhesive, typically conductivity of boards ranges between = 0.021 - 0.025 W/mK

Heating system upgrade

Feature:	Variant 1—gas	Variant 2—electric
Heat generator	Regular condensing boiler	Air to air heat pump
Efficiency:	90%	250%
Fuel:	Mains gas	Electricity
SH Controls type:	Programmer, Room thermostat, TRV's	Time and temperature zone control
Hot water source (HW):	Primary heating system	Electric immersion
HW Cylinder:	96 litre, factory insulated	96 litre, factory insulated
HW Controls type:	7-day programmer, Cylinder thermostat	7-day programmer, Cylinder thermostat
Ventilation:	DCV	DCV

Refurbishment steps—variant 2 (electric heating)

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**733** (actual state)	**166** (actual state)	**G**
1	**Basic measures**	Add	100% Draught stripping, Replacing all bulbs with CFLs, Installing 80 mm lagging jacket on the cylinder	N/A	705	160	G
2	**Wall insulation**	Add	Dry line/internally insulate with 72.5-82.5mm thermal laminate board.	0.27	578	131	G
3	**Roof insulation**	Add	52.5mm thermal laminate fixed to underside of roof	0.5	315	71	E1
4	**Windows and Doors**	Replace	Triple glazed low-e windows, argon filled, 16mm gap. PVC or wooden doors.	0.9 / 1.5	250	57	D1
	Systems upgrade:						
5	**Space and water heating system and controls and renewable energy**	Replace	Air to air heat pump, 250% efficient, individual temperature controls for each room. High efficiency hot water cylinder, heated by the immersion heater. Demand Control Ventilation (DCV) installed. 2 photovoltaic panels installed on southern aspect of communal roof.		**117**	**27**	**B2**



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time*

Measure	Estimated costs	Payback (y)
Step 1	€ 219	1.7
Step 2	€ 2,060	3.6
Step 3	€ 2,198	1.9
Step 4	€ 3,709	12.8
Step 5	€ 10,032	16.9
Total:	**€ 18,218**	**6.6**

Advanced upgrade summary

Primary energy reduced by:	**616 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**139 kgCO$_2$/m^2/y**

*Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

16. Detached house, cavity walls, 1978-1982

Building elements :		Insulation	U - value
Walls	300 mm cavity walls, partially filled	15-25 mm	1.1
Roofs	Pitched, insulation between joists	100 mm	0.4
Floors	Solid	10-15 mm	0.64
Windows	Double glazed, metal frame, 6mm gap	N/A	3.7
Doors	Solid timber	none	3.0

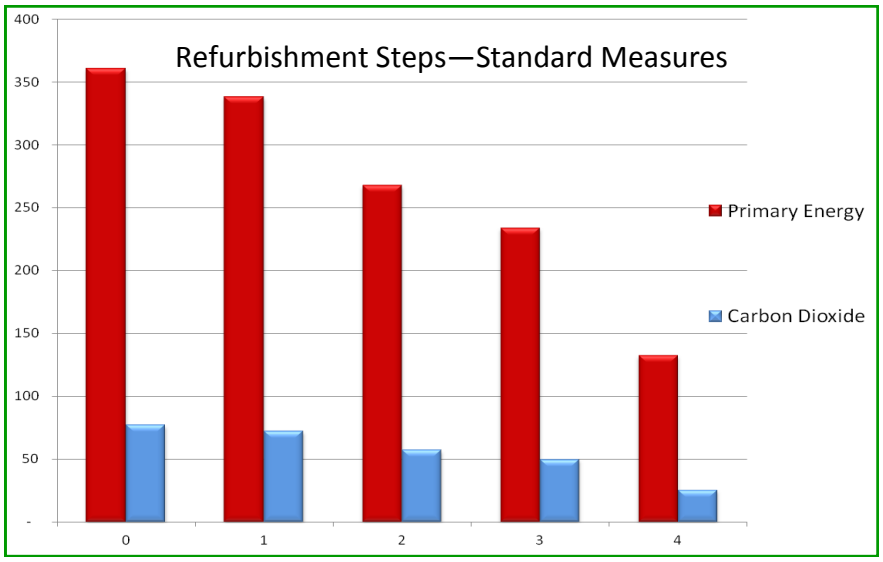
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Mains gas	70%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated with loose jacket, 35 mm thick, no thermostat		
Controls	Time clock only		

Description

Red-brick fronted detached house with cavity wall construction, i.e. wall contains a 100mm cavity part-filled with a 50mm insulation board. More commonly found outside of Dublin and neighbouring counties.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**360** (actual state)	**77** (actual state)	**E2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	338	72	E1
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with loose fill insulation	0.36 (for 50mm)	267	57	D2
3	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap. Insulated PVC/wooden doors.	1.4/2.0	234	50	D1
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating. Hot water cylinder insulated with 50 mm spray foam. Secondary heating system removed and chimney is sealed		**132**	**25**	**B3**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

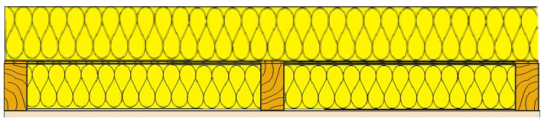
Measure	Estimated costs	Payback (y)
Step 1	€ 1,249	5.0
Step 2	€ 2,309	4.4
Step 3	€ 10,615	41.7
Step 4	€ 4,520	5.5
Total:	**€ 18,692**	**10.1**

Standard upgrade summary

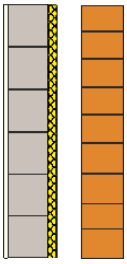
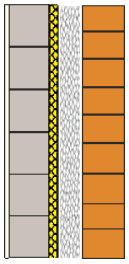
Primary energy reduced by:	**228 kWh/m²/y**
Emission of carbon dioxide reduced by:	**52 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

100 mm of mineral wool between the ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard)

Before		After	
	Cavity walls, outer brick and inner block with plasterwork, partially insulated U-value =1.1 W/m^{2}K		Remaining cavity filled with the beads through the number of holes drilled in the outer brickwork. Conductivity of beads up to 0.033 W/mK

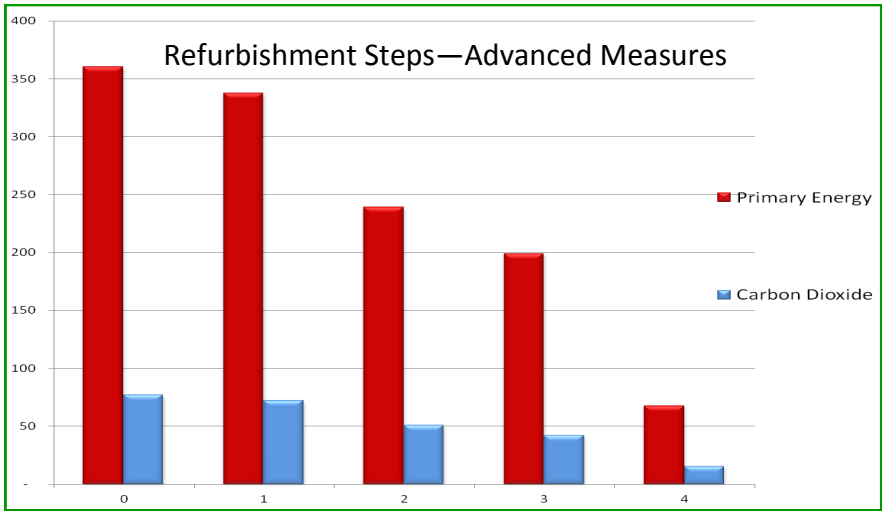
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control, load compensation
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**360** (actual state)	**77** (actual state)	**E2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation. and installation of required roof vents	0.13	338	72	E1
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads, with combination of dry-lining (front) and external wall insulation (sides and rear). Thickness: 50-100 mm	0.15	239	51	D1
3	**Windows and Doors**	Replace	Triple glazed low-e windows, argon filled, 16mm gap Insulated doors.	0.9 / 1.5	199	42	C3
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% , two separate heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). 3 photovoltaic panels installed on the southern aspect of the property. Chimney sealed. Secondary heating system removed		**68**	**15**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,249	5.0
Step 2	€ 16,108	21.7
Step 3	€ 11,892	39.2
Step 4	€ 19,601	22.6
Total:	**€ 48,787**	**22.6**

Advanced upgrade summary

Consumption of primary energy reduced by:	**292 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**62 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

17. Terraced house, cavity walls, 1978-1982

Description:

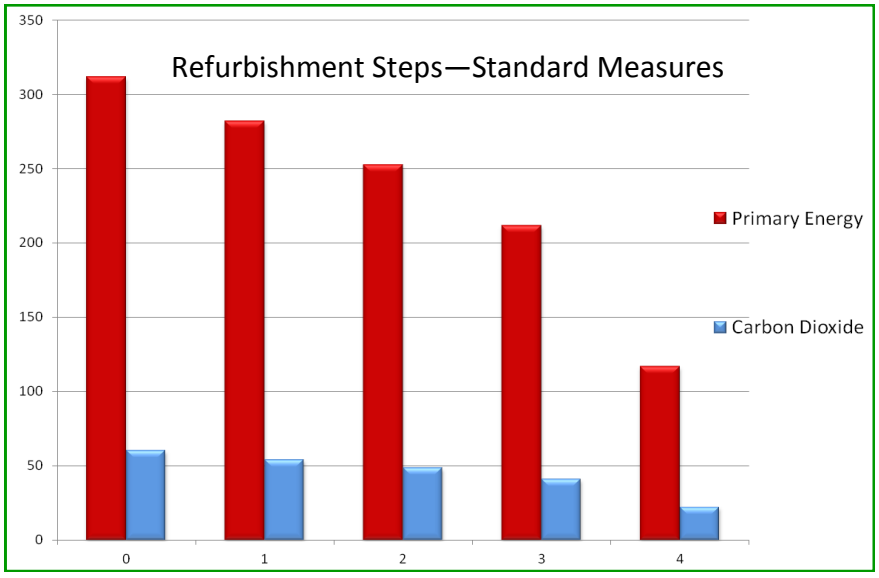
Terraced house with cavity walls containing 25mm insulation boards. This one was found in Dublin but it could be anywhere in Ireland. This house is a perfect candidate for cavity wall insulation. Solid floors were standard for this period and so floor insulation options are limited.

Building elements :		Insulation	U - value
Walls	300 mm cavity walls, partially filled	15-25 mm	1.1
Roofs	Pitched, insulation between joists	100 mm	0.4
Floors	Solid	10-15 mm	0.64
Windows	Double glazed, metal frame, 6mm gap	N/A	3.7
Doors	Double glazed, metal frame, 6mm gap	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Mains gas	70%
Secondary	Gas fire, coal effect	Mains gas	20%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated with loose jacket, 35 mm thick, no thermostat		
Controls	Time clock only		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**311** (actual state)	**60** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	282	54	D2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads	0.41 (for 50mm)	252	48	D1
3	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap, Insulated doors	1.4 / 2.0	211	41	C3
	Systems upgrade:						
4	**Space and water heating system and Controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating . Hot water cylinder insulated with 50 mm spray foam. Secondary heating system removed and chimney is sealed.	**117**	**22**	**B2**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

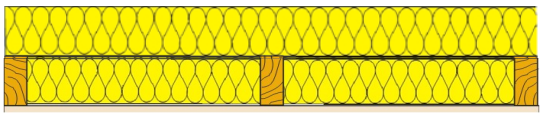
Measure	Estimated costs	Payback (y)
Step 1	€ 1,042	4.9
Step 2	€ 539	3.4
Step 3	€ 7,047	31.5
Step 4	€ 4,520	7.6
Total:	**€ 13,148**	**11.1**

Standard upgrade summary

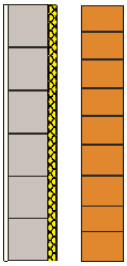
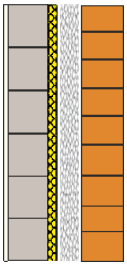
Primary energy reduced by:	**194 kWh/m²/y**
Carbon dioxide reduced by:	**38 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

100 mm of mineral wool between the ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard)

Before		After	
	Cavity walls, outer brick and inner block with plasterwork, partially insulated U-value =1.1 W/m^{2}K		Remaining cavity filled with the beads through the number of holes drilled in the outer brickwork. Conductivity of beads up to 0.033 W/mK

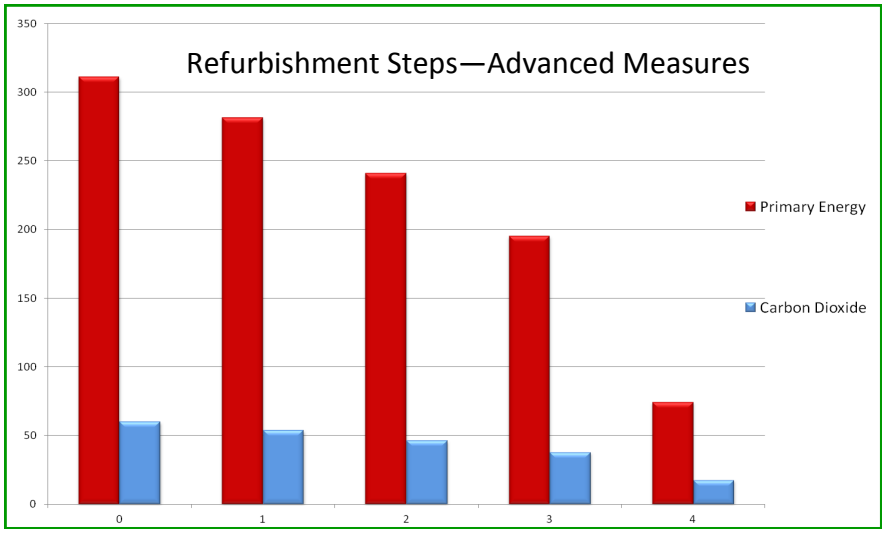
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control, load compensation
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	DCV

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**311** (actual state)	**60** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	282	54	D2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads, with combination of dry-lining (front) and external wall insulation (rear). Thickness: 150-200 mm	0.15	241	46	D1
3	**Windows and Doors**	Replace	Triple glazing, 16mm gap, argon filled, low-e coating. Insulated doors (glazed & solid)	0.9 / 1.5	195	38	C3
	Systems upgrade:						
4	**Space and water heating system and Controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Demand Control Ventilation (DCV). Secondary heating system is replaced with a solid fuel burner (75% efficient) chimney is sealed and flue is installed. 2 photovoltaic panels installed on the southern aspect		**75**	**18**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,042	4.9
Step 2	€ 3,154	14.2
Step 3	€ 7,983	32.0
Step 4	€ 17,275	28.4
Total:	**€ 29,453**	**22.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**236 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**42 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

18. Detached house, hollow block walls, 1978-1982

Description:

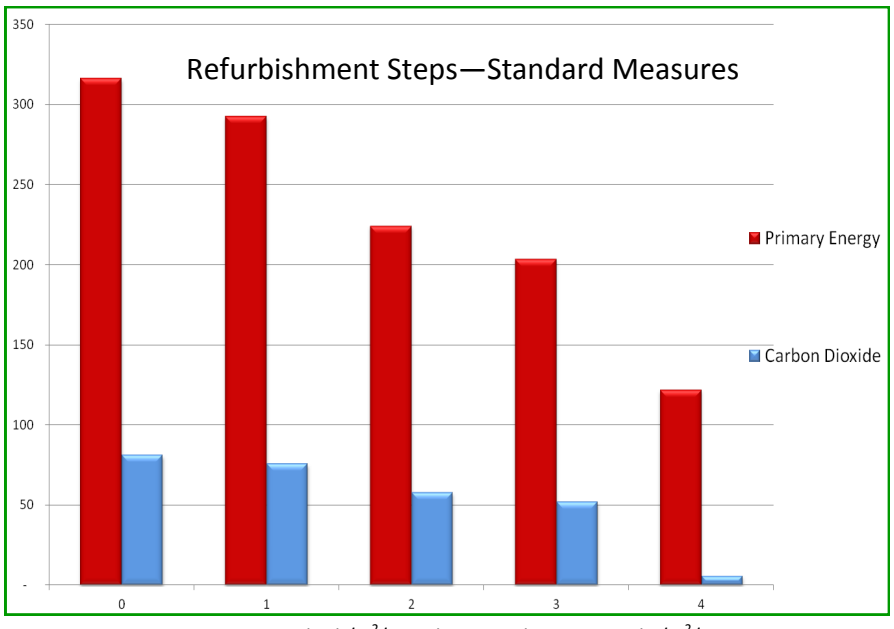
Detached house with hollow block walls. These walls would be dry-lined internally with perhaps 25mm of insulation board on timber battens or else 50mm of fibre insulation may be placed between the battens.

Building elements :		Insulation	U - value
Walls	Concrete hollow block, drylined	25-50 mm	1.1
Roofs	Pitched, insulation between joists	100 mm	0.4
Floors	Solid	10-15 mm	0.64
Windows	Double glazed, metal frame, 6mm gap	N/A	3.7
Doors	Double glazed, metal frame, 6mm gap	none	3.0

Heating systems characteristics:		Fuel	Effi-ciency
Primary	Central heating boiler, pipe work un-insulated.	Heating oil	75%
Secondary	Open fire in grate	Solid multi-fuel	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated with loose jacket, 35 mm thick, no thermostat		
Controls	Time clock only		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**316** (actual state)	**81** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	293	76	D2
2	**Wall insulation**	Replace insulation	Re- Dry line/internally insulate walls with 72.5-82.5mm thermal laminate board.	0.27	224	58	C3
3	**Windows and Doors**	Replace	Double glazed low-e windows and doors, air filled, 16mm gap	1.4/2.0	204	52	C3
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing wood pellet boiler (89.5% efficiency) two separate heating zones with time and thermostatic control, independent water heating .Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and chimney has been sealed.		**122**	**6**	**B2**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

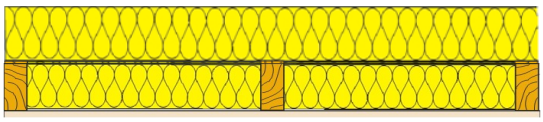
Measure	Estimated costs	Payback (y)
Step 1	€ 2,050	6.5
Step 2	€ 13,497	17.9
Step 3	€ 9,129	40.0
Step 4	€ 8,682	8.4
Total:	**€ 31,896**	**13.7**

Standard upgrade summary

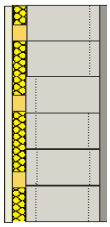
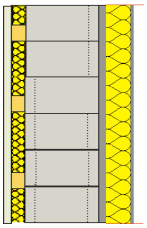
Consumption of primary energy reduced by:	**194 kWh/m²/y**
Emission of carbon dioxide reduced by:	**75 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

100 mm of mineral wool between the ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (advanced)

Before		After	
	Concrete hollow block walls, dry-lined insulation between the timber battens, U-value =1.1 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

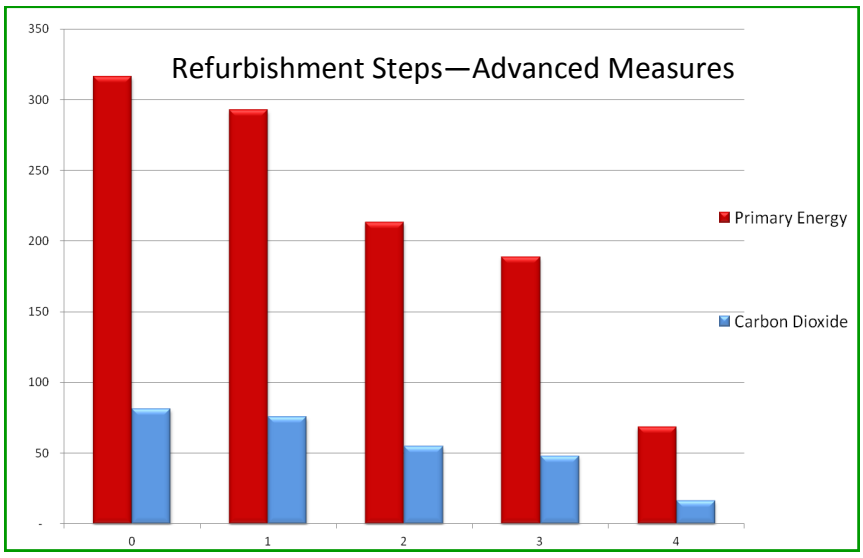
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Condensing wood pellet boiler	Ground source heat pump
Efficiency:	89.5%	400%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control, load compensation
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U -values	**316** (actual state)	**81** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents.	0.13	293	76	D2
2	**Wall insulation**	Add	Walls insulated externally with 150-200 mm thick rigid insulation boards	0.15	213	55	C3
3	**Windows and Doors**	Replace	Triple glazed low-e windows and doors, argon filled, 16mm gap	0.9 / 1.5	204	48	C2
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Ground source heat pump 400% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). 4 photovoltaic panels installed on the southern aspect of the property. Existing secondary heating system replaced by solid fuel burner (75% efficient). Chimney sealed and flue installed.		**68**	**16**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 2,050	6.5
Step 2	€ 34,258	39.0
Step 3	€ 9,992	36.8
Step 4	€ 25,951	19.5
Total:	**€ 72,251**	**25.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**248 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**65 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

19. Terraced house, hollow block, 1978-1982

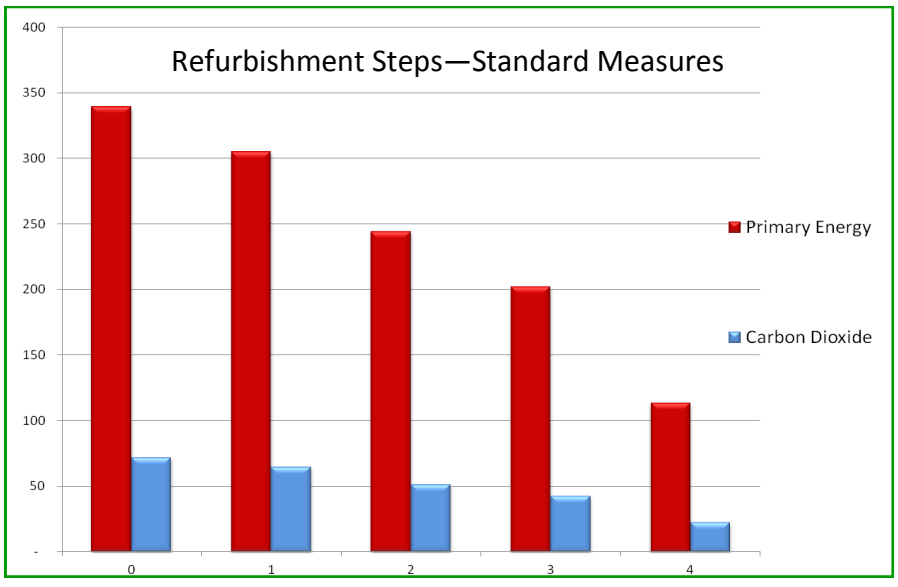
Building elements :		Insulation	U - value
Walls	Concrete hollow block, drylined	15-25 mm	1.1
Roofs	Pitched, insulation between joists	100 mm	0.4
Floors	Solid	10-15 mm	0.57
Windows	Double glazed, metal frame, 6mm gap	N/A	3.7
Doors	Double glazed, metal frame, 6mm gap (front) Solid wood (kitchen door)	N/A none	3.7 3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Mains gas	70%
Secondary	Open fire in grate	Solid multi-fuel	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated with loose jacket, 35 mm thick, no thermostat.		
Controls	Programmer.		

Description:
Mid or end of terrace house commonly built in Dublin with a red-brick front with a small cavity behind it on the ground floor and 9 inch hollow block walls elsewhere. Insulation first appeared in 1978 and these walls would typically be dry lined with 25mm polystyrene board or with 50mm of insulation fibre between battens.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**340** (actual state)	**72** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	305	64	E1
2	**Wall insulation**	Replace insulation	Re- Dry line/internally insulate walls with 72.5-82.5mm thermal laminate board.	0.27	244	51	D1
3	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap Insulated doors.	1.4 / 2.0	202	42	C3
	Systems upgrade:						
4	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating. Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system is removed and replaced by a solid fuel burner.	**114**	**49**	**B2**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

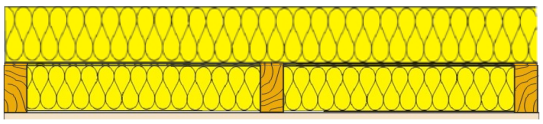
Measure	Estimated costs	Payback (y)
Step 1	€ 927	4.0
Step 2	€ 6,097	19.8
Step 3	€ 8,644	40.8
Step 4	€ 5,520	10.4
Total:	**€ 21,188**	**16.5**

Standard upgrade summary

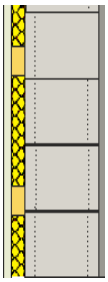
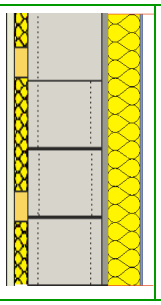
Primary energy reduced by:	**226 kWh/m²/y**
Emission of carbon dioxide reduced by:	**23 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

100 mm of mineral wool between the ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (advanced)

Before		After	
	Concrete hollow block walls, dry-lined insulation between the timber battens, U-value =1.1 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

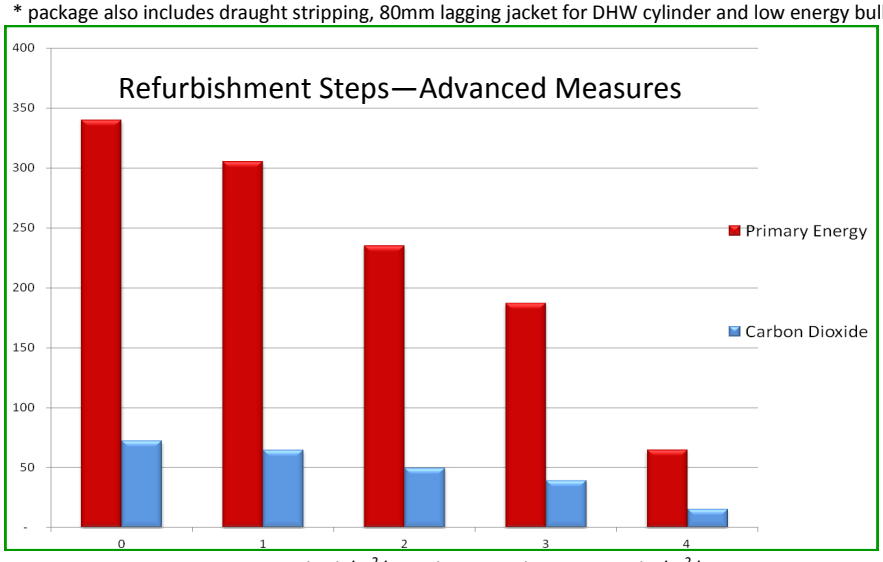
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**340** (actual state)	**72** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents.	0.13	305	64	E1
2	**Wall insulation**	Add	Walls insulated externally with 100-150 mm thick rigid insulation board	0.21	235	49	D1
3	**Windows and Doors**	Replace	Triple glazed low-e windows, argon filled, 16mm gap PVC/wooden doors, insulated	0.9 / 1.5	187	39	C2
	Systems upgrade:						
4	**Space and water heating system and Controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). 2 photovoltaic panels installed on the southern aspect of the property. Secondary heating system is replaced with a solid fuel burner (75% efficient). Chimney is sealed and flue installed		**65**	**15**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 927	4.0
Step 2	€ 14,028	39.7
Step 3	€ 9,695	40.1
Step 4	€ 19,515	33.0
Total:	**€ 44,165**	**31.1**

Advanced upgrade summary

Primary energy reduced by:	**275 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**57 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

20. Detached bungalow, cavity walls, 1983-1993

Description:

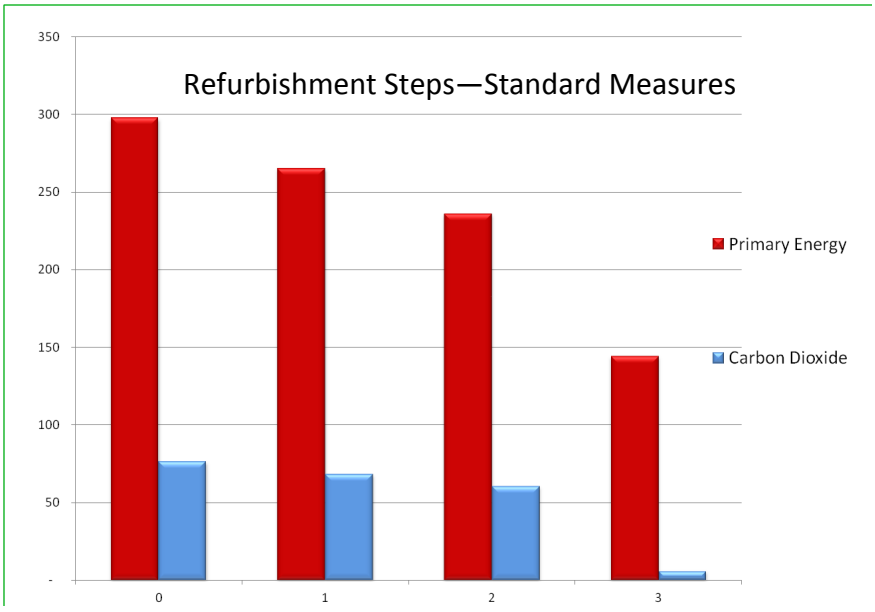
Very typical rural bungalow from the 1980s. 50mm of polystyrene wall insulation was normally fitted during construction. The part-filled cavity can be full-filled by pumping in additional insulation beads.

Building elements :		Insulation	U - value
Walls	Cavity walls, partially filled	25-50 mm	0.6
Roofs	Pitched, insulation between joists	100 mm	0.4
Floors	Solid	10-15 mm	0.57
Windows	Double glazed, wooden frame, 6 mm gap	N/A	3.1
Doors	Solid wooden	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Heating oil	75%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated, spray foam 30mm, no cylinder thermostat.		
Controls	Programmer.		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**298** (actual state)	**76** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	265	68	D2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads, with combination of dry lining/internally insulating with 82.5mm thermal laminate boards.	0.21	236	61	D1
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Condensing wood pellet boiler (89.5% efficiency) two separate heating zones with time and thermostatic control, independent water heating .Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and chimney has been sealed.	**144**	**6**	**B3**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

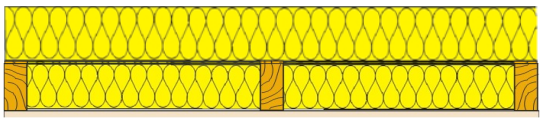
Measure	Estimated costs	Payback (y)
Step 1	€ 2,167	5.4
Step 2	€ 14,146	43.4
Step 3	€ 8,682	7.6
Total	**€ 24,995**	**13.4**

Standard upgrade summary

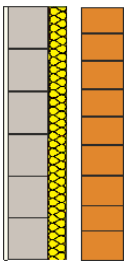
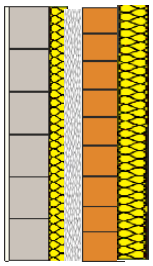
Primary energy reduced by:	**154 kWh/m²/y**
Emission of carbon dioxide reduced by:	**70 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

100 mm of mineral wool between the ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (advanced)

Before		After	
	Cavity walls, partially filled with insulation boards, 25-50 mm thick. U-value =0.6 W/m^{2}K		Remaining cavity filled with insulation beads, conductivity =0.033 W/mK. External insulation added, conductivity = 0.021 - 0.033 W/mK

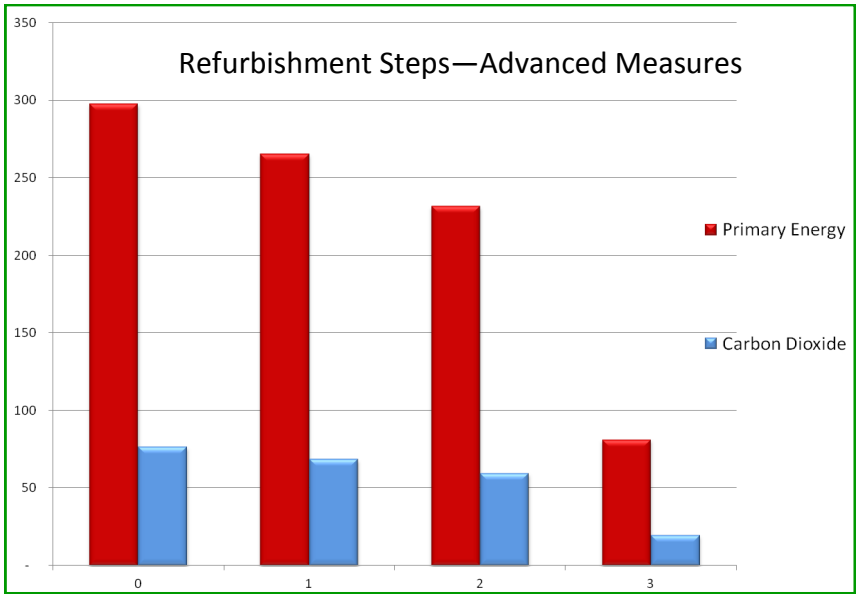
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Ground source heat pump
Efficiency:	90%	400%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**298** (actual state)	**76** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents. .	0.13	265	68	D2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads, with combination of externally insulating with rigid insulation board (150-200mm thick)	0.15	232	59	D1
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Ground source heat pump 400%, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). Existing secondary heating system is replaced by a solid fuel burner (75% efficient). 6 photovoltaic panels on the southern aspect		**81**	**19**	**B1**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 2,167	5.4
Step 2	€ 26,713	70.9
Step 3	€ 27,101	16.4
Total:	**€ 55,981**	**23.1**

Advanced upgrade summary

Consumption of primary energy reduced by:	**217 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**57 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

21. Semi detached house, cavity walls, 1983-1993

Building elements :		Insulation	U - value
Walls	Cavity walls, partially filled	25-50 mm	0.6
Roofs	Pitched, insulation between joists	100 mm	0.4
Floors	Solid	10-15 mm	0.64
Windows	Double glazed, PVC frame, 6 mm gap	N/A	3.1
Doors	Solid wooden	none	3.0

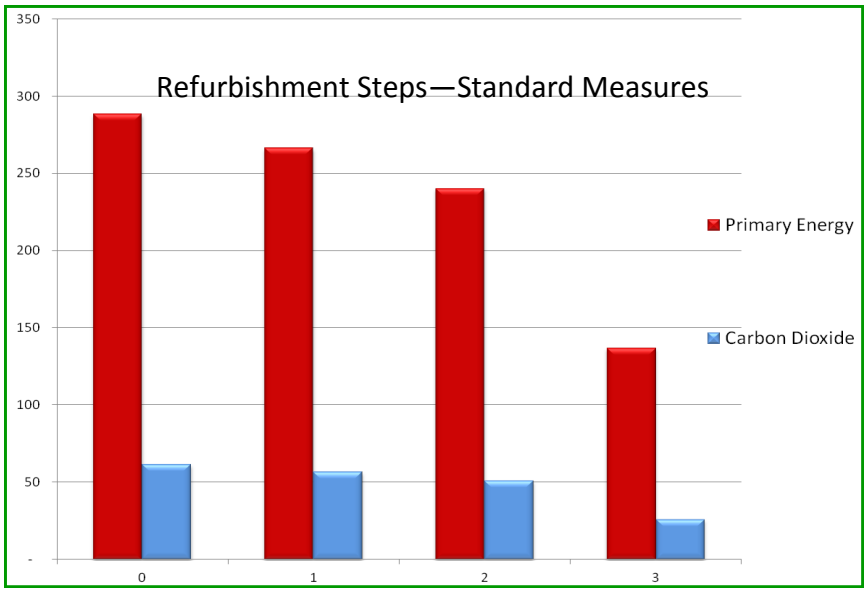
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Mains gas	75%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated, loose jacket 35mm, no cylinder thermostat.		
Controls	Programmer.		

Description:

Semi-detached house with part-filled cavity walls and solid floors. The part-filled cavity can be full-filled by pumping in additional insulation beads. This house type is common throughout Ireland during the 1980s.

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**288** (actual state)	**62** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents.	0.13	266	57	D2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads, with combination of dry lining/internally insulating with 82.5mm thermal laminate boards.	0.21	240	51	D1
	Systems upgrade:						
3	**Space and water heating system and controls and renew-able energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating. Hot water cylinder insulated with 50 mm spray foam. Secondary heating system replaced with solid fuel burner (75% efficient). All chimneys are sealed and flue installed.		**137**	**26**	**B3**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

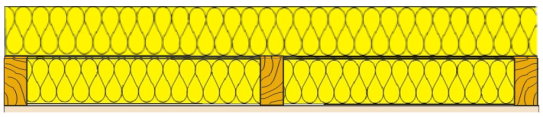
Measure	Estimated costs	Payback (y)
Step 1	€ 792	4.3
Step 2	€ 8,837	57.0
Step 3	€ 4,520	6.7
Total:	**€ 14,148**	**14.0**

Standard upgrade summary

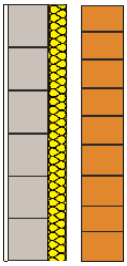
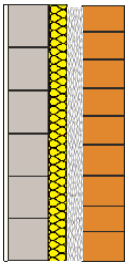
Consumption of primary energy reduced by:	**151 kWh/m²/y**
Emission of carbon dioxide reduced by:	**36 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

100 mm of mineral wool between ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (advanced)

Before		After	
	Cavity walls, partially filled with insulation boards, 25-50 mm thick. U-value = 0.6 W/m^{2}K		Remaining cavity filled with insulation beads, conductivity = 0.033 W/mK

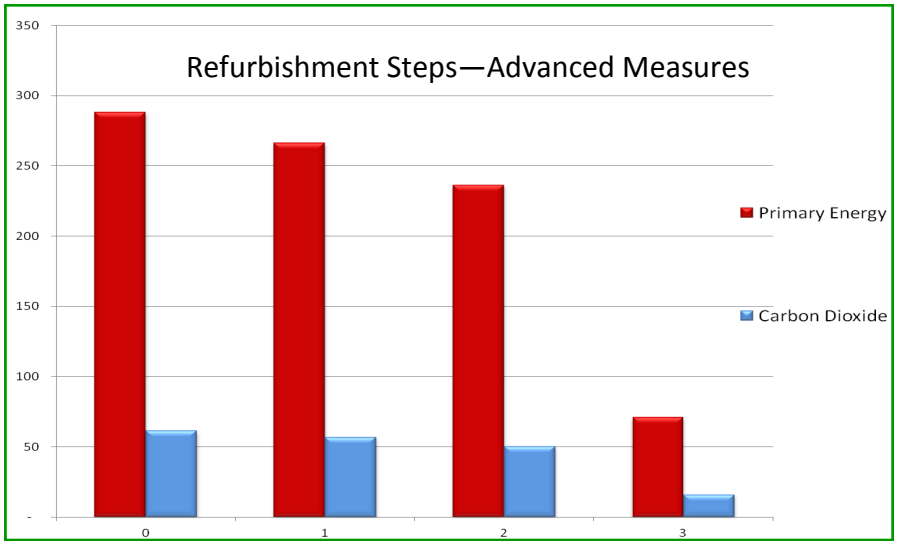
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**288** (actual state)	**62** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents. .	0.13	266	57	D2
2	**Wall insulation**	Add	Remaining cavity (50mm) filled with insulation beads, walls insulated internally with 52.5-72.5mm thermal laminate boards.	0.21	236	50	D1
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). 4 photovoltaic panels installed on the southern aspect of the property. Secondary heating system removed and chimney sealed.	**71**	**16**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 792	4.3
Step 2	€ 9,118	50.8
Step 3	€ 19,515	21.8
Total:	**€ 29,425**	**23.4**

Advanced upgrade summary

Consumption of primary energy reduced by:	**217 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**46 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

22. Detached bungalow, hollow block walls, 1983-1993

Description:

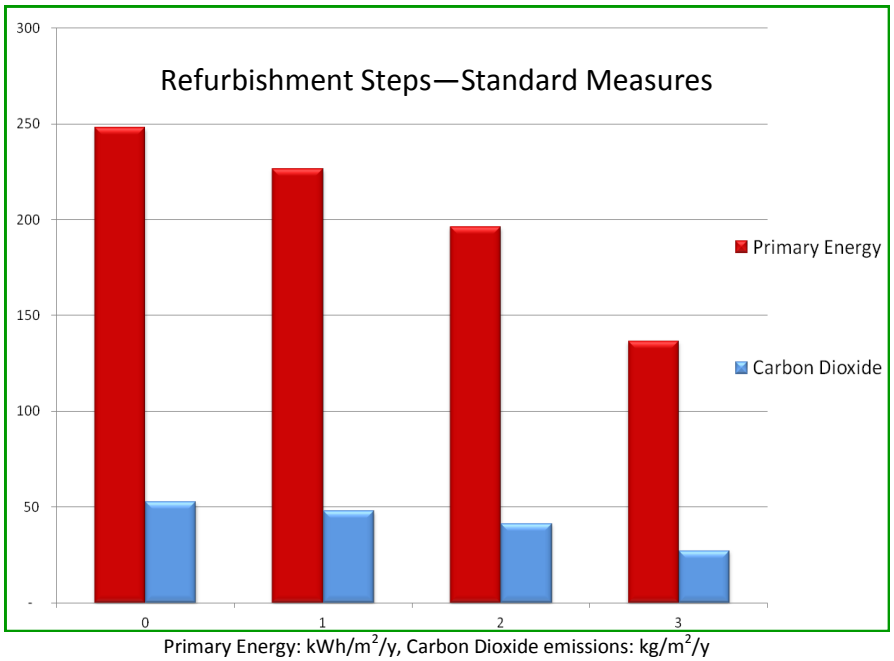
This house was found in Dublin and had hollow block walls with internal dry-lining. If it was located outside Dublin, cavity wall construction would be more likely. The room in the roof would have had modest fibre insulation at the time of construction but could be improved.

Building elements :		Insulation	U - value
Walls	Concrete hollow block	25-50 mm	0.6
Roofs	Pitched, insulation between joists Insulation between rafters	100 mm 100 mm	0.4 0.4
Floors	Solid	10-15 mm	0.64
Windows	Double glazed, PVC frame, 6 mm gap	N/A	3.1
Doors	Solid wooden	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Mains gas	75%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated with loose jacket 35mm, cylinder thermostat present.		
Controls	Programmer and room thermostat		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**248** (actual state)	**53** (actual state)	**D1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	227	48	D1
2	**Wall Insulation**	Add	External insulation 100-150mm thick	0.21	196	42	C2
	Windows and Doors	-	Replacement of double glazed windows to achieve current standards (1.4W/m²K and 2.0 W/m²K) is also possible, but due to long payback times, this step is not generally recommended. (80-90 year payback)			
	Systems upgrade:					
3	**Space and water heating system and Controls and renew-able energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating. Hot water cylinder insulated with 50 mm spray foam.	**137**	**27**	**B3**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

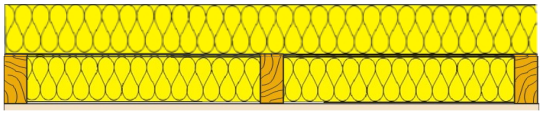
Measure	Estimated costs	Payback (y)
Step 1	€ 2,311	8.9
Step 2	€ 24,495	90.4
Step 3	€ 5,370	10.6
Total:	**€ 32,175**	**31.0**

Standard upgrade summary

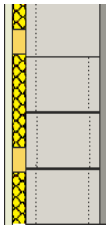
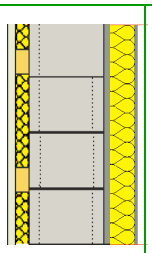
Consumption of primary energy reduced by:	**111 kWh/m²/y**
Emission of carbon dioxide reduced by:	**26 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

100 mm of mineral wool between ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard & advanced)

Before		After	
	Concrete hollow block with render outside and minimal dry-lining inside U-value = 0.6 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

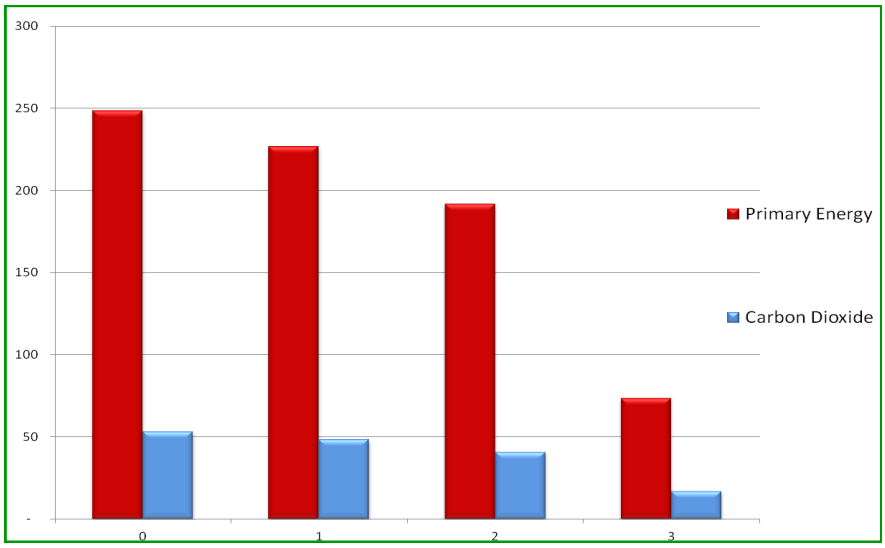
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**248** (actual state)	**53** (actual state)	**D1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	227	48	D1
2	**Wall Insulation**	Add	Application of external insulation; 150-200mm thick	0.15	192	41	C2
	Doors and Windows	-	Replacement of double glazed windows to achieve a higher energy rating (0.9W/m²K and 1.5 W/m²K) is also possible, but due to long payback times, this step is not generally recommended. (80-90 year payback)				
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). Secondary heating system is removed and chimney sealed. 5 photovoltaic panels have been installed on the southern aspect		**74**	**17**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 2,311	8.9
Step 2	€ 28,859	92.0
Step 3	€ 20,601	41.4
Total:	**€ 51,770**	**48.35**

Advanced upgrade summary

Consumption of primary energy reduced by:	**174 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**36 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

23. Terraced house, hollow block walls, 1983-1993

Description:

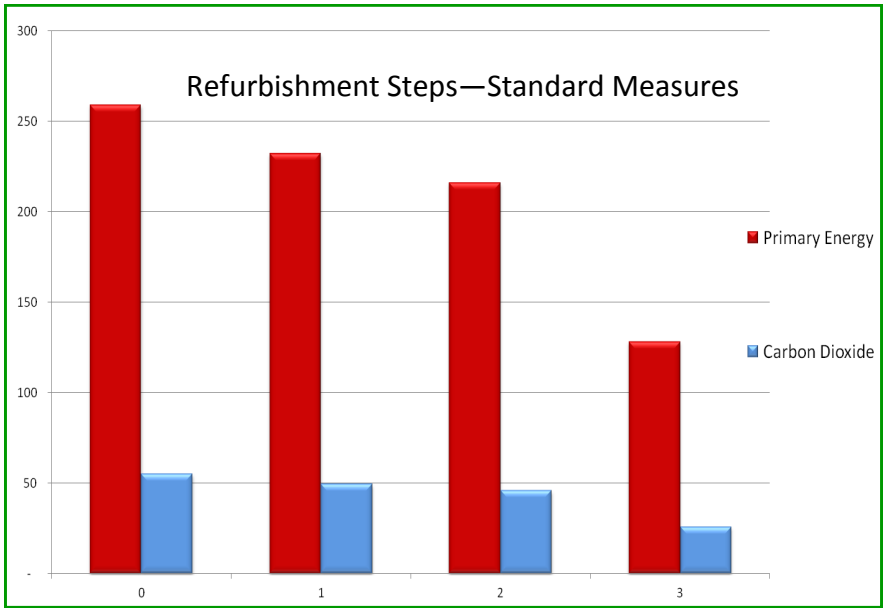
Very typical house built in Dublin and east coast area during the 1980s with hollow block walls that were dry-lined with 50mm of fibre insulation between wooden battens fixed to the walls. See notes on wall insulation options below. Solid floors are common with this house type.

Building elements :		Insulation	U - value
Walls	Concrete hollow block with internal dry-lining	25-50 mm	0.6
Roofs	Pitched, insulation between joists	100 mm	0.4
Floors	Solid	10-15 mm	0.48
Windows	Double glazed, metal frame, 12 mm gap	n.a	3.4
Doors	Solid wooden	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Mains gas	75%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	Insulated, loose jacket 35mm thick, no cylinder thermostat.		
Controls	Programmer		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**259** (actual state)	**55** (actual state)	**D1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation and installation of required roof vents .	0.13	232	49	D1
2	**Wall insulation**	Add	100-120mm External insulation	0.21	216	49	C3
	Windows and Doors	-	Replacement of double glazed windows to achieve current standards (1.4W/m²K and 2.0 W/m²K) is also possible, but due to long payback times, this step is not generally recommended.				
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating. Hot water cylinder insulated with 50 mm spray foam.		**128**	**26**	**B3**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

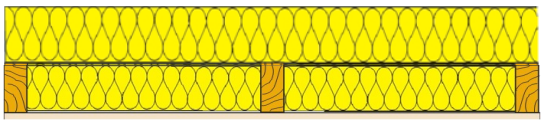
Measure	Estimated costs	Payback (y)
Step 1	€ 790	5.0
Step 2	€ 4,261	59.9
Step 3	€ 5,520	12.0
Total:	**€ 10,571**	**15.3**

Standard upgrade summary

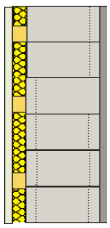
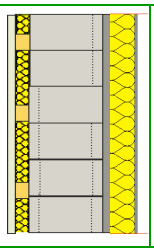
Primary energy reduced by:	**131 kWh/m²/y**
Emission of carbon dioxide reduced by:	**29 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

100 mm of mineral wool between ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard & advanced)

Before		After	
	Concrete hollow block with render outside and minimal dry-lining inside, un insulated. U-value = 0.6 W/m^{2}K		External insulation added, typically the conductivity of appropriate insulation boards ranges between = 0.021 - 0.033 W/mK

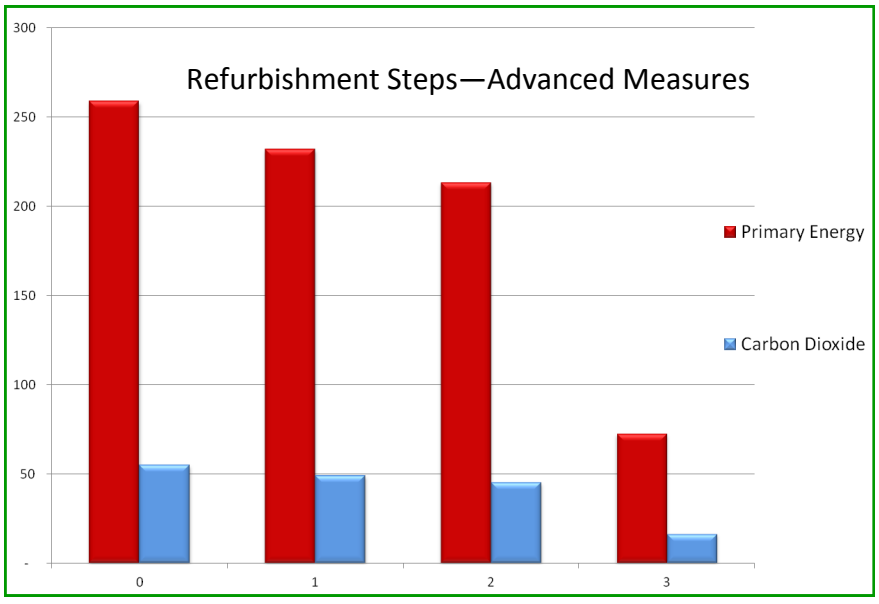
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**259** (actual state)	**55** (actual state)	**D1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	232	49	D1
2	**Wall insulation**	Add	External insulation 150-200mm thick	0.15	213	45	C3
	Windows and Doors	-	Replacement of double glazed windows to achieve current standards (1.4W/m²K and 2.0 W/m²K) is also possible, but due to long payback times, this step is not generally recommended.				
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). 3 photovoltaic panels installed on the southern aspect of the property		**72**	**16**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 790	5.0
Step 2	€ 8,517	103.7
Step 3	€ 21,268	37.4
Total:	**€ 30,574**	**37.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**187 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**39 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

24. Detached bungalow, cavity walls, 1994-2004

Building elements :		Insulation	U - value
Walls	Cavity walls, partially filled	50 mm	0.55
Roofs	Pitched, insulation between joists	150 mm	0.41
Floors	Solid	20-30mm	0.26
Windows	Double glazed, PVC/wood, 12 mm gap	N/A	2.8
Doors	Solid wooden	none	3

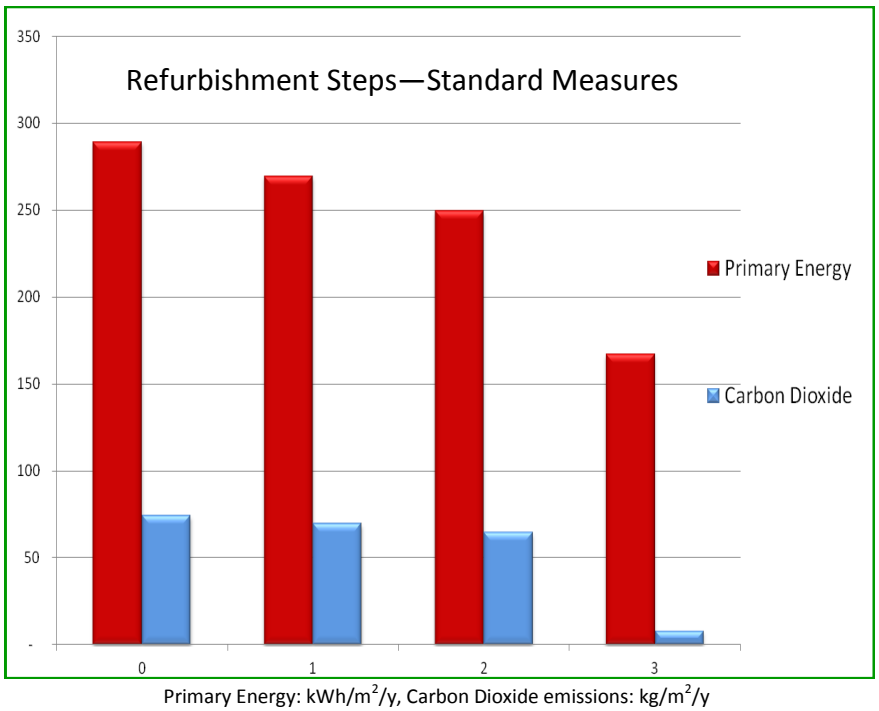
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Heating oil	75%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Separated time controls,.		
Cylinder	Insulated with loose jacket, 50 mm, no cylinder thermostat		
Controls	Programmer for space heating and hot water, room thermostat.		

Description:

Semi-detached bungalow with cavity walls part-filled with 50mm polystyrene insulation boards. The part-filled cavity can be full-filled by pumping in additional insulation beads. The solid floor was insulated at the time of construction.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**289** (actual state)	**74** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation and installation of required roof vents	0.13	269	69	D2
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.	0.32	249	64	D1
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Condensing wood pellet boiler (89.5% efficiency) two separate heating zones with time and thermostatic control, independent water heating .Hot water cylinder insulated with 50 mm spray foam. Existing secondary heating system has been removed and chimney is sealed.	**167**	**8**	**C1**

*also includes draughts tripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

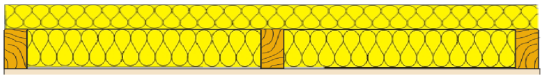
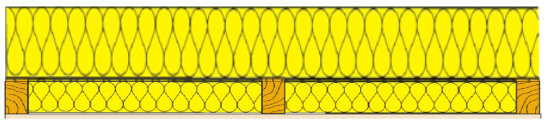
Measure	Estimated costs	Payback (y)
Step 1	€ 1,060	7.8
Step 2	€ 1,226	10.5
Step 3	€ 8,682	15.2
Total:	**€ 10,968**	**13.3**

Standard upgrade summary

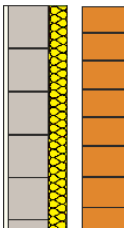
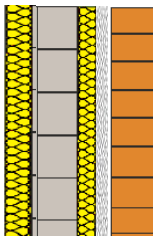
Primary energy reduced by:	**122 kWh/m²/y**
Emission of carbon dioxide reduced by:	**66 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

150 mm of mineral wool between ceiling joists	Before: 
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (advanced)

Before		After	
	Cavity walls, partially filled with insulation boards, 50 mm thick. U-value =0.55 W/m^{2}K		Remaining cavity filled with insulation beads, conductivity =0.033 W/mK. Dry lining with thermal laminate board, conductivity =0.021—0.025

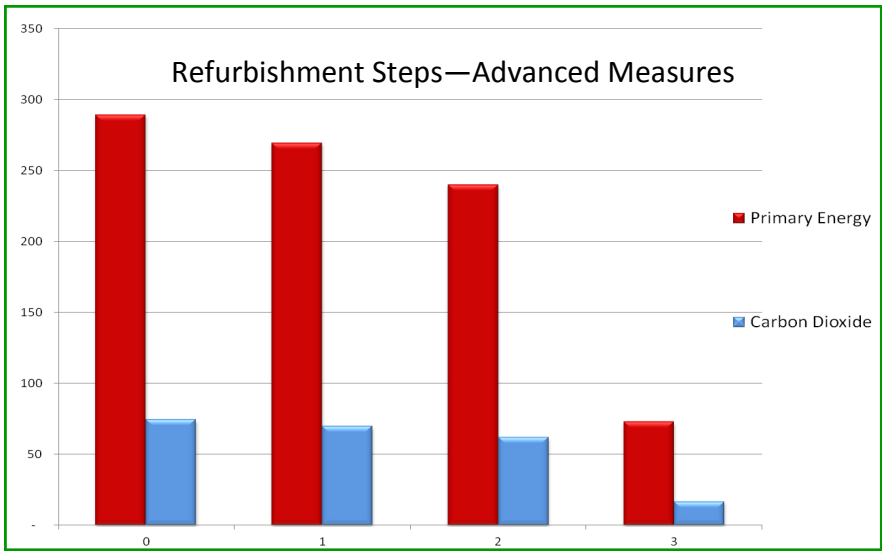
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U -values	**289** (actual state)	**75** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation. and installation of required roof vents.	0.13	269	69	D2
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.. Internally, 32.5-50mm thermal laminate boards are fixed to the inner leaf of the cavity wall.	0.21	240	62	D1
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace & Add	Air source heat pump 380% two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). 5 photovoltaic panels installed on the southern aspect of the property. Secondary space heater is removed and chimney is sealed.		**73**	**16**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,060	7.8
Step 2	€ 8,712	50.3
Step 3	€ 20,015	21.2
Total:	**€ 29,786**	**23.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**216 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**59 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

25. Terraced House, cavity walls, 1994-2004

Building elements :		Insulation	U - value
Walls	Cavity walls, partially filled	50 mm	0.55
Roofs	Pitched, insulation between joists	150 mm	0.36
Floors	Solid	20-30mm	0.26
Windows	Double glazed, PVC/wood, 12 mm gap	N/A	2.8
Doors	Solid wooden	none	3

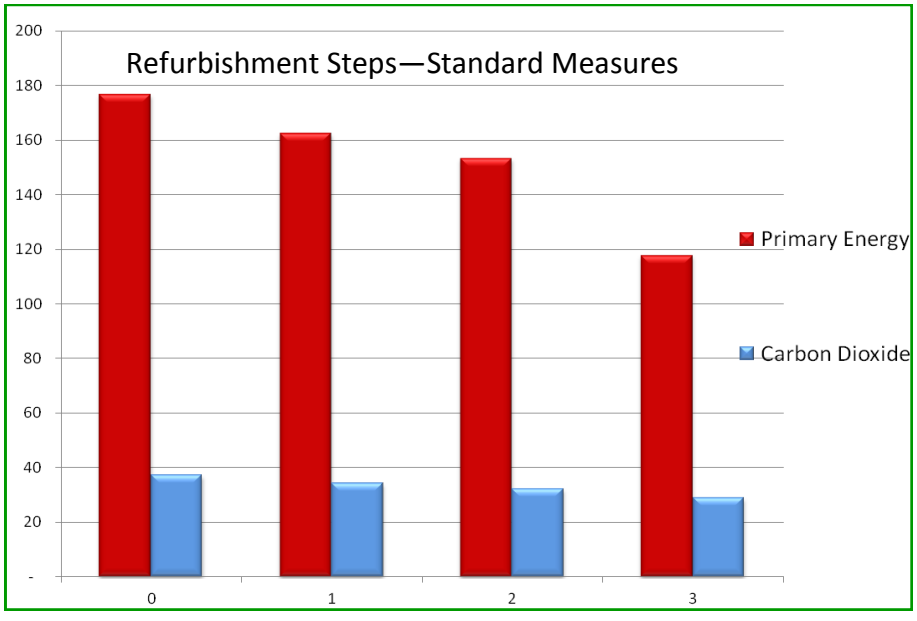
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipe work un-insulated.	Heating oil	80%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Independent time control of space & water heating.		
Cylinder	Factory insulated, 35 mm spray foam, cylinder thermostat		
Controls	Programmer for space heating and hot water, room thermostat, TRVs		

Description:

Mid terrace house with part-filled cavity walls. The part-filled cavity can be full-filled by pumping in additional insulation beads. The floors would most likely have been insulated during construction.

Refurbishment steps — standard				Prim. energy $kWh/m^2/y$	Carbon Dioxide $kgCO_2/m^2/y$	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**177** (actual state)	**37** (actual state)	**C2**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation	0.13	164	34	C1
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.	0.32	155	32	C1
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace & Add	Condensing boiler 90% efficient, additional heating zone. Secondary heating system removed and chimney is sealed.		**119**	**29**	**B2**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: $kWh/m^2/y$, Carbon Dioxide emissions: $kg/m^2/y$

Estimated costs and payback time**

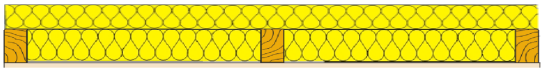
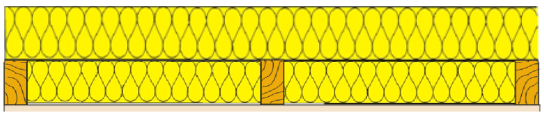
Measure	Estimated costs	Payback (y)
Step 1	€ 729	8.8
Step 2	€ 788	20.9
Step 2	€ 4,931	38.1
Total:	**€ 6,448**	**25.8**

Standard upgrade summary

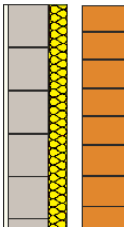
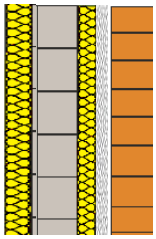
Primary energy reduced by:	**58 $kWh/m^2/y$**
Emission of carbon dioxide reduced by:	**8 $kgCO_2/m^2/y$**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

150 mm of mineral wool between ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (advanced)

Before		After	
	Cavity walls, partially filled with insulation boards, 50 mm thick. U-value =0.55 W/m^{2}K		Remaining cavity filled with insulation beads, conductivity =0.033 W/mK. Drylining with thermal laminate board, conductivity =0.021—0.025

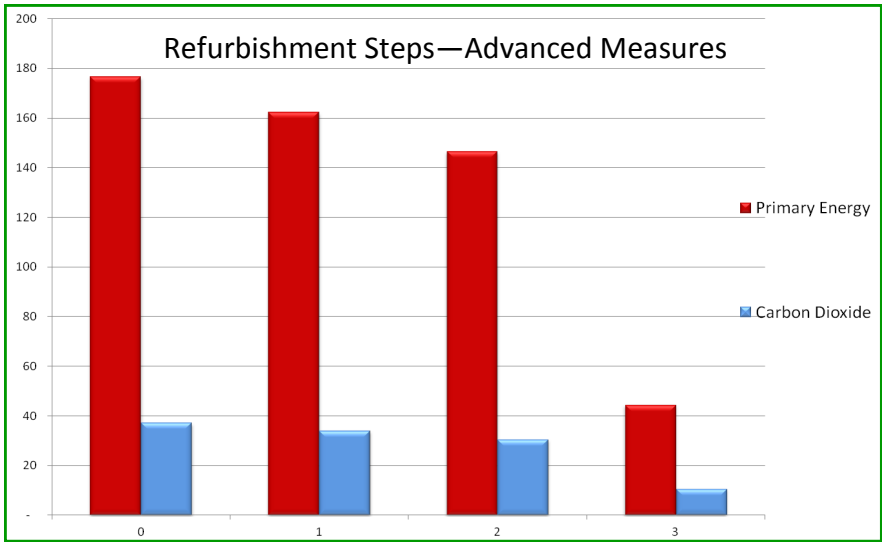
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**177** (actual state)	**37** (actual state)	**C2**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation.	0.13	164	34	C1
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.. Internally, 82.5mm thermal laminate boards are fixed to the inner leaf of the cavity wall.	0.15	148	31	B3
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace & Add	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). Secondary heating system replaced with solid fuel burner (75% efficient). 5 photovoltaic panels installed on southern aspect of property.	**46**	**11**	**A2**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 729	8.8
Step 2	€ 4,450	67.6
Step 3	€ 21,015	62.4
Total	**€ 26,193**	**53.9**

Advanced upgrade summary

Primary energy reduced by:	**131 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**26 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

26. Detached bungalow, timber frame, 1994-2004

Building elements :		Insulation	U - value
Walls	Timber frame	50 –100 mm	0.55
Roofs	Pitched, insulation between joists	150 mm	0.26
Floors	Solid	20-30mm	0.41
Windows	Double glazed, wood/PVC frame, 12 mm gap	n.a	2.8
Doors	Solid wooden	none	3.0

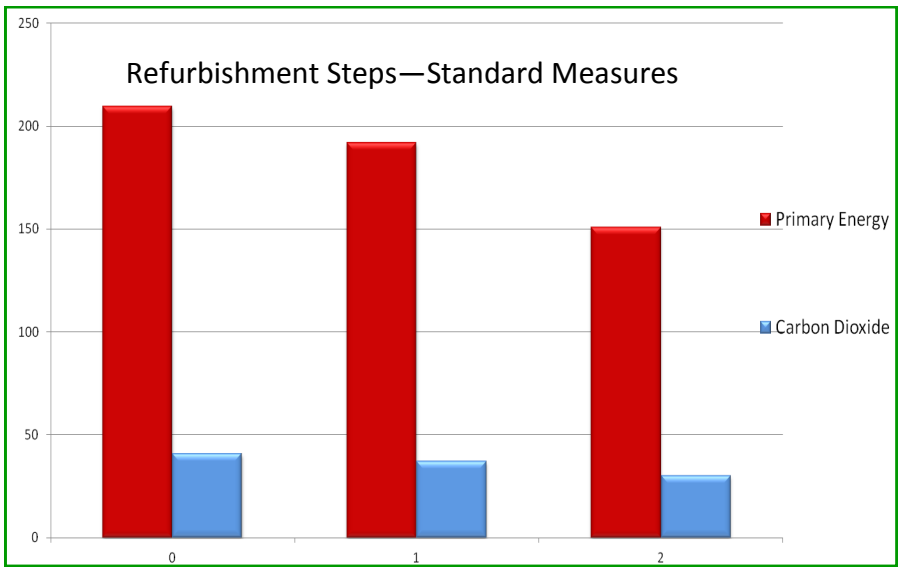
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, primary pipe work un -insulated.	Gas	80%
Secondary	Electric heaters	Electricity	100%
Hot water	From primary heating system. Separated time controls,.		
Cylinder	Insulated with 35mm spray foam, cylinder thermostat		
Controls	Separated timers for SH and DHW, room thermostat		

Description:

Timber frame construction started to become increasingly popular in the late 1990s and has made up more than 10% of the market from 2000 onwards. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**210** (actual state)	**41** (actual state)	**C3**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation and installation of required roof vents.	0.13	193	37	C2
	Systems upgrade:					
2	**Space and water heating system and controls and renewable energy**	Replace	Condensing gas boiler 90% efficient, additional space heating zone. Secondary heating system replaced by solid fuel burner (75% efficiency)	**152**	**30**	**C1**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

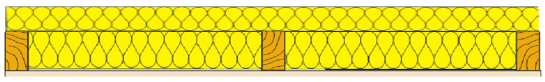
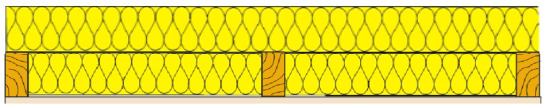
Measure	Estimated costs	Payback (y)
Step 1	€ 2,330	16.2
Step 2	€ 4,378	12.3
Total:	**€ 6,707**	**13.4**

Standard upgrade summary

Consumption of primary energy reduced by:	**58 kWh/m²/y**
Emission of carbon dioxide reduced by:	**11 kgCO₂/m²/y**

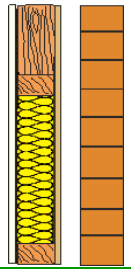
**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

150 mm of mineral wool between ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall construction

Timber frame



Timber frame wall with the outer brickwork and ventilated drainage cavity. Insulation between the studs. U-value = 0.55 W/m^{2}K

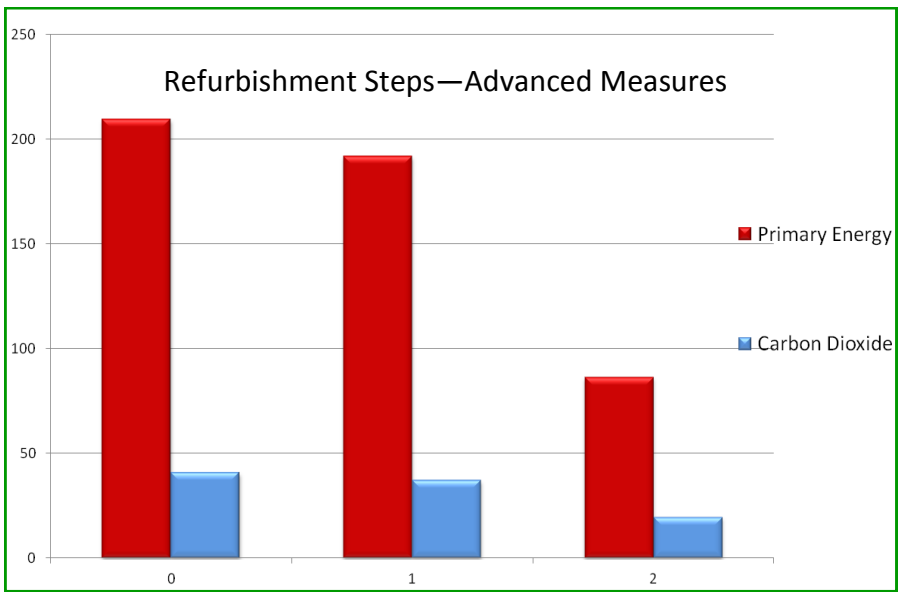
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**210** (actual state)	**41** (actual state)	**C3**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation and installation of required roof vents.	0.13	193	37	C2
	Systems upgrade:						
2	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). Secondary heating system is replaced by Solid Fuel Burner (75% efficiency), chimney is sealed and flue is installed. 4 photovoltaic panels installed on the southern aspect of the property	**87**	**20**	**B1**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 2,330	16.2
Step 2	€ 19,515	37.3
Total:	**€ 21,845**	**32.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**123 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**21 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

27. End of terrace house, timber frame, 1994-2004

Description:

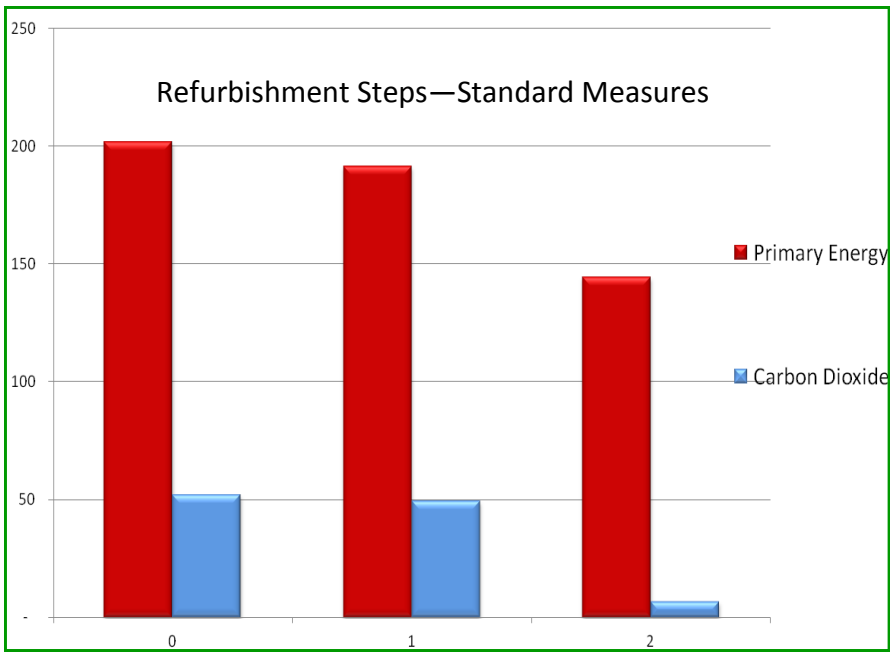
Timber frame construction started to become increasingly popular in the late 1990s and has made up more than 10% of the market from 2000 onwards. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

Building elements :		Insulation	U - value
Walls	Timber frame	50 –100 mm	0.55
Roofs	Pitched, insulation between joists	150 mm	0.26
Floors	Solid	20-30mm	0.41
Windows	Double glazed, wood/PVC frame, 12 mm gap	N/A	2.8
Doors	Solid wooden	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, primary pipe work un -insulated.	Heating oil	80%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Separated time controls.		
Cylinder	Insulated with 35mm spray foam, cylinder thermostat		
Controls	Separated timers for SH and DHW, room thermostat		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	201 (actual state)	**52** (actual state)	**C3**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation and installation of required roof vents	0.13	193	50	C2
	Systems upgrade:					
2	**Space and water heating system and controls and renewable energy**	Replace	Wood pellet boiler 90% efficient, additional space heating zone, secondary heating removed and chimney sealed.	**145**	**7**	**B3**

*also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m²/y, Carbon Dioxide emissions: kg/m²/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,082	16.9
Step 2	€ 8,682	32.7
Total:	**€ 9,764**	**29.6**

Standard upgrade summary

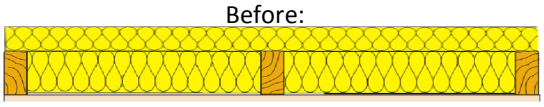
Consumption of primary energy reduced by:	**56kWh/m²/y**
Emission of carbon dioxide reduced by:	**45 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

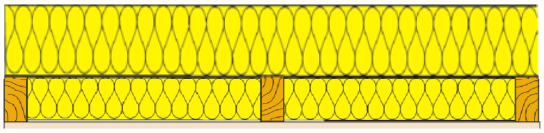
150 mm of mineral wool between ceiling joists

Before:



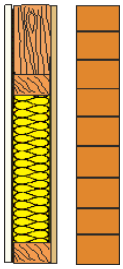
Typical roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK

After:



Typical wall construction

Timber frame



Timber frame wall with the outer brickwork and ventilated drainage cavity. Insulation between the studs. U-value = 0.55 W/m^{2}K

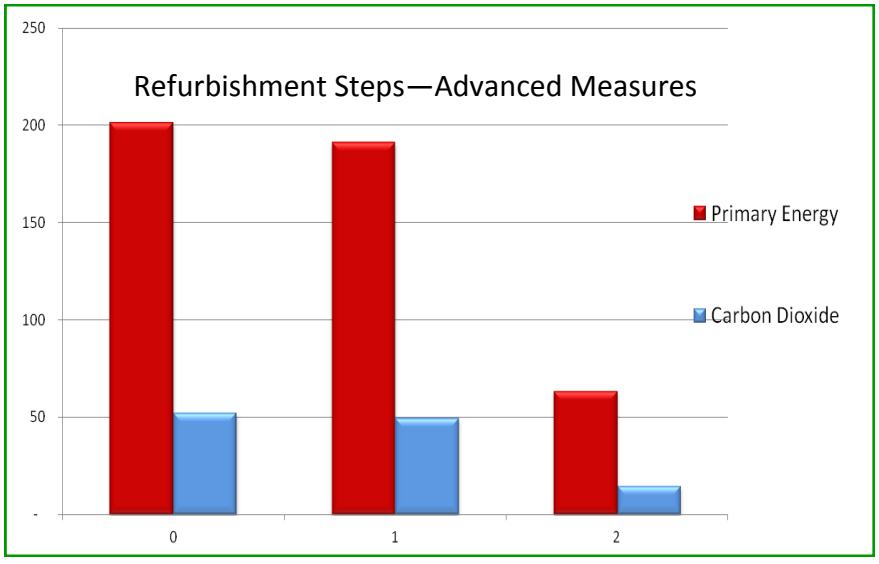
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Wood pellet condensing boiler	Air source heat pump
Efficiency:	89.5%	380%
Fuel:	Wood pellets	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**201** (actual state)	**52** (actual state)	**C3**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation and installation of required roof vents.	0.13	193	50	C2
	Systems upgrade:						
2	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). Secondary heating system replaced by solid fuel burner (75% efficient). 5 photovoltaic panels fixed to the southern aspect of the property	**63**	**14**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 1,082	16.9
Step 2	€ 20,515	37.9
Total:	**€ 21,597**	**35.7**

Advanced upgrade summary

Consumption of primary energy reduced by:	**138kWh/m^2/y**
Emission of carbon dioxide reduced by:	**38 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

28. Detached house, cavity walls, 2005-2010

Building elements :		Insulation	U - value
Walls	Cavity walls, partially filled	50-70 mm	0.37
Roofs	Pitched, insulation between joists	200 mm	0.2
Floors	Solid	40-80 mm	0.25
Windows	Double glazed, Low-E, wood/PVC frame, 16 mm gap	N/A	2.0
Doors	Solid wooden	none	3.0

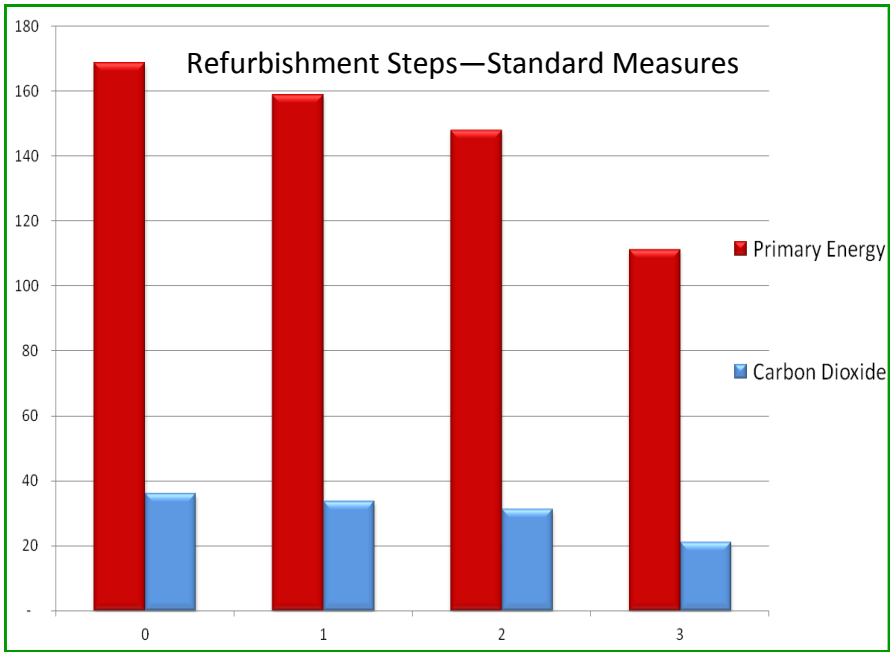
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, primary pipe work insulated.	Mains gas	80%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Separated time controls.		
Cylinder	Factory insulated, 50mm, cylinder thermostat		
Controls	Separated timers for SH and DHW, room thermostat, TRV's		

Description:

The cavity walls of this house are well insulated with U values as low as 0.27 W/m^{2}K and the floors are well insulated. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

Refurbishment steps — standard				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**168** (actual state)	**36** (actual state)	**C1**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation and installation of required roof vents.	0.13	159	34	C1
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.	0.25	148	31	B3
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Add/ replace	Gas condensing boiler 90% efficient, additional space heating zone, secondary heating system removed and chimney is sealed.	**111**	**21**	**B2**

*also includes draught stripping , 80mm lagging jacket for DHW cylinder (if insulation is not present)



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

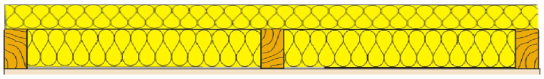
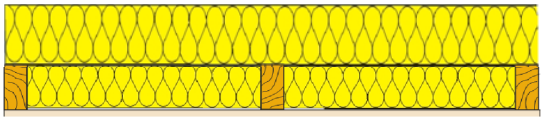
Measure	Estimated costs	Payback (y)
Step 1	€ 415	3.8
Step 2	€ 2,404	33.0
Step 3	€2,733	13.4
Total:	**€ 5,552**	**14.4**

Standard upgrade summary

Consumption of primary energy reduced by:	**57 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**15 kgCO$_2$/m^2/y**

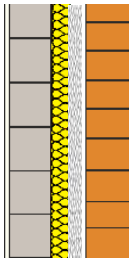
**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

200 mm of mineral wool between ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (Standard & Advanced)

Cavity walls, partially filled with rigid board (existing) and loose fill



Cavity walls, partially filled with the expanded polystyrene boards, U-value = 0.37 W/m^{2}K. Remaining cavity (approx. 50mm) filled with beads, conductivity = 0.033W/mK

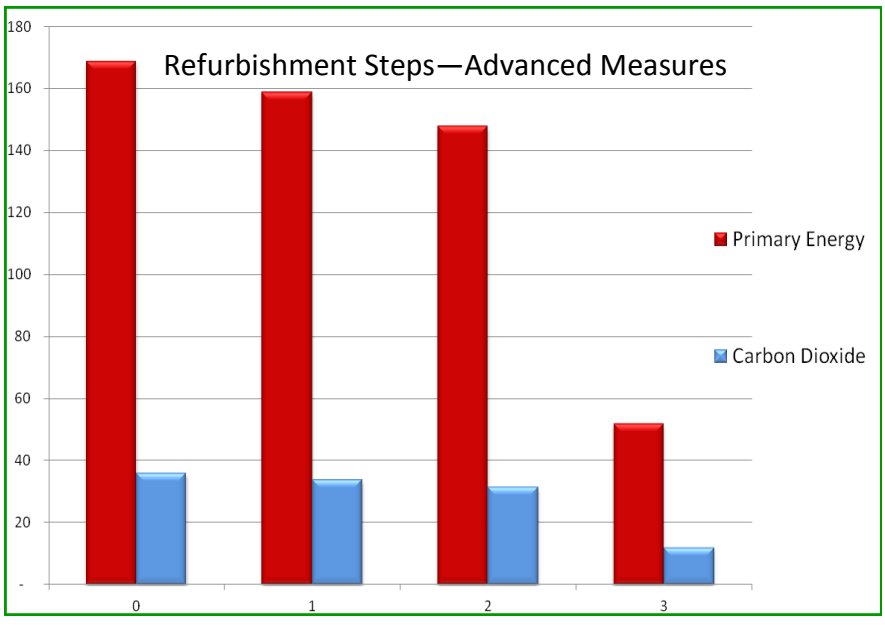
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains Gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**168** (actual state)	**36** (actual state)	**C1**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation	0.13	159	34	C1
2	**Wall Insulation**	Add	Remaining cavity filled with insulation beads.	0.25	148	31	B3
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mech. ventilation with heat recovery (MVHR). Secondary heating system removed and chimney is sealed. 6 photovoltaic panels have been installed on the southern aspect of the property.		**52**	**12**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 415	3.8
Step 2	€ 2,089	28.7
Step 3	€20,365	40.9
Total:	**€ 22,869**	**33.7**

Advanced upgrade summary

Consumption of primary energy reduced by:	**116 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**24 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

29. Terraced house, cavity walls, 2005-2010

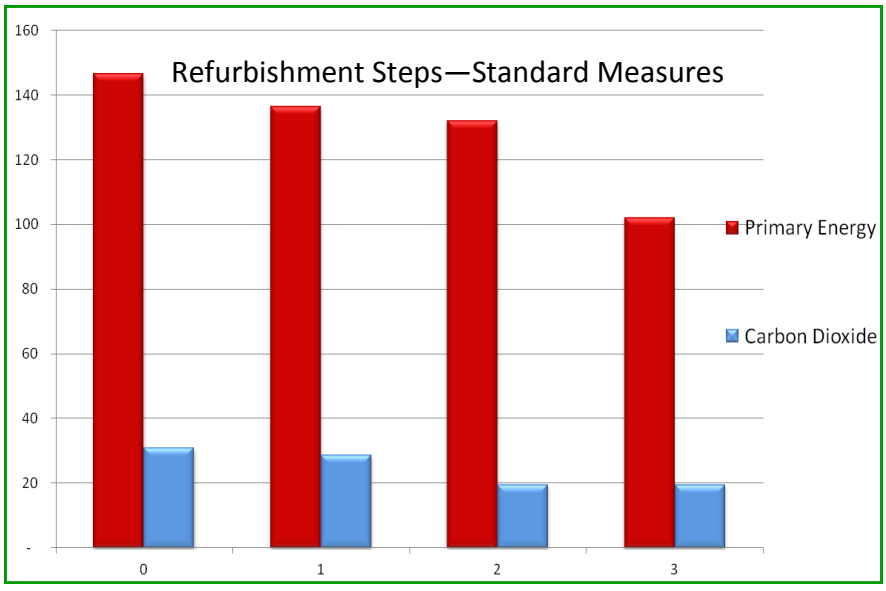
Building elements :		Insulation	U - value
Walls	Cavity walls, partially filled	50-70 mm	0.37
Roofs	Pitched, insulation between joists	200 mm	0.2
Floors	Solid concrete	40-80 mm	0.26
Windows	Double glazed, Low-E, wood/PVC frame, 16 mm gap	N/A	2.0
Doors	Solid wooden	none	3.0
Heating systems characteristics:		**Fuel**	**Efficiency**
Primary	Central heating boiler, primary pipe work insulated.	Mains gas	80%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Separated time controls.		
Cylinder	Factory insulated, 35mm spray foam, cylinder thermostat		
Controls	Separated timers for SH and DHW, room thermostat, TRVs		

Description:

The cavity walls of this house are well insulated with U values as low as 0.27 W/m^2/K and the floors are well insulated. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

Refurbishment steps — standard				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**147** (actual state)	**31** (actual state)	**B3**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation and installation of roof vents if necessary.	0.13	136	29	**B3**
2	**Wall Insulation**	Add	Remaining cavity filled with bead insulation	0.25	132	20	**B3**
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Add/ replace	Gas condensing boiler 90% efficient, additional space heating zone, secondary heating system is removed and chimney us sealed.	**102**	**20**	**B2**

*also includes draught stripping (if not present), 80mm lagging jacket for DHW cylinder (if insulation is not present) and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

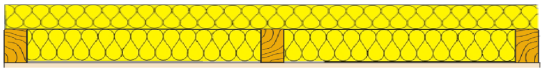
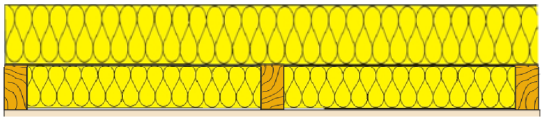
Measure	Estimated costs	Payback (y)
Step 1	€ 446	3.6
Step 2	€ 873	29.0
Step 3	€3,528	20.3
Total:	**€ 4,847**	**14.7**

Standard upgrade summary

Consumption of primary energy reduced by:	**45kWh/m^2/y**
Emission of carbon dioxide reduced by:	**11 kgCO$_2$/m^2/y**

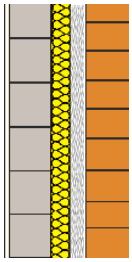
**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

200 mm of mineral wool between and above the ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard & advanced)

Cavity walls, partially filled with rigid board (existing) and loose fill



Cavity walls, partially filled with expanded polystyrene boards, U-value = 0.37 W/m^{2}K. Remaining cavity (approx. 50mm) filled with beads, conductivity = 0.033W/mK

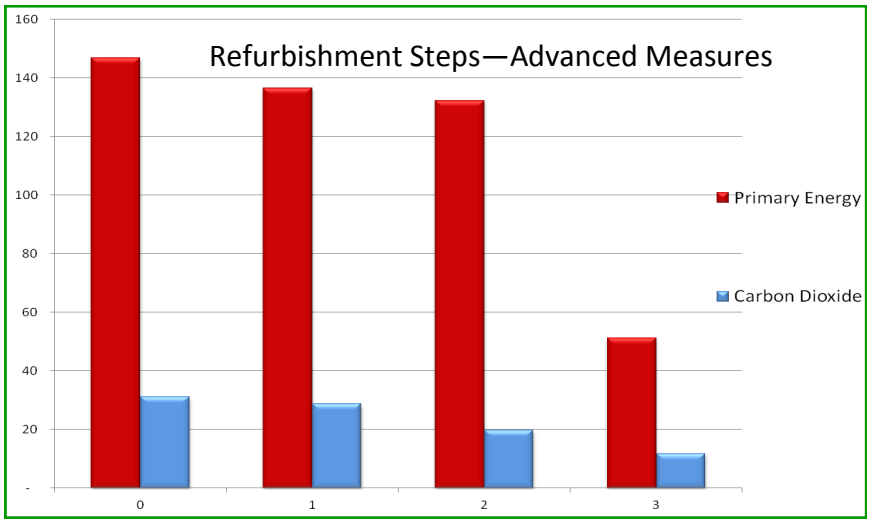
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Mains Gas	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source:	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**147** (actual state)	**31** (actual state)	**B3**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation and installation of required roof vents if necessary.	0.13	136	29	B3
2	**Wall Insulation**	Add	Remaining cavity filled with bead insulation	0.25	132	20	B3
	Systems upgrade:						
3	**Space and water heating system and controls and renewable energy**	Replace	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). Secondary space heating system is removed and chimney is sealed.	**51**	**12**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder (if not present) and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 446	3.6
Step 2	€ 873	29.0
Step 3	€19,365	45.5
Total:	**€ 20,684**	**35.6**

Advanced upgrade summary

Consumption of primary energy reduced by:	**96 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**19 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

30. Detached house, timber frame, 2005-2010

Description:

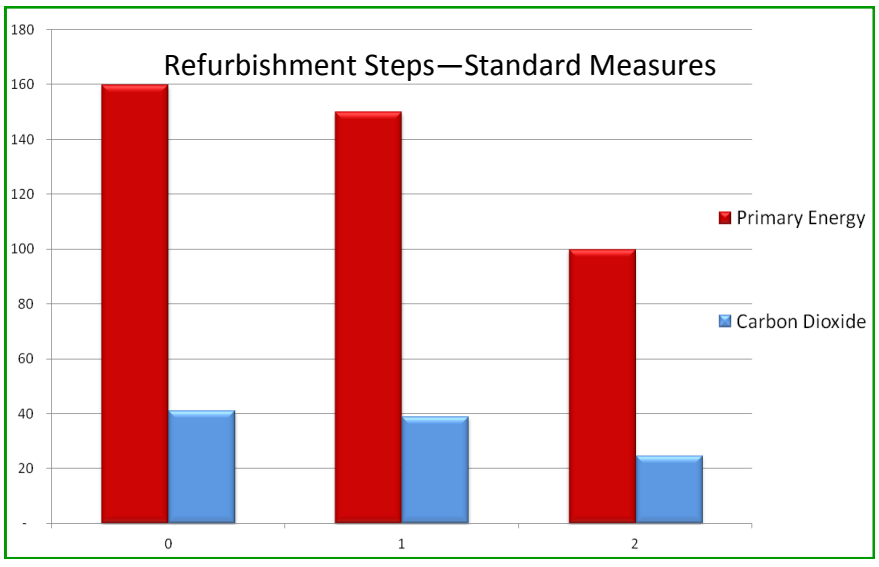
Timber frame construction accounted for more than 10% of the new house market from 2000 onwards. The walls are well insulated with U values as low as 0.27 W/m^{2}K and the floors are well insulated. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

Building elements :		Insulation	U - value
Walls	Timber frame	100 mm	0.37
Roofs	Pitched, insulation between joists	200 mm	0.2
Floors	Solid concrete	40-80 mm	0.34
Windows	Double glazed, Low-E, wood/PVC frame, 16 mm gap	N/A	2.0
Doors	Solid wooden	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, primary pipe work insulated.	Heating oil	80%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Separated time controls.		
Cylinder	Factory insulated, 35 mm spray foam, cylinder thermostat		
Controls	Separated controls for SH and DHW, room stat, TRV's, boiler interlock		

Refurbishment steps — standard					Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**160** (actual state)	**41** (actual state)	**C1**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation and installation of required roof vents if necessary.	0.13	150	39	C1
	Systems upgrade:						
2	**Space and water heating system and controls and renewable energy**	Add / Replace	Condensing boiler 90% efficient, additional heating zone, secondary heating removed and chimney has been sealed. 4 photovoltaic panels have been installed on the southern aspect of the property.		**100**	**25**	**B1**

*also includes draught stripping (if not present), 80mm lagging jacket for DHW cylinder (if insulation is not present) and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

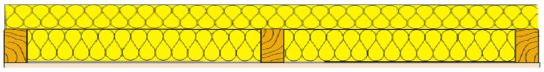
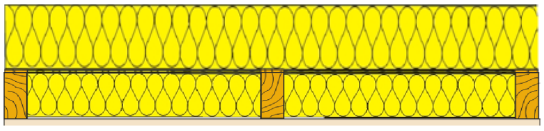
Measure	Estimated costs	Payback (y)
Step 1	€ 606	3.8
Step 2	€ 4,183	7.7
Total:	**€ 4,789**	**6.8**

Standard upgrade summary

Consumption of primary energy reduced by:	**60 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**16 kgCO$_2$/m^2/y**

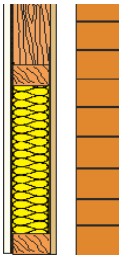
**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

200 mm of mineral wool between and above the ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall construction

Timber frame wall



Timber frame wall with the outer brickwork and ventilated drainage cavity. Insulation between the studs. U-value = 0.37 W/m^{2}K

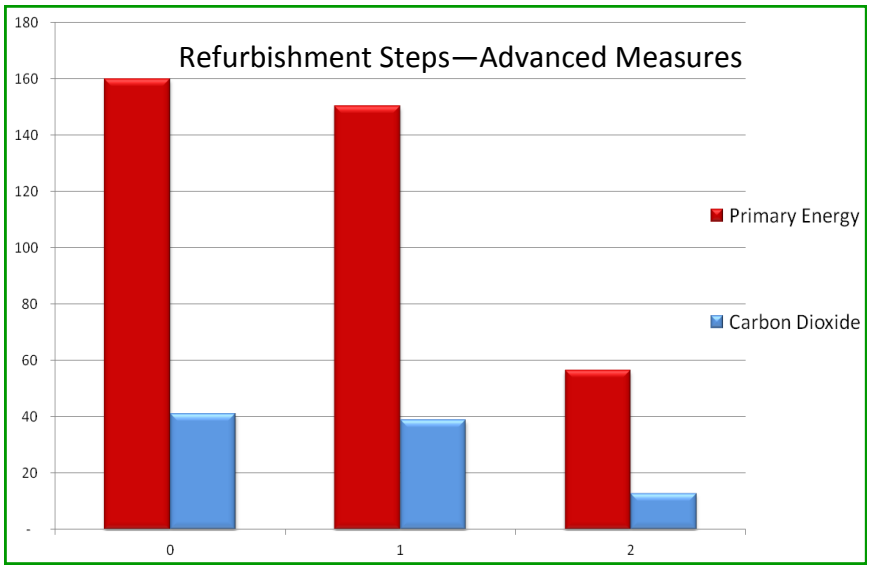
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	Heating oil	Electricity
SH Controls type:	Full zone control	Full zone control
Hot water source (HW):	Primary heating system	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	120 litre, factory insulated	200 litre combined cylinder, factory insulated
HW Controls type:	Time and thermostatic	Time and thermostatic
Ventilation:	Natural	MVHR, 92% efficient

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**160** (actual state)	**41** (actual state)	**C1**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation.	0.13	150	39	C1
	Systems upgrade:						
2	**Space and water heating system and controls and renewable energy**	Replace/ add	Air source heat pump 380% efficient, two separated heating zones with time and thermostatic control, independent water heating, solar thermal panels providing 50% of hot water demand with combined HW cylinder. Mechanical ventilation with heat recovery (MVHR). Secondary heating system is removed and chimneys are sealed. 8 photovoltaic panels have been installed on the southern aspect of the property.	**56**	**13**	**B1**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder (if not present) and low



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 606	3.8
Step 2	€ 22,101	21.0
Total:	**€ 22,707**	**18.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**104 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**28 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

Co-funded by the Intelligent Energy Europe Programme of the European Union

31. Semi detached house, timber frame, 2005-2010

Description:

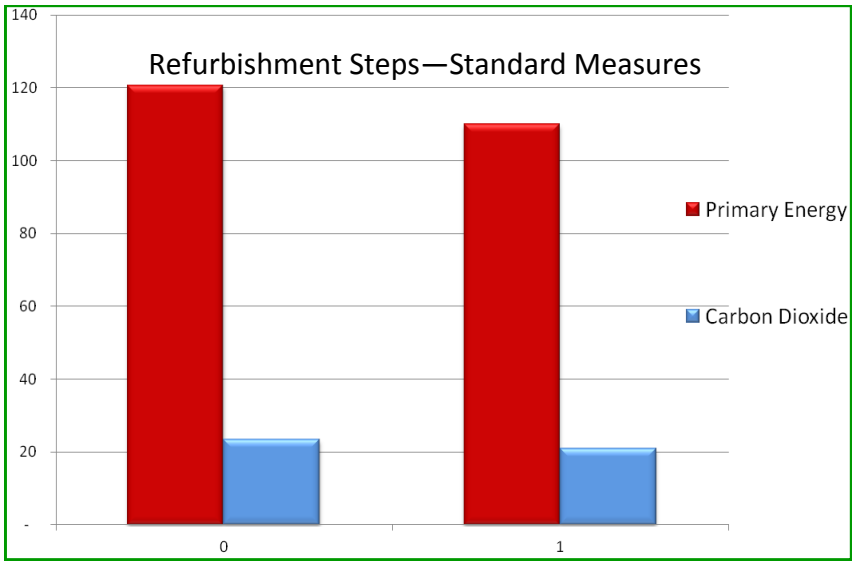
The walls of this timber frame house are well insulated with U values as low as 0.27 W/m^{2}K and the floors are well insulated. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

Building elements :		Insulation	U - value
Walls	Timber frame	100 mm	0.37
Roofs	Pitched, insulation between joists	200 mm	0.2
Floors	Solid concrete	40-80 mm	0.25
Windows	Double glazed, Low-E, wood/PVC frame, 16 mm gap	N/A	2.0
Doors	Solid wooden	none	3.0

Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, primary pipe work insulated.	Mains gas	90%
Secondary	None.	N/A	N/A
Hot water	From primary heating system. Separated time controls.		
Cylinder	Factory insulated, 50 mm, cylinder thermostat		
Controls	Full zone control, boiler interlock		

Refurbishment steps — standard					Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**121** (actual state)	**23** (actual state)	**B2**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation	0.13	110	21	B2
	Systems upgrade:						
2	**Space and water heating system and controls and renew-able energy**	N/A	Heating system meets all current requirements		**N/A**	**n.a**	**N/A**

*also includes draught stripping (if not present), 80mm lagging jacket for DHW cylinder (if insulation is not present) and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

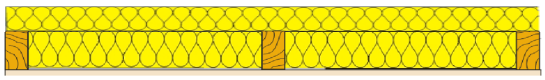
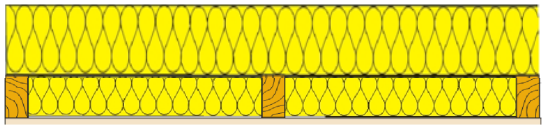
Measure	Estimated costs	Payback (y)
Step 1	€ 391	3.6
Total:	**€ 391**	**3.6**

Standard upgrade summary

Consumption of primary energy reduced by:	**11 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**2 kgCO$_2$/m^2/y**

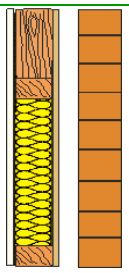
**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

200 mm of mineral wool between and above the ceiling joists	Before: 
Typical upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall construction

Timber frame wall



Timber frame wall with the outer brickwork and ventilated drainage cavity. Insulation between the studs. U-value = 0.37 W/m^{2}K

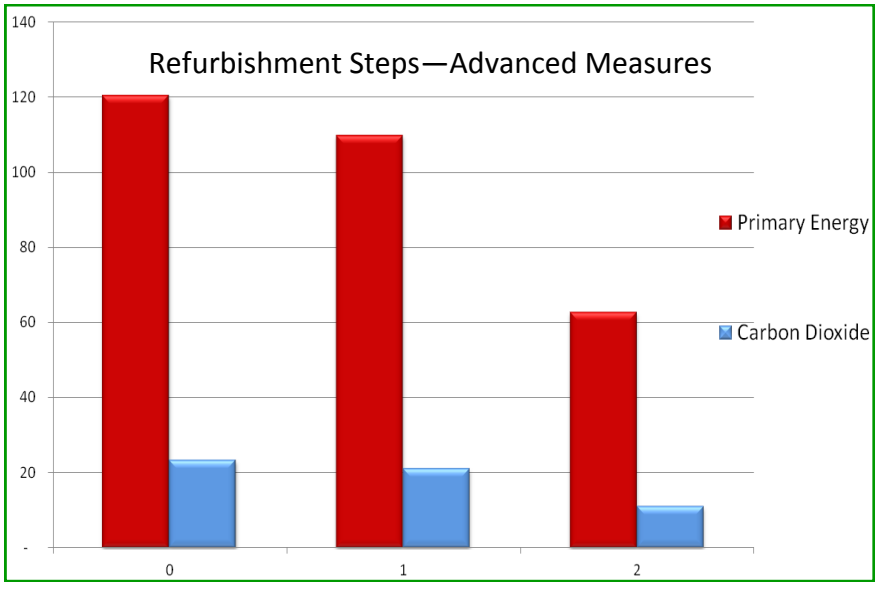
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	N/A	N/A
Efficiency:	N/A	N/A
Fuel:	N/A	N/A
SH Controls type:	N/A	N/A
Hot water source (HW):	N/A	Primary heating system and solar thermal panels providing 50% of HW demand
HW Cylinder:	N/A	N/A
HW Controls type:	N/A	N/A
Ventilation:	N/A	N/A

Refurbishment steps — advanced

				Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**121** (actual state)	**23** (actual state)	**B2**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation.	0.13	110	21	B2
	Systems upgrade:						
2	**Space and water heating system and controls and renewable energy**	Replace/ add	Solar thermal panels providing 50% of hot water demand. 6 photovoltaic panels have been installed on the southern aspect of the property.		**63**	**11**	**A3**

* package also includes draught stripping, 80mm lagging jacket for DHW cylinder (if not present) and low energy bulbs.



Primary Energy: kWh/m^2/y, Carbon Dioxide emissions: kg/m^2/y

Estimated costs and payback time**

Measure	Estimated costs	Payback (y)
Step 1	€ 391	3.6
Step 2	€ 12,364	30
Total:	€ 12,754	**24.5**

Advanced upgrade summary

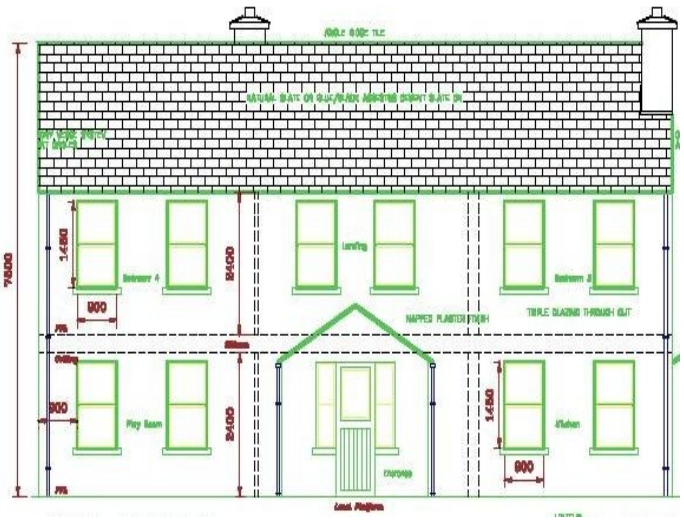
Consumption of primary energy reduced by:	**58 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**12 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2014). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Analysis conducted in association with IHER Energy Services, www.iher.ie

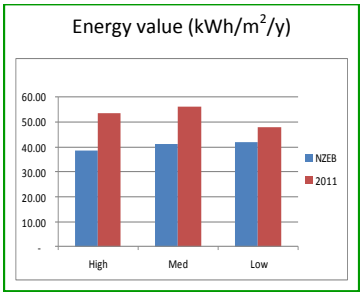
Co-funded by the Intelligent Energy Europe Programme of the European Union

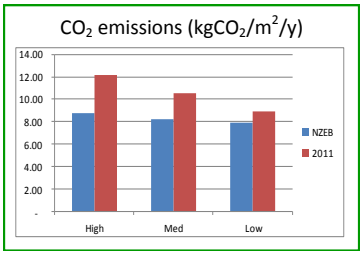
32. Detached House: Variants for 2011 & NZEB (2016)



House Description

The 2011 Building Regulations (TGD L) require an energy performance that is 60% better than the 2005 standard (based on a defined reference dwelling). The next proposed revision in 2016 will set Ireland's energy performance level at 70% better than the same 2005 standard, thus becoming the Nearly Zero Energy Buildings (NZEB) standard as required for all EU member states.
The detached house analysed below has a total floor area of 229m^2.





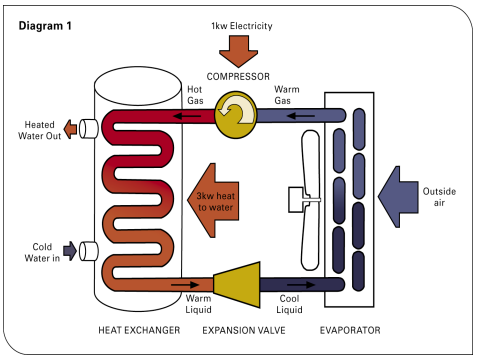
2011 Building Regulations variants			
Variables	**Renewable contribution**		
	High - 50%, with electricity as primary heating fuel	**Medium - 40%**	**Low - 22%**
Floor U-value	0.15 W/m^{2}K	0.18 W/m^{2}K	0.14 W/m^{2}K
Wall U-value	0.21 W/m^{2}K	0.18 W/m^{2}K	0.14 W/m^{2}K
Roof U-value	0.16 W/m^{2}K	0.13 W/m^{2}K	0.10 W/m^{2}K
Window U-value	1.3 W/m^{2}K	1.2 W/m^{2}K	0.7 W/m^{2}K
Door U-value	3.0 W/m^{2}K	1.8 W/m^{2}K	1.2 W/m^{2}K
Thermal Bridging Factor	0.08	0.08	0.08
Air Permeability	5m^3/hr/m^2 @50Pa	5m^3/hr/m^2 @50Pa	2m^3/hr/m^2 @50Pa
Primary Heating	Heat Pump - 386%	Gas boiler - 90%	Gas boiler - 90%
Secondary Heating	None	Gas heater	Wood pellet stove
Heat Emitters	Under floor heating	Radiators	Radiators
Heating Controls	Time & temperature zone control	Time & temperature zone control	Time & temperature zone control
Ventilation Strategy	Natural with 5 extract	DCMEV (SFP: 0.46)	MVHR (SFP: 0.67, 92%)
Hot Water	Heat pump & immersion Cylinder: 210 litres	Gas boiler + solar thermal. Cylinder: 300 litres	Gas boiler Cylinder: 150 litres
Renewable Energy	Heat pump + 6 PV panels	Solar thermal + 6 PV panels	4 PV panels
Results			
Primary Energy	53.56 kWh/m^2/y	56.21 kWh/m^2/y	47.86 kWh/m^2/y
CO_2 Emissions	12.13 kgCO_2/m^2/y	10.54 kgCO_2/m^2/y	8.91 kgCO_2/m^2/y
EPC / CPC	0.374 / 0.398	0.392 / 0.346	0.334 / 0.292
Rating	A3	A3	A2

The range of measures shown in the variants provide just three design options. Of course, building designers can select many different design options using different U values, air permeability levels and combinations of heating systems, renewable technologies and onsite energy generation to achieve compliance with the 2011 Building Regulations and the proposed NZEB standard.

Co-funded by the Intelligent Energy Europe Programme of the European Union

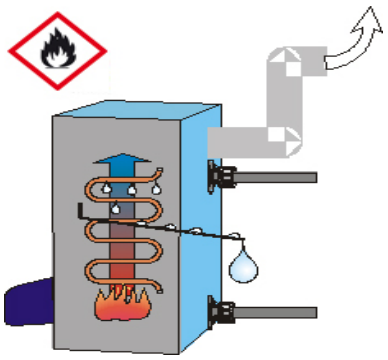
Air Source Heat Pump (ASHP)

An ASHP absorbs low temperature heat from the outside air, compresses it and delivers it at a higher temperature via warm air heaters, water-filled radiators, underfloor heating and/or domestic hot water . The technology is similar to that of a refrigerator or air conditioning unit. Just as the pipes on the back of a refrigerator become warm as the interior cools, so an ASHP warms the inside of a building whilst cooling the outside air.



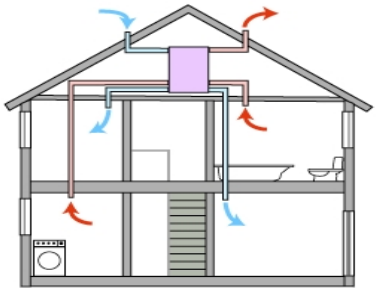
Condensing boiler

The current building regulations require that all new oil or gas boilers have a minimum efficiency of 90% and thus must be condensing boilers. When oil or gas is burned, hydrogen links with oxygen to form water. This water vapour or steam contains about 8% of the total fuel's energy. As the water vapour produced during combustion is condensed back into water , it enables extra heat to be reclaimed from the flue gases.



Heat Recovery Ventilation (HRV)

Buildings are intentionally made more airtight in order to reduce heat loss. Consequently they are less well ventilated . While opening a window does provide ventilation, the building's heat and humidity is then lost in the winter and gained in the summer. MVHR (or HRV) provides constant fresh air via a fan driven system that recoers heat from the exhaust air and uses it to pre-heat the incoming air, thus saving energy in the process.



Nearly Zero Energy Buildings variants

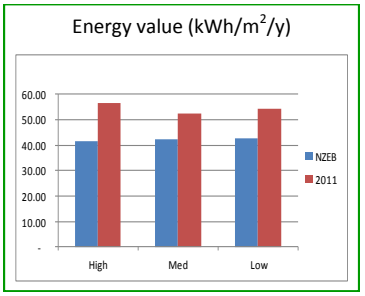
Variables	Renewable contribution		
	High – 59%, with electricity as primary heating fuel	**Medium - 31%**	**Low - 23%**
Floor U-value	0.15 W/m^{2}K	0.16 W/m^{2}K	0.14 W/m^{2}K
Wall U-value	0.18 W/m^{2}K	0.16 W/m^{2}K	0.14 W/m^{2}K
Roof U-value	0.13 W/m^{2}K	0.10 W/m^{2}K	0.10 W/m^{2}K
Window U-value	1.2 W/m^{2}K	1.2 W/m^{2}K	0.7 W/m^{2}K
Door U-value	1.8 W/m^{2}K	1.2 W/m^{2}K	1.2 W/m^{2}K
Thermal Bridging Factor	0.04	0.04	0.04
Air Permeability	3m^3/hr/m^2 @50Pa	2m^3/hr/m^2 @50Pa	2m^3/hr/m^2 @50Pa
Primary Heating	Heat pump - 386%	Gas boiler - 90%	Gas boiler - 90%
Secondary Heating	None	Gas fire	Wood pellet stove
Heat Emitters	Under floor heating	Radiators	Radiators
Heating Controls	Time & temperature zone control	Time & temperature zone control	Time & temperature zone control
Ventilation Strategy	MVHR (SFP: 0.67, 92%)	MVHR (SFP: 0.67, 92%)	MVHR (SFP: 0.67, 92%)
Hot Water	Heat pump & immersion. Cylinder: 210 litres	Gas boiler + solar thermal. Cylinder: 300 litres	Gas boiler. Cylinder: 150 litres
Renewable Energy	Heat pump + 8 PV panels	Solar thermal + 2 PV panels	4 PV Panels
Results			
Primary Energy	38.62 kWh/m^2/y	41.32 kWh/m^2/y	41.85 kWh/m^2/y
CO_2 Emissions	8.75 kgCO_2/m^2/y	8.24 kgCO_2/m^2/y	7.93 kgCO_2/m^2/y
EPC / CPC	0.269 / 0.287	0.288 / 0.270	0.292 / 0.260
Rating	A2	A2	A2

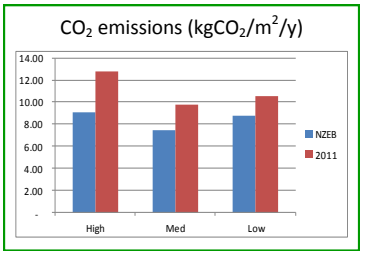
Co-funded by the Intelligent Energy Europe Programme of the European Union

33. Semi Det. House: Variants for 2011 & NZEB (2016)

House Description

The 2011 Building Regulations (TGD L) require an energy performance that is 60% better than the 2005 standard (based on a defined reference dwelling). The next proposed revision in 2016 will set Ireland's energy performance level at 70% better than the same 2005 standard, thus becoming the Nearly Zero Energy Buildings (NZEB) standard as required for all EU member states.
The semi-detached house analysed below has a total floor area of 117m^2.





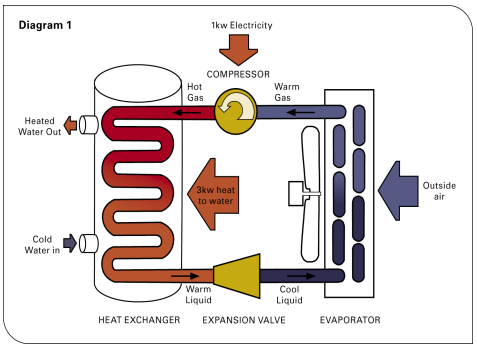
2011 Building Regulations variants			
Variables	**Renewable contribution**		
	High - 49%, with electricity as primary heating fuel	**Medium - 35%**	**Low - 21%**
Floor U-value	0.15 W/m^{2}K	0.18 W/m^{2}K	0.14 W/m^{2}K
Wall U-value	0.21 W/m^{2}K	0.18 W/m^{2}K	0.14 W/m^{2}K
Roof U-value	0.16 W/m^{2}K	0.13 W/m^{2}K	0.10 W/m^{2}K
Window U-value	1.3 W/m^{2}K	1.2 W/m^{2}K	0.7 W/m^{2}K
Door U-value	3.0 W/m^{2}K	1.8 W/m^{2}K	1.2 W/m^{2}K
Thermal Bridging Factor	0.08	0.08	0.04
Air Permeability	5m^3/hr/m^2 @50Pa	5m^3/hr/m^2 @50Pa	3m^3/hr/m^2 @50Pa
Primary Heating	Heat pump – 386%	Gas boiler - 90%	Gas boiler - 90%
Secondary Heating	None	Gas heater	Wood pellet stove
Heat Emitters	Under floor heating	Radiators	Radiators
Heating Controls	Time & temperature zone control	Time & temperature zone control	Time & temperature zone control
Ventilation Strategy	Natural with 4 extracts	MVHR (SFP: 0.67, 92%)	DCMEV (SPF: 0.46)
Hot Water	heat pump & immersion. Cylinder: 210 litres	Gas boiler - 90% Cylinder: 150 litres	Gas boiler & solar thermal Cylinder: 300 litres
Renewable Energy	Heat pump + 4 PV panels	4 PV panels	Solar thermal
Results			
Primary Energy	56.48 kWh/m^2/y	52.41 kWh/m^2/y	54.3 kWh/m^2/y
CO_2 Emissions	12.79 kgCO_2/m^2/y	9.75 kgCO_2/m^2/y	10.56 kgCO_2/m^2/y
EPC / CPC	0.380 / 0.409	0.312 / 0.352	0.365 / 0.338
Rating	A3	A3	A3

The range of measures shown in the variants provide just three design options. Of course, building designers can select many different design options using different U values, air permeability levels and combinations of heating systems, renewable technologies and onsite energy generation to achieve compliance with the 2011 Building Regulations and the proposed NZEB standard.

Co-funded by the Intelligent Energy Europe Programme of the European Union

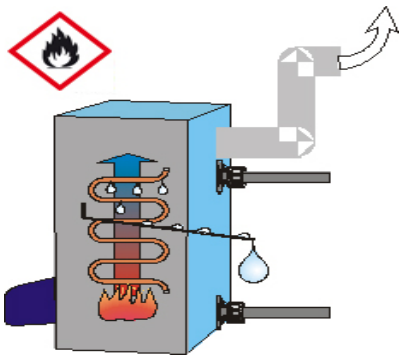
Air Source Heat Pump (ASHP)

An ASHP absorbs low temperature heat from the outside air, compresses it and delivers it at a higher temperature via warm air heaters, water-filled radiators, under floor heating and/or domestic hot water . The technology is similar to that of a refrigerator or air conditioning unit. Just as the pipes on the back of a refrigerator become warm as the interior cools, so an ASHP warms the inside of a building whilst cooling the outside air.



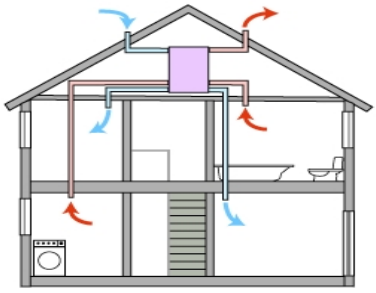
Condensing boiler

The current building regulations require that all new oil or gas boilers have a minimum efficiency of 90% and thus must be condensing boilers. When oil or gas is burned, hydrogen links with oxygen to form water. This water vapour or steam contains about 8% of the total fuel's energy. As the water vapour produced during combustion is condensed back into water , it enables extra heat to be reclaimed from the flue gases.



Heat Recovery Ventilation (HRV)

Buildings are intentionally made more airtight in order to reduce heat loss. Consequently they are less well ventilated . While opening a window does provide ventilation, the building's heat and humidity is then lost in the winter and gained in the summer. MVHR (or HRV) provides constant fresh air via a fan driven system that recoers heat from the exhaust air and uses it to pre-heat the incoming air, thus saving energy in the process.

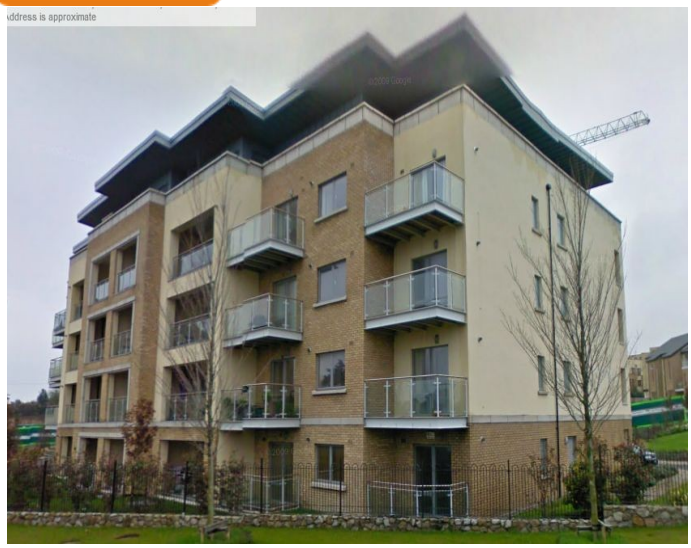


Nearly Zero Energy Buildings variants

Variables	Renewable contribution		
	High -75%, with electricity as primary heating fuel	**Medium - 65%**	**Low - 29%**
Floor U-value	0.15 W/m^{2}K	0.16 W/m^{2}K	0.14 W/m^{2}K
Wall U-value	0.18 W/m^{2}K	0.16 W/m^{2}K	0.14 W/m^{2}K
Roof U-value	0.13 W/m^{2}K	0.10 W/m^{2}K	0.10 W/m^{2}K
Window U-value	1.2 W/m^{2}K	1.2 W/m^{2}K	0.7 W/m^{2}K
Door U-value	1.8 W/m^{2}K	1.2 W/m^{2}K	1.2 W/m^{2}K
Thermal Bridging Factor	0.04	0.04	0.04
Air Permeability	2m^3/hr/m^2 @50Pa	2m^3/hr/m^2 @50Pa	2m^3/hr/m^2 @50Pa
Primary Heating	Heat pump - 386%	Gas boiler - 90%	Gas boiler - 90%
Secondary Heating	Wood pellet stove	None	None
Heat Emitters	Under floor heating	Radiators	Radiators
Heating Controls	Time & temperature zone control	Time & temperature zone control	Time & temperature zone control
Ventilation Strategy	MVHR (SFP: 0.67, 92%)	DCMEV (SFP: 0.46)	MVHR (SFP: 0.67, 92%)
Hot Water	heat pump & immersion Cylinder: 210 litres	Gas boiler - 90% Cylinder: 150 litres	Gas boiler & solar thermal Cylinder: 300 litres
Renewable Energy	Heat pump + 6 PV panels	6 PV panels	Solar thermal
Results			
Primary Energy	41.35 kWh/m^2/y	42.41 kWh/m^2/y	42.82 kWh/m^2/y
CO_2 Emissions	9.09 kgCO_2/m^2/y	7.46 kgCO_2/m^2/y	8.8 kgCO_2/m^2/y
EPC / CPC	0.278 / 0.290	0.285 / 0.238	0.288 / 0.281
Rating	A2	A2	A2

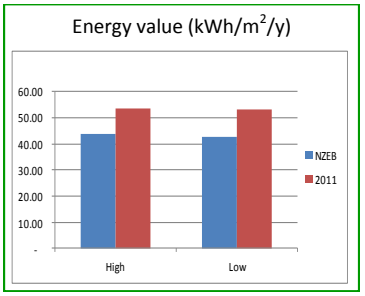
Co-funded by the Intelligent Energy Europe Programme of the European Union

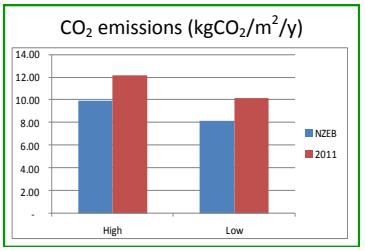
34. Ground floor apartment: Variants for 2011 & NZEB



Building Description

The 2011 Building Regulations (TGD L) require an energy performance that is 60% better than the 2005 standard (based on a defined reference dwelling). The next proposed revision in 2016 will set Ireland's energy performance level for at 70% better than the same 2005 standard, thus becoming the Nearly Zero Energy Buildings (NZEB) standard as required for all EU member states.
The apartment analysed below has a total floor area of 75m^2.





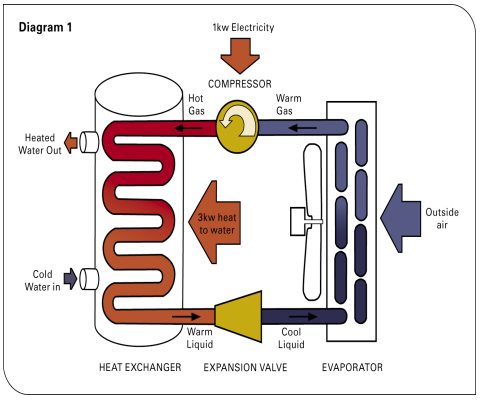
2011 Building Regulations variants		
Variables	**Renewable contribution**	
	High (36%)	**Low (20%)**
Floor U-value (applies to ground fl. apt.)	0 15 W/m^{2}K	0.21 W/m^{2}K
Wall U-value	0.21 W/m^{2}K	0.21 W/m^{2}K
Roof U-value (applies to top floor apt.)	0.16 W/m^{2}K	0.16 W/m^{2}K
Window U-value	1.3 W/m^{2}K	1.3 W/m^{2}K
Thermal Bridging Factor	0.08	0.08
Air Permeability	5m^3/hr/m^2 @50Pa	5m^3/hr/m^2 @50Pa
Primary Heating	Air Source Heat Pump - 386%	Community gas boilers - 90%
Secondary Heating	None	None
Heat Emitters	Under floor heating	Radiators
Heating Controls	Time & temperature zone control	Time & temperature zone control
Ventilation Strategy	MVHR (SFP:0.67, 92%)	MVHR (SFP:0.67, 92%)
Hot Water	Heat pump & Immersion Cylinder: 110L	Community gas boilers - 90% Plate heat exchanger
Renewable Energy	Heat pump & PV panels	PV panels
Results		
Primary Energy	53.66 kWh/m^2/y	53.33 kWh/m^2/y
CO_2 Emissions	12.16 kgCO_2/m^2/y	10.17 kgCO_2/m^2/y
EPC / CPC	0.361 / 0.393	0.329 / 0.359
Rating	A3	A3

The range of measures shown in the variants provide just three design options. Of course, building designers can select many different design options using different U values, air permeability levels and combinations of heating systems, renewable technologies and onsite energy generation to achieve compliance with the 2011 Building Regulations and the proposed NZEB standard.

Co-funded by the Intelligent Energy Europe Programme of the European Union

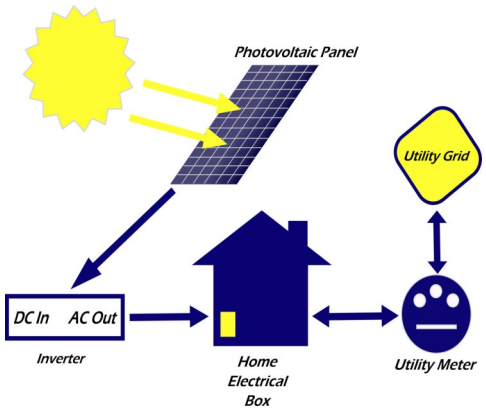
Air Source Heat Pump (ASHP)

An ASHP absorbs low temperature heat from the outside air, compresses it and delivers it at a higher temperature via warm air heaters, water-filled radiators, under floor heating and/or domestic hot water . The technology is similar to that of a refrigerator or air conditioning unit. Just as the pipes on the back of a refrigerator become warm as the interior cools, so an ASHP warms the inside of a building whilst cooling the outside air.



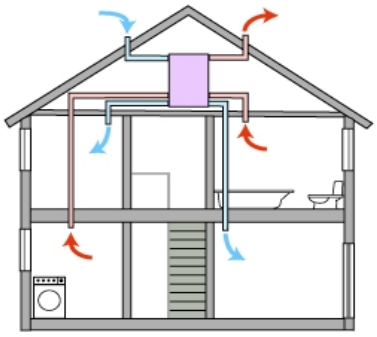
Photovoltaic Panels (PV)

Photovoltaic (PV) solar panels provide a method of generating electrical current when light photons displace electrons within the cells of the PV module. The DC output from the PV array is then converted to AC at 50 Hertz using an inverter and is then connected into the main fuse-board. Each PV panel has peak output of 250 Watts approx.. PV operates without any moving parts or emissions during operation and is a clean and sustainable energy technology.



Heat Recovery Ventilation (HRV)

Buildings are intentionally made more air-tight in order to reduce heat loss. Consequently they are less well ventilated . While opening a window does provide ventilation, the building's heat and humidity is then lost in the winter and gained in the summer. MVHR (or HRV) provides constant fresh air via a fan driven system that recoers heat from the exhaust air and uses it to pre-heat the incoming air, thus saving energy in the process.



Nearly Zero Energy Buildings variants

Variables	Renewable contribution	
	High (57%)	**Low (25%)**
Floor U-value (applies to ground fl. apt.)	0.14 W/m^{2}K	0.14 W/m^{2}K
Wall U-value	0.14 W/m^{2}K	0.14 W/m^{2}K
Roof U-value (applies to top floor apt.)	0.14 W/m^{2}K	0.14 W/m^{2}K
Window U-value	0.7 W/m^{2}K	0.7 W/m^{2}K
Thermal Bridging Factor	0.04	0.04
Air Permeability	2m^3/hr/m^2 @50Pa	2m^3/hr/m^2 @50Pa
Primary Heating	Air Source Heat Pump - 400%	Community gas boilers - 90%
Secondary Heating	None	None
Heat Emitters	Under floor Heating	Radiators
Heating Controls	Time & temperature zone control	Time & temperature zone control
Ventilation Strategy	MVHR (SFP:0.67, 92%)	MVHR (SFP:0.67, 92%)
Hot Water	Heat pump & Immersion Cylinder: 110L	Community gas boilers - 90% Plate heat exchangers
Renewable Energy	Heat pump & PV panels	PV panels
Results		
Primary Energy	43.76 kWh/m^2/y	42.59 kWh/m^2/y
CO_2 Emissions	9.91 kgCO_2/m^2/y	8.15 kgCO_2/m^2/y
EPC / CPC	0.295 / 0.321	0.287 / 0.264
Rating	A2	A2

Co-funded by the Intelligent Energy Europe Programme of the European Union

A

Air tightness layer

An air tightness membrane is a non-woven fibre structure which resists air infiltration and water intrusion, yet is engineered to readily allow moisture vapour to diffuse through the sheet, helping prevent mould and mildew build up and wood rot. The fibrous structure is engineered with microscopic pores that readily allow moisture vapour to evaporate but are so small that bulk water and air cannot penetrate.

B

Background vent:

A background vent or ventilator refers to an opening which is typically located in a wall or a window and enables natural ventilation to occur. Background ventilators typically have an adjustable setting, which enables the user to open / close at their leisure. The ventilated opening is sealed both inside and out to prevent air circulating within the wall construction.

However, there are also permanent ventilators (which are present in rooms which have an open solid fuel burner) which do not have this function.

C

Cavity Wall:

A cavity wall refers to a double skin construction which is separated by a clear cavity. In older dwellings, pre 1978, there was often no insulation present in the cavity. However, gradually over time, insulation was inserted in the cavity (fixed to the inner leaf) to increase the thermal capacity of the dwelling's fabric and became thicker as time went on.

Cavity wall insulation brush:

A cavity wall insulation brush refers to the component which is installed on the boundary in semi detached / terraced housing when pumping a wall cavity with bead insulation to prevent overspill into the adjoining property (See Insulation Bead for more info).

Condensing Boiler:

A condenser boiler recovers and utilises the heat that would otherwise be lost up the flue thus increasing its efficiency compared to a non-condensing boiler

D

DEAP (Dwelling Energy Assessment Procedure):

The Irish official method for calculating and rating the energy performance of dwellings.

Delivered Energy (in kWh/year):

This corresponds to the energy consumption measured at the dwelling and normally appears on the energy bills for the assumed standardised occupancy and end uses considered in the DEAP calculation method.

Demand Control Ventilation (DCV)

Demand control ventilation (DCV) is a ventilation control method that combines extracts fans in wet rooms with humidistat-controlled vents in other habitable rooms. As moisture levels rise in the dwelling due to washing, cooking, bathing etc the humidity sensors open the vents wider thus increasing the air flow. The motorised extract fans sense the change in pressure and run at a higher speed until the abnormal moisture levels are eliminated. Unlike MVHR systems, there is no heat recovery facility built into the system, as DCV is typically concerned with providing good, indoor air quality.

DHW

Domestic hot water.

Double / Triple Glazing

This refers to the number of layers of glazing within a window unit. Double glazed units have 2 layers of glass which are separated by a sealed cavity, either filled with air or a gas to increase the thermal performance of the unit. Triple glazed units have 3 layers of glass, again the cavities are sealed and filled with either air or a gas. While triple glazed units do achieve a higher U-value, typically the solar transmittance tends to be lower.

Draught-Stripping:

Draught stripping products are strips that are fixed around windows, interior and exterior doors, and loft hatches to reduce draughts.

Dry lining / Internal Wall Insulation (IWI):

This is the application of an insulated layer to the inner leaf of a structure to increase the thermal performance of the building's fabric. Dry lining requires a series of components to ensure it performs adequately and to prevent accelerated degradation of the structure through interstitial condensation. The inclusion of an air tightness and moisture control layer (fixed to the warm side of the insulation) and hydrophobic coating on the outer leaf of the structure can be applied to limit the development of interstitial condensation.

Care must be taken not to exceed a U-value of 0.27W/m^2K when insulating dwellings over one storey. This is primarily due to the cold bridge which exists at first floor level. Floor joists which have been built into the masonry are now in a more vulnerable state than previously, due to condensation occurring on the end of the floor joists.

E

EPS

Expanded polystyrene (EPS) foam is a closed-cell insulation that's manufactured by "expanding" a polystyrene polymer; the appearance is typically a white foam plastic insulation material (the likes of which can be found as merchandise packaging).

External Wall Insulation (EWI):

This is the application of rigid insulation (Polystyrene, Stone wool, Wood fibre) to the outer leaf of a structure to increase the thermal performance of the building's fabric. Unlike dry-lining, externally insulating the envelope of a structure provides the opportunity to seal the entire wall area with a continuous layer of insulation. Additionally, it provides the opportunity to overcome traditional cold bridges i.e. window cills can be cut back and replaced with similar approved insulated cill and window reveals can be removed and replaced with insulation to overlap the window frame. In some circumstances, EWI which enables the fabric to breath is necessary, particularly in older buildings in which the building fabric is porous. EWI products which are breathable and facilitate the movement of moisture through the fabric must be specified.

However, prior to applying external insulation to the building envelope, a few key issues should be resolved. Depending on the building finish, planning permission may be required if the intention is to chance the aesthetics; however, every measure should be taken to respect the architectural heritage of the property. The introduction of 'brick slips' to mimic the original aesthetic may not comply with local planning authorities. Furthermore, home owners may be limited in what depth of insulation that can be applied, as it may not comply with local authorities planning guidelines / local development plan.

Electric Immersion:

An electrical heating element, usually thermostatically controlled, for heating the liquid in which it is immersed, especially as a fixture in a domestic hot-water tank.

F

Fibre Insulation:

This insulation normally comes in the form of mineral glass fibre or stone wool is used between joists or rafters in roof construction or between timber studs in wall constructions. Additionally, the stone wool fibre insulation products can be used for internal wall, external wall and cavity fill applications.

G

Gable:
The part of a wall that encloses the end of a pitched roof.

H

Heat pumps:
A heat pump characteristically draws heat from the ambient environment, whether it is from the air, water or the ground. Through a process of compressing and decompressing liquids which circulate around a heat pump system, they can be used to circulate heat from that environment into the dwelling. The heat is circulated within the dwelling via a conventional measure such as, radiators or an under floor heating network or by a warm air circulation network. Air to air, air to water and ground to water heat pumps are typically powered by electricity, but are highly efficient – this tends to offset the electricity consumption and justify their use as space and water heaters.

Hit and Miss Vent:
This refers to the adjustable function on a background ventilator.

Hollow-block construction:
A hollow block wall commonly refers to a single leaf wall construction using 9 inch masonry block containing hollow sections.

HW controls:
Water heating controls such as cylinder thermostat.

Hydrophobic coating:
A hydrophobic coating refers to a surface applied solution that is applied to a mineral substrate i.e. brick, stone, concrete etc. which prevents the ingress of moisture from the exterior, while leaving the mineral substrate fully permeable to water vapour exchange, thus allowing the building fabric to remain porous and have the ability to breathe.

I

Interstitial condensation:
This refers to the penetration of moisture from inside the house (via permeable materials) into the buildings various elements (walls, roofs etc.). It occurs as a result of the temperature and pressure difference (internal and external), which push warm humid air through permeable materials until it reaches a point cool enough to condense on. The danger with interstitial condensation is that it occurs within the wall construction and is not visible to the naked eye. Care must be taken to eliminate this problem during construction through the introduction of a moisture control layer.

Insulation Beads:
Polystyrene beads designed for pumping into cavity wall constructions. The beads are normally bound by glue to enhance performance and prevent movement or spillage if either part of the outer or inner leaf is punctured.

J

Joists:
The term given to the series of horizontal structural components (Timber or steel) which make up a floor / flat roof. In housing construction timber joists are commonly used, and are arranged in a parallel series at fixed measurements to provide a structural deck. Services and insulation usually run between joists.

L

Lagging Jacket:
An insulated jacket which is retro-fitted over an existing hot water cylinder or cold water tank in an attic space.

M

Mechanical Ventilation with Heat Recovery:
This is a ventilation system that uses a heat exchanger to recover waste heat. The heat from the warm stale air from the various wet rooms in the dwelling e.g. (bathroom, kitchen) is recovered and used to heat the incoming cool fresh air (at the heat exchanger). To ensure a MVHR system runs at its maximum efficiency, the building should be well sealed and air tight.

Methodology:
A body of practices, procedures and rules used by those who work in a discipline or engage in an inquiry; a set of working methods.

Mineral Wool:
This is made from molten glass, stone or slag that is spun into a fibre-like structure. Inorganic rock or slag is the main components (typically *98%*) of stone wool. The remaining *2%* organic content is generally a thermosetting resin binder (an adhesive) and a little oil.

Moisture control barrier:
A moisture control barrier or an intelligent vapor barrier (in the form of a membrane) restricts the movement of moisture through the building envelope. Although it is permeable, the barrier restricts the movement of moisture from the warm side of the wall (inside) to the cold side (outside). Where a barrier as such 'controls' the movement of moisture through the buildings fabric, it can also act as an air tightness barrier. Note, a moisture control layer is not to be confused with a vapour barrier layer (i.e. plastic) which is impermeable and does not permit the movement of moisture within the buildings fabric.

P

Photovoltaic:
This refers to the generation of electricity through the conversion of solar radiation into direct current electricity (DC) using photovoltaic panels. The DC electricity is converted to AC electricity by an inverter, and is then directly fed into the main fuseboard of the building. A typical PV panel has a peak power of 250W approximately.

Primary energy (in kWh/year):
This includes delivered energy, plus an allowance for the energy "overhead" incurred in extracting, processing and transporting a fuel or other energy carrier to the dwelling. In the case of electricity, the generation efficiency of power stations is included as well as energy losses in the electricity transmission and distribution networks. The primary energy and CO2 emissions factors for electricity are updated in DEAP as new National Energy Balance figures are published.

R

Refurbishment:
This refers to the upgrading of the dwellings fabric through various measures e.g. window replacement, insulating the building fabric, updating the heating system etc..

Retrofit:
The installation of a new device /system in an existing dwelling. Also interchangeable with upgrade or refurbishment.

Rigid Insulation:
For the purposes of this brochure, rigid insulation board refers to the line of insulation products which come in board form. Phenolic, Urethane and Polyisocyanurate (PIR) boards are the most commonly used in the Irish market. Typically, boards are covered with a reflective foil layer either side and are suited for numerous insulation applications i.e. dry lining, partial cavity wall fill, roof (flat and pitched), floor (solid and suspended), etc.

S

Secondary space heating system:
This refers to space heating systems which supplement the primary heating system. Open fires, and stoves are commonly found in older dwellings, while in newer dwellings, gas fired (coal effect) heaters and electric heaters are commonly found.

Sectional Drawing:
Relating to or based upon a section (i.e. as if cut through by an intersecting plane); "a sectional view"; "sectional drawings"

SH controls:
Space heating controls such as room thermostat, programmer etc...

Societal:
Of or relating to the structure, organization, or functioning of society

Soffit Vent:
A Soffit vent refers to a vent (circular or linear) which has been installed in the soffit board to facilitate cross ventilation in the unheated roof void of a dwelling.

Solar thermal:
Solar thermal refers to the use of solar collectors to generate energy to heat water for domestic purposes. Solar collectors, either in the form of a flat plate or evacuated tube system are installed on the roof of the dwelling, preferably facing south at a 30˚ angle. While solar thermal will not be responsible for generating heat for the entire DHW load, typically it will contribute up to 50% of the energy required.

Solid floor:
This refers to a cast in-situ concrete floor, typically in older dwellings there will be no insulation present. Dwellings built in more recent times will have insulation which can range from 50-150mm rigid insulation, all which depends on period of construction.

Suspended timber floors:
A suspended timber floor refers to a raised floor with a void underneath for air circulation (to prevent rotting of floor joists). In older dwellings, floor boards will have a standard edge and are simply butted up against each other, hence making it easier to remove. In more recent dwellings which still utilise this method of construction, tongue and groove floor boards are common but can sometimes cause difficulty when seeking to remove a section of floor area for access reasons.

T

Thermal conductivity:
The thermal conductivity value is the rate at which heat passes through a specific building material, expressed as the amount of heat that flows per unit time through a unit area with a temperature gradient of one degree per unit distance. The thermal conductivity of an insulation product enables the user to select the most suitable product for the job, typically the lower the value, the better the insulation.

Thermal laminate board:
A thermal laminate board refers to a composite board which consists of 12.5mm plasterboard bonded to a rigid insulation board (usually Phenolic, Urethane and Polyisocyanurate (PIR) with a foil backing). Boards are commonly mechanically fixed or bonded with adhesive (also referred to as ‘dabs’) to the masonry substrate. This is commonly

Tile vent / Slate vent:
A tile / slate vent is a roofing element which supports cross ventilation of the unheated roof void of a dwelling. Unlike the soffit vent, these vents are fitted on the roof and generally have the same profile of tile / slate in question. Due to their higher ventilation capacity, there are fewer installations required.

Timber Battens:
Horizontal or vertical timber sections or strips are fixed to walls or to pitched roofs to which rigid insulation boards or plasterboards are mechanically fixed.

TRV (Thermostatic Radiator Valve):
A self-regulating valve fitted to hot water heating system radiators. The TRV contains a bellows that will close the valve on a rise in air temperature in the room, stopping the flow of heating water to the heat emitter. The TRV has a number of settings that can be used to set the desired air temperature in each room.

Typology:
The study or systematic classification of types that have characteristics or traits in common.

U

Urethane:
Urethane insulation is a building product used to prevent air transfer through the exterior walls of a home. It is comprised of polymer chains connected by organic compounds known as carbonates, or urethanes. The terms *urethane* and *polyurethane* are used interchangeably when it comes to most applications, including insulation.

U-Value (Thermal Transmittance):
This is the rate of transfer of heat (in watts) through one square metre of a structure divided by the difference in temperature across the structure. It is expressed in watts per square metre per Kelvin, or W/m^2K. Well-insulated parts of a building have a low thermal transmittance whereas poorly-insulated parts of a building have a high thermal transmittance

W

Wood Pellet Boiler:
Wood pellets are a type of wood fuel, generally made from compacted sawdust or other wastes from sawmilling and other wood products manufacture. High-efficiency wood pellet boilers have been developed in recent years, typically offering combustion efficiencies of over 85%.

X

XPS
Extruded polystyrene (XPS) foam is a rigid insulation that's also formed with polystyrene polymer, but manufactured using an extrusion process, and is often manufactured with a distinctive color to identify product brand.

Co-funded by the Intelligent Energy Europe Programme of the European Union

Disclaimer

The figures displayed in Appendix A are the result of market research carried out by IHER Energy Services Ltd in July - August 2014. The data collected has been used for research purposes, and only as an indicator for the current cost of carrying out the described upgrades / measures. Costs were gathered from various sources and an average was derived from this data in order to accurately reflect current industry rates.

Table 7: Price of works for roof upgrades

Roof		
Measure including installation cost	Target U-Value (W/m^2K)	Cost per m^2/ unit
Loft Roll Insulation		
300mm of Mineral Wool Insulation	0.13	€10.08
200mm of Mineral Wool Insulation	0.13	€8.37
100mm of Mineral Wool Insulation	0.13	€6.67
Rigid insulation		
50mm thermal laminate board to underside of rafter	0.25	€26.20
Flat roof: add 82.5mm board with k=0.022 or better for 20m2 flat roof	0.25	€48.24
Roof Ventilation		
Vent Tile with 20,000mm^2/m capacity placed @ 2000mm c/c	N/A	€60.00
Vent Tile with 10,000mm^2/m capacity placed @ 1000mm c/c	N/A	€60.00
Circular soffit vent with 10,000mm^2/m capacity placed @ 200mm c/c	N/A	€4.00
Clear eaves	N/A	€20.00
Clear Attic	N/A	€20.00
Insulate trap door with 100mm Rigid Insulation	N/A	€10.00
Raised access walkway (per linear metre)	N/A	€7.00
Flat roof Ventilator	N/A	€50.00

Co-funded by the Intelligent Energy Europe Programme of the European Union

Appendix A: Price of works

Table 8: Price of works for Wall Insulation upgrades

Walls		
Measure including installation cost	Target U-Value (W/m^2K)	Cost per m^2
External Wall Insulation		
Single Storey		
Add 100mm EWI to **Bungalow** (wall area - 135m^2)	0.27	€130.53
Add 150mm EWI to **Bungalow** (wall area - 135m^2)	0.21	€143.58
Add 200mm EWI to Bungalow (wall area - 135m^2)	0.15	€156.63
2 Storey		
Add 100 mm EWI to **detached house** (wall area - 170m^2)	0.27	€130.53
Add 150 mm EWI to **detached house** (wall area - 170m^2)	0.21	€143.58
Add 200 mm EWI to **detached house** (wall area - 170m^2)	0.15	€156.63
Add 100mm EWI to **semi detached house** (wall area - 100m^2)	0.27	€113.50
Add 150mm EWI to **semi detached house** (wall area - 100m^2)	0.21	€124.85
Add 200mm EWI to **semi detached house** (wall area - 100m^2)	0.15	€136.20
Add 100mm EWI to **mid-terrace house** (wall area - 45m^2)	0.27	€113.50
Add 150mm EWI to **mid-terrace house** (wall area - 45m^2)	0.21	€124.85
Add 200mm EWI to **mid-terrace house** (wall area - 45m^2)	0.15	€136.20

Cavity Fill Insulation (Gross wall Area)		
Single Storey		
Add 100mm bead to **Bungalow** (cavity wall area - 115m^2)	0.21	€10.12
Add 50mm bead to **Bungalow** (cavity wall area - 115m^2)	0.27	€8.23
2 Storey		
Add 100mm bead to **detached house** (cavity wall area - 145m^2)	0.21	€10.12
Add 50mm bead to **detached house** (cavity wall area - 145m^2)	0.27	€8.23
Add 100mm bead to **semi detached house** (cavity wall area - 85m^2)	0.21	€10.12
Add 50mm bead to **semi detached house** (cavity wall area - 85m^2)	0.27	€8.23
Add 100mm bead to **mid terrace detached house** (cavity wall area - 40m^2)	0.21	€10.12
Add 50mm bead to **mid terrace detached house** (cavity wall area -	0.27	€8.23

Co-funded by the Intelligent Energy Europe Programme of the European Union

Table 8: Price of works for Wall Insulation upgrades (Cont'd)

Internal Wall insulation (Gross wall area)	Target U-Value (W/m²K)	
Internal wall insulation 42.5mm Composite Insulated Panel	0.48	€76.61
Internal wall insulation 62.5mm Composite Insulated Panel	0.34	€79.45
Internal wall insulation 82.5mm Composite Insulated Panel	0.27	€82.86

Wall Ventilation (Cavity Fill)	Cost
Wall Vent - 110mm diameter across 320mm wall complete with vent, duct and hit & miss grill	€45.00
Cavity brush (Installed on boundary walls)	€8.00

Table 9: Price of works for floor Insulation upgrades

Floors		
Measure including installation cost	Target U-Value (W/m²K)	Cost per m²
Suspended floor insulation 160mm fibre between joists (50m2 area)	0.21	€9.08
Suspended floor insulation 100mm rigid board (k=0.22) between joists (50m2)	0.21	€30.65

Table 10: Price of works for Window and Door upgrades

Windows and Doors		
Measure including installation cost	Target U-Value (W/m²K)	Cost per m²
Assuming approx 18m² of windows is required		
Double glazing Upvc	1.6	€325.00
Double glazing Upvc	1.4	€397.25
Triple glazing Upvc	0.9	€450.00
Insulated Doors	1.5	€397.25

Table 11: Price of works for heating system upgrades

Space and Water Heating	
Measure including installation cost	Cost
90% efficient Condensing Gas boiler	€1,845.37
90% efficient Combi boiler	€2,150.00
90% efficient Condensing Gas boiler & controls (Room Stat, Pro-	€2,837.50
90% Condensing Oil boiler & controls (Room Stat, Programme,	€3,972.50
Condensing Wood pellet boiler	€7,000.00
Air to Water Heat Pump (Unit, Tank & Controller)	€5,000.00
Ground Source Heat Pump (Unit, Tank & Controller)	€10,000.00
Heating controls package	€1,532.25
Secondary heating system (Solid Fuel Stove, 75% Efficient)	€1,000.00

Co-funded by the Intelligent Energy Europe Programme of the European Union

Appendix A: Price of works

Table 12: Price of works for Ventilation system upgrades

Ventilation	
Measure including installation cost	Cost
Mechanical Ventilation with Heat Recovery, associated ductwork and outlets.	€4,300.00
Demand Control Ventilation, associated ductwork and outlets	€2,500.00

Table 13: Price of works for Renewable energy installation

Renewable energy	
Measure including installation cost	Cost
Solar Thermal Panels (2m2 evacuated tube)	€6,242.50
250W Photovoltaic Panel	€500 .00 per panel

Co-funded by the Intelligent Energy Europe Programme of the European Union