Building Typology Brochure
Ireland

A detailed study on the energy performance of typical Irish dwellings

May 2012












INTELLIGENT ENERGY EUROPE

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ENERGY ACTION THE WARM CHARITY

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Introduction

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

At the beginning of the project, a quick survey showed that very limited typology data was available in the participating member countries. (The participating countries are Germany, France, Italy, Denmark, Sweden, Belgium, Poland, Austria, Czech Republic, Greece, Slovenia, Ireland and Bulgaria).

Information on TABULA is being made available to energy consultants and the general public via two key channels, namely through (1) the TABULA building typology webtool 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 is 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).

This document contains details of the brochures created for 30 Irish residential building types within TABULA. Individual double-sided A4 brochures are available separately for each building type.

The following introductory sections provide some useful information relating to the structure of this new Irish typology and the brochure content.

Creation of the Irish Building Typology

30 typical Irish house & apartment types identified by the Irish TABULA project team are included in the Irish TABULA brochure. The typical 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, 5 distinct Irish construction age bands were identified based on 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). Hence, there were no building standards applying to dwellings built before 1977.

The 5 construction age bands selected for the Irish TABULA typology are shown in Table 1 overleaf. The first age band contains dwellings built in the 1800s, some built in the 1920s, 1950s and 1970s etc.. While the different styles will be further classified in TABULA, as none of these buildings had any insulation installed when constructed, they all fall within the same construction age band.

Table 1: Irish Construction Age Bands

Construction Year Class	Code
1800-1977	1
1978-1982	2
1983-1993	3
1994-2004	4
2005-onwards	5

The 30 Irish dwelling types are spread across these 5 age bands. They include both detached, semi-detached and terraced houses plus one pre 1977 apartment with 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 2005 standards.

Construction Details

The individual brochures for the 30 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.

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

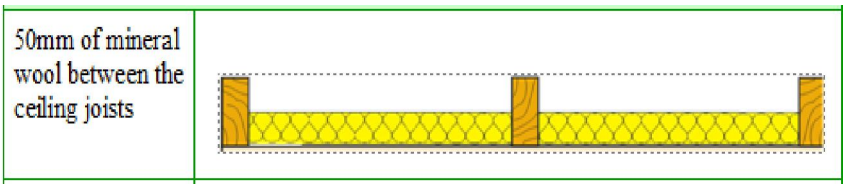


Figure 1

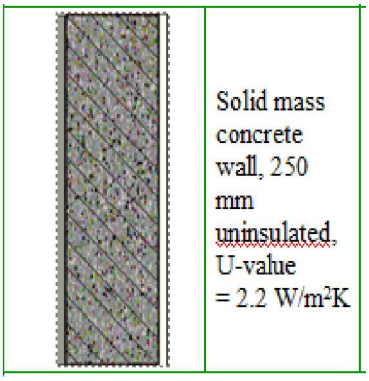


Figure 2

Characteristics of Typical Irish Buildings

When determining the energy related characteristics of a house built in the 1930s, 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 will 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 will have had roughly 50mm of roof insulation installed during the 1970s and that it will have had an oil or gas central heating system with minimal heating controls installed at the same time. This approach was adopted for all 30 typical Irish buildings.

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

Refurbishment Analysis for each Dwelling Type

As well as indentifying these national house types, two stages of refurbishment of each dwelling type are examined in TABULA. Data on the 2 stages of retrofit are contained in each of the 30 brochures.

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

The first stage of refurbishment for Irish dwellings is broadly based on the SEAI Better Energy Homes (BEH) standard for roof and wall insulation and heating system upgrades. The Stage 1 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 uninsulated wooden floors, the replacement of windows and the provision of spray foam cylinder insulation. The Stage 1 refurbishment measures are listed in Table 1 below.

Table 2: Stage 1 Refurbishment

Stage 1 Measures	Upgrade Standards
Roof U-Value	0.13W/m^{2}K
Flat roofs	0.22 W/m^{2}K
Wall U-Value	0.27 W/m^{2}K
Wooden Floor (replace)	0.25 W/m^{2}K
Windows U-Value	2 W/m^{2}K
Doors (PVC)	2 W/m^{2}K
Space heat generator efficiency	90% gas, 90% oil
Water heat generator efficiency	90% gas, 90% oil
Heating controls	Full zone control
Cylinder Insulation	50mm, spray foam

The second stage of refurbishment is for a more advanced level of refurbishment. The measures for the stage 2 refurbishment are detailed in table 3 below. The U values for flat roofs, walls and windows have been reduced broadly to match the stop-gap or area-weighted average values within 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.)

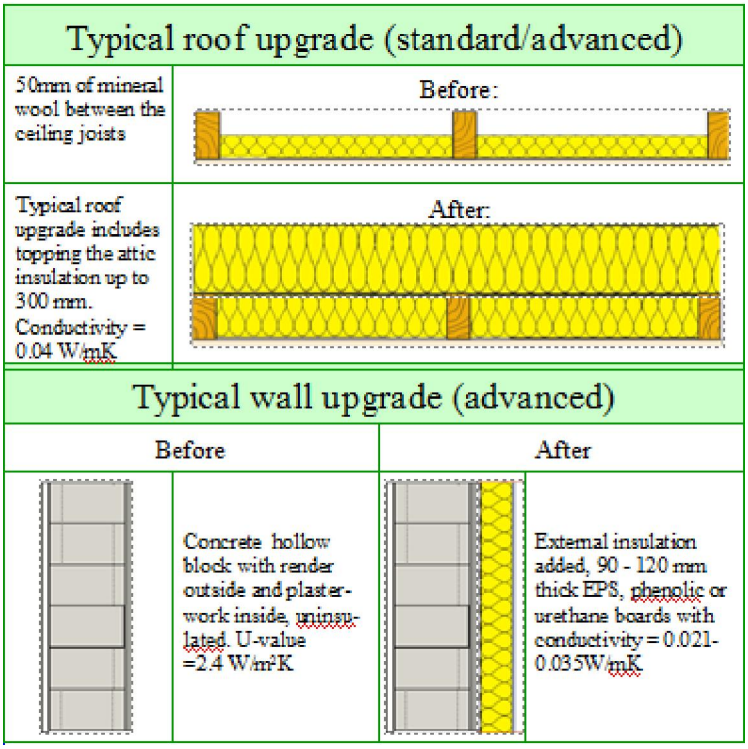
Table 3: Stage 2 Refurbishment

Stage 2 Measures	**Upgrade Standards**
Roof U-Value	0.13 W/m2K
Flat roof	0.2 W/m^2K
Wall U-Value	0.21 W/m^2K
Windows U-Value	1.3 W/m^2K
Doors (PVC)	2 W/m^2K
Space heat generator efficiency	Heat pump: 380% min air, 400% ground
Water heat generator efficiency	Heat pump: 380% min air, 400% ground
Plus Solar thermal ($4m^2$ to $6m^2$)	40% contribution of total energy (10% electric immersion)
Heating controls	Full zone control
Cylinder Insulation	50mm, spray foam
Mechanical Heat Recovery Ventilation	90% minimum efficiency

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 show the likely results from partial upgrades.

An example from house type 11 is shown in figure 3 below.

Figure 3: Building Fabric Upgrade Steps



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 short survey of market prices in 2011. 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 house type 10 is shown in table 4 below.

Table 4: Estimated costs & payback time for Type 10

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 14, 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 in Table 4 may be longer than estimated.

Summary of BER Calculation Results

The improvement in BER scores for the 30 dwelling types are shown in Table 5.

Stage 1 measures improve the BER scores to a range between C1 and B2. The stage 2 measures improved the BER ratings to a range between B3 and A3.

Table 5: BER Results Summary

no	Age Band:	House type	Current State	Stage 1	Stage 2
1	1900-1977	SFH.01.Gen	G	B3	B1
2	1900-1977	TH.01.Gen	G	B3	B1
3	1900-1977	SFH.01.Stone	G	C1	B1
4	1900-1977	TH.01.Stone	G	C1	B2
5	1900-1977	SFH.01.225SB	G	C1	B3
6	1900-1977	TH.01.225SB	G	B3	B1
7	1900-1977	SFH.01.325SB	G	B2	B1
8	1900-1977	TH.01.325SB	G	C1	B2
9	1900-1977	SFH.01.MassConc	G	C1	B3
10	1900-1977	TH.01.MassConc	F	B2	B1
11	1900-1977	SFH.01.Hblock	G	B3	B1
12	1900-1977	TH.01.HBlockFBF	G	B3	B1

13	1900-1977	TH.01.HBlockHBF	G	B2	B1
14	1900-1977	AB.01.Gen	G	B3 (Var 1)	C1 (Var 2)
14	1978-1982	SFH.02.Gen	E2	B3	B1
15	1978-1982	TH.02.Gen	E1	B2	B1
16	1978-1982	SFH.02.Hblock	E1	B3	B1
17	1978-1982	TH.02.Hblock	E2	B2	B1
18	1983-1993	SFH.03.Gen	E1	B3	B2
19	1983-1993	TH.03.Gen	D2	B3	B2
20	1983-1993	SFH.03.Hblock	D1	B2	B1
21	1983-1993	TH.03.Hblock	D2	B2	A3
22	1994-2004	SFH.04.Gen	D2	C1	B3
23	1994-2004	TH.04.Gen	C2	B2	B1
24	1994-2004	SFH.04.Tframe	C3	B3	B2
25	1994-2004	TH.04.Tframe	C3	B3	B2
26	2005-onw	SFH.05.Gen	C1	B2	B1
27	2005-onw	TH.05.Gen	B3	B2	B1
28	2005-onw	SFH.05.Tframe	C1	B2	B1
29	2005-onw	TH.05.Tframe	B2	B2	B1

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 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 6 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 6: 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.01.Gen	483.85	365.91	117.94	24%
TH.01.Gen	489.08	314.14	174.94	36%
SFH.01.Stone	618.18	440.14	178.04	29%
TH.01.Stone	607.41	410.36	197.05	32%
SFH.01.225SB	634.04	443.34	190.70	30%
TH.01.225SB	463.56	390.24	73.32	16%
SFH.01.325SB	453.53	383.00	70.53	16%
TH.01.325SB	631.70	381.47	250.23	40%

SFH.01.MassConc	656.59	507.00	149.59	23%
TH.01.MassConc	398.14	364.00	34.14	9%
SFH.01.Hblock	549.40	398.18	151.22	28%
TH.01.HBlockFBF	499.43	333.92	165.51	33%
TH.01.HBlockHBF	456.75	333.92	165.51	33%
SFH.02.Gen	365.73	237.96	127.77	35%
TH.02.Gen	317.67	262.15	55.52	17%
SFH.02.Hblock	321.72	258.70	63.02	20%
TH.02.Hblock	346.16	270.13	76.03	22%
SFH.03.Gen	302.52	271.60	30.92	10%
TH.03.Gen	293.97	260.88	33.09	11%
SFH.03.Hblock	250.87	232.27	18.60	7%
TH.03.Hblock	265.12	267.16	-2.04	-1%
SFH.04.Gen	292.27	244.87	47.40	16%
TH.04.Gen	179.55	227.11	-47.56	-26%
SFH.04.Tframe	214.70	265.98	-51.28	-24%
TH.04.Tframe	203.99	220.44	-16.45	-8%
SFH.05.Gen	171.12	162.20	8.92	5%
TH.05.Gen	149.74	167.26	-17.52	-12%
SFH.05.Tframe	162.37	147.36	15.01	9%
TH.05.Tframe	123.21	154.26	-31.05	-25%

It is notable that the for the pre1977 house types, the average primary energy values from the NAS database are about 30% lower than the values for the TABULA house type.

This difference is due to several factors including:

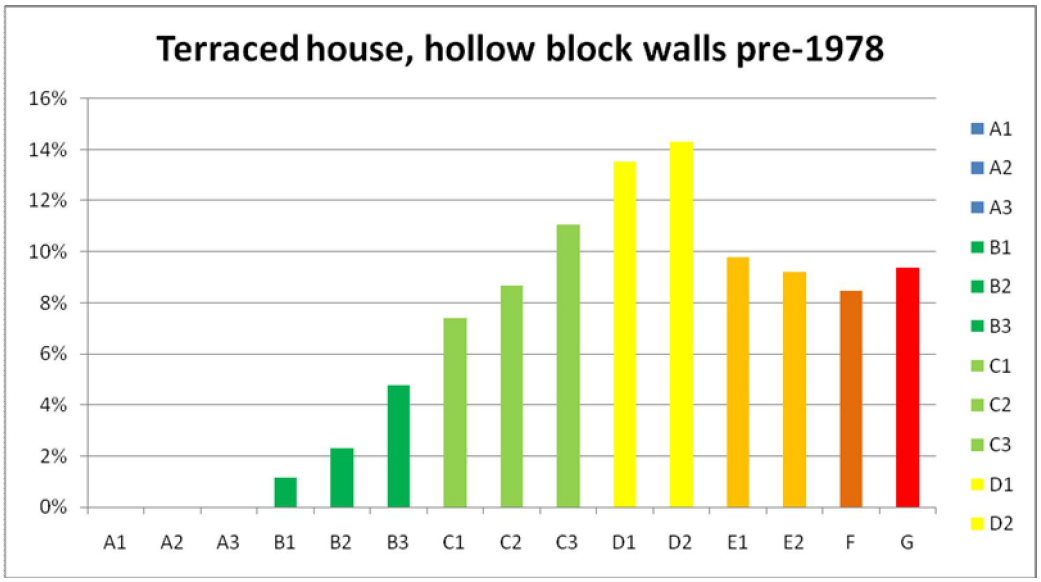
* the EPC database includes EPCs for many dwellings that have been retrofitted with energy upgrades. (In order to avail of grants from the Government for refurbishment works, post works EPCs are required.) Thus, many of the EPCs for the old dwellings will have better primary energy values than typical 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 figure4 shows the range of published BER scores for a Type 11 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 11, that the standard refurbishment of the building fabric brings the TABULA dwelling from a G to a D1 rating.

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

Figure 4: Analysis of Type 11 BER Scores from NAS, October 2011



Observations

The development of this suite of brochures of typical Irish dwellings will hopefully act as a useful information source 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 home-owners.

1. Detached House, stone walls, pre-1978

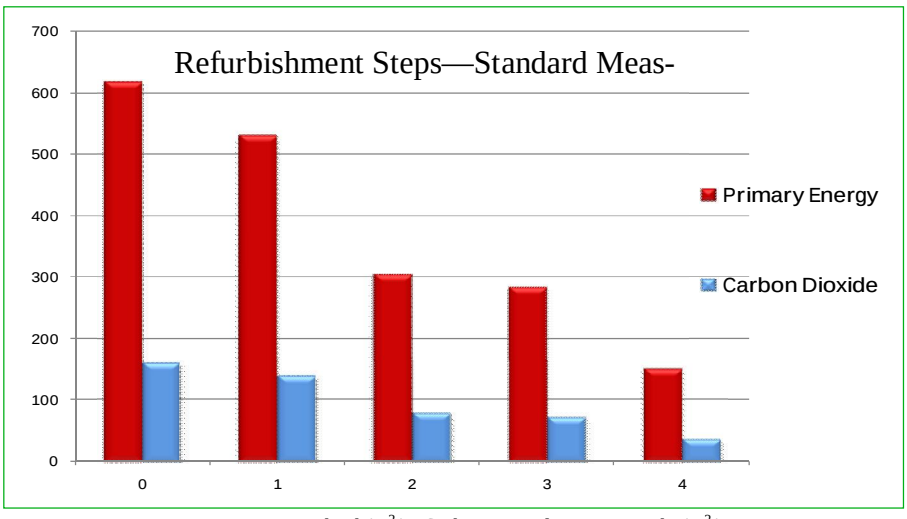
Description: Stone walls were common up to the 1930s in rural areas/ towns. Walls can be 300mm to 400mm thick. The type of stone will influence the insulation options as not all stone wall types are suited for additional insulation.

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, pipework uninsulated	Heating oil (kerosene)	65%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Uninsulated, 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	**618** (actual state)	**159** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	531	138	G
2	**Wall insulation**	Add	External insulation or internal drylining. Thickness of the insulation: 70-100 mm	0.27	306	79	E1
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Wooden/PVC doors, insulated	2.0	284	73	D2
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**151**	**37**	**C1**

*also includes draughtstripping, 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**

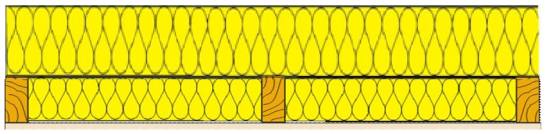
Measure	Estimated costs	Payback (y)
Step 1	€ 1,060	1.5
Step 2	€ 18,600	8.8
Step 3	€ 4,225	19.9
Step 4	€ 3,500	2.9
Total:	**€ 27,385**	**6.5**

Standard upgrade summary

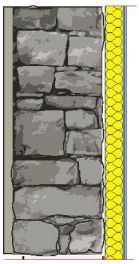
Consumption of primary energy reduced by:	**467 kWh/m²/y**
Emission of carbon dioxide reduced by:	**122 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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, EPS, urethane or phenolic boards, conductivity = 0.021 - 0.031 W/mK

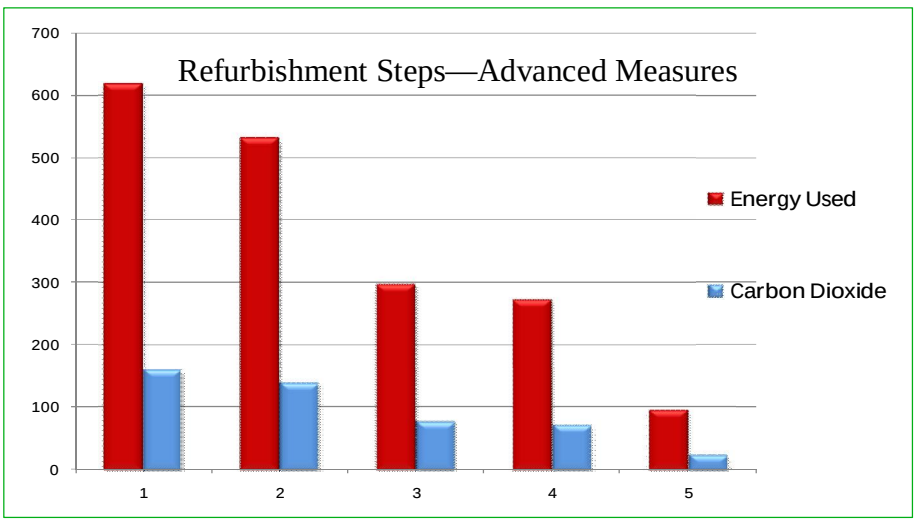
Heating system upgrade

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, 90% 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	**618** (actual state)	**159** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist	0.13	531	138	G
2	**Wall insulation**	Add	External wall insulation. Thickness: 90-150 mm	0.21	298	77	D2
4	**Windows and Doors**	Replace	Triple glazed, argon filled, low-e windows and doors	1.3	273	70	D2
	Systems upgrade:						
5	**Space and water heating system and controls**	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. Mechanical ventilation with heat recovery (MVHR).		**95**	**23**	**B1**

* package also includes draughtstripping, 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	€ 1,060	1.5
Step 2	€ 20,460	9.3
Step 3	€ 5,600	23.5
Step 4	€ 16,100	9.6
Total:	**€ 43,220**	**9.6**

Advanced upgrade summary

Consumption of primary energy reduced by:	**523 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**136 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

2. End of terrace house, stone walls, pre-1978

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, pipework uninsulated	Mains gas	65%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Uninsulated, 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	**607** (actual state)	**129** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	534	114	G
2	**Wall insulation**	Add	External insulation or internal drylining. Thickness of the insulation: 70-100 mm	0.27	363	77	E2
3	**Flat roof insulation**	Add	Insulation boards, rigid urethane/phenolic (100-110mm)	0.22	298	64	D2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap PVC/Timber doors, insulated	2.0	275	59	D2
	Systems upgrade:						
5	**Space and water heating system and controls**	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.		**155**	**30**	**C1**

*also includes draughtstripping, 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**

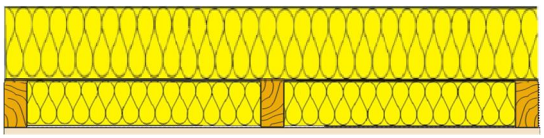
Measure	Estimated costs	Payback (y)
Step 1	€ 665	1.7
Step 2	€ 13,700	18.9
Step 3	€ 3,400	12.5
Step 4	€ 3,600	37.5
Step 5	€ 3,000	5.1
Total:	**€ 24,500**	**11.8**

Standard upgrade summary

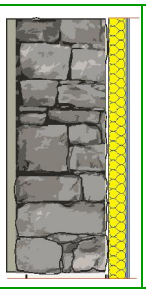
Consumption of primary energy reduced by:	**452 kWh/m²/y**
Emission of carbon dioxide reduced by:	**99 kg CO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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, EPS, urethane or phenolic boards, conductivity = 0.021 - 0.031 W/mK

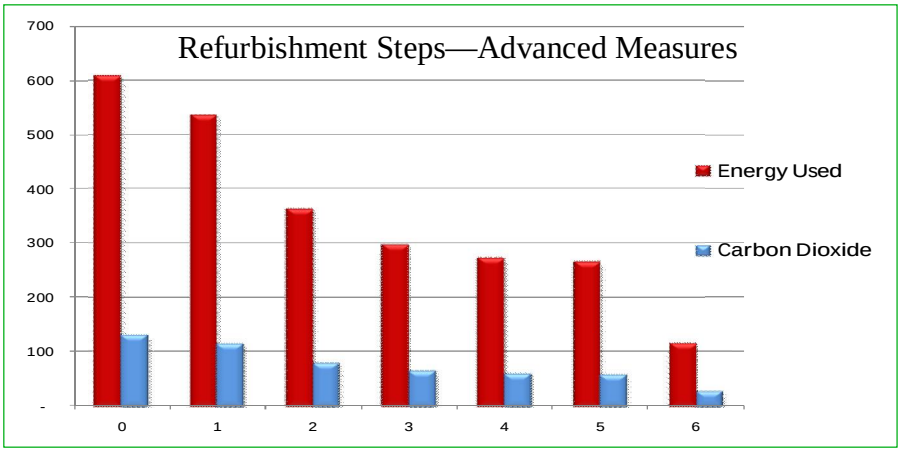
Heating system upgrade

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, 90% 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	**607** (actual state)	**129** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist	0.13	534	114	G
2	**Wall insulation**	Add	External wall insulation. Thickness : 90-150 mm	0.21	363	77	E2
3	**Flat roof**	Add	Insulation boards, rigid urethane/phenolic (100-110mm)	0.22	298	64	D2
4	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, argon filled, low-e windows	2.0 1.3	273	58	D2
5	**Suspended floor**	Replace	Suspended floor replaced, insulation boards added between the floor joists, 70-100mm	0.25	266	57	D2
	Systems upgrade:						
6	**Space and water heating system and controls**	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).		**115**	**27**	**B2**

* package also includes draughtstripping, 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	€ 665	1.7
Step 2	€ 15,100	20.8
Step 3	€ 3,400	12.5
Step 4	€ 4,750	45.6
Step 5	€ 1,140	35.8
Step 6	€ 11,100	18.7
Total:	**€ 36,155**	**18.7**

Advanced upgrade summary

Consumption of primary energy reduced by:	**492 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 (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

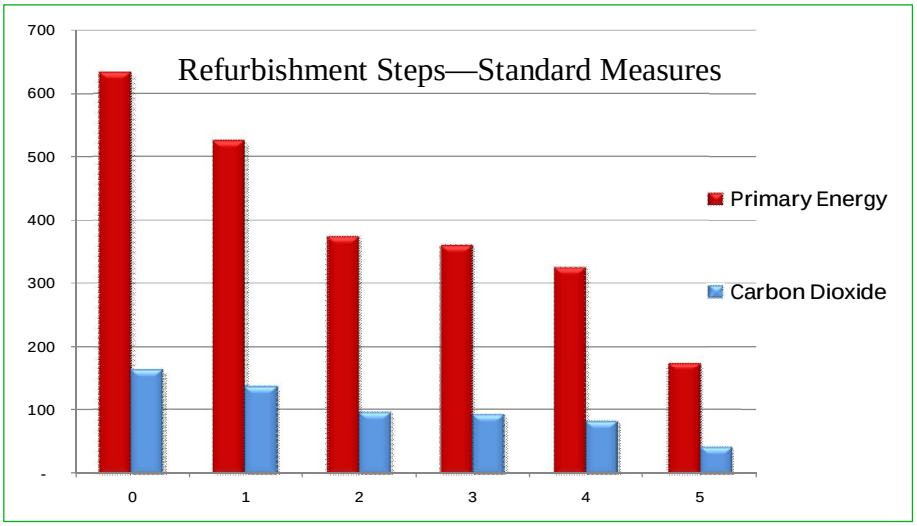
3. Bungalow, solid brick walls, pre-1978

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, pipework uninsulated	Heating oil	65%
Secondary	Open fire in grate	Coal	30%
Hot water	From primary heating system. Electric immersion used in Summer.		
Cylinder	Uninsulated, no cylinder thermostat.		
Controls	Programmer only		

Description
One-off bungalow with uninsulated 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	**634** (actual state)	**162** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	526	136	G
2	**Wall insulation**	Add	External wall insulation. Thickness of the boards: 70-100 mm	0.27	375	96	E2
3	**Flat roof insulation**	Add	Insulation boards, rigid urethane/phenolic (100-110mm)	0.22	360	92	E2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap PVC/Timber doors, insulated	2.0	326	83	E1
	Systems upgrade:						
5	**Space and water heating system and controls**	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.		**174**	**43**	**C1**

*also includes draughtstripping, 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**

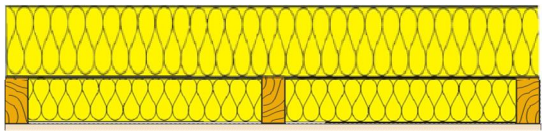
Measure	Estimated costs	Payback (y)
Step 1	€ 1,350	1.9
Step 2	€ 11,940	10.9
Step 3	€ 830	7.5
Step 4	€ 5,250	21.1
Step 5	€ 3,500	3.3
Total:	**€ 22,900**	**7.1**

Standard upgrade summary

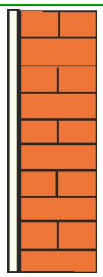
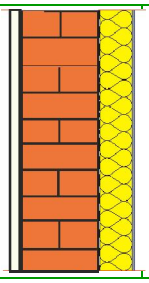
Consumption of primary energy reduced by:	**460 kWh/m²/y**
Emission of carbon dioxide reduced by:	**119 kg CO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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, uninsulated, U-value = 2.1 W/m^{2}K		External insulation added, EPS, urethane or phenolic boards, conductivity = 0.021 - 0.031 W/mK

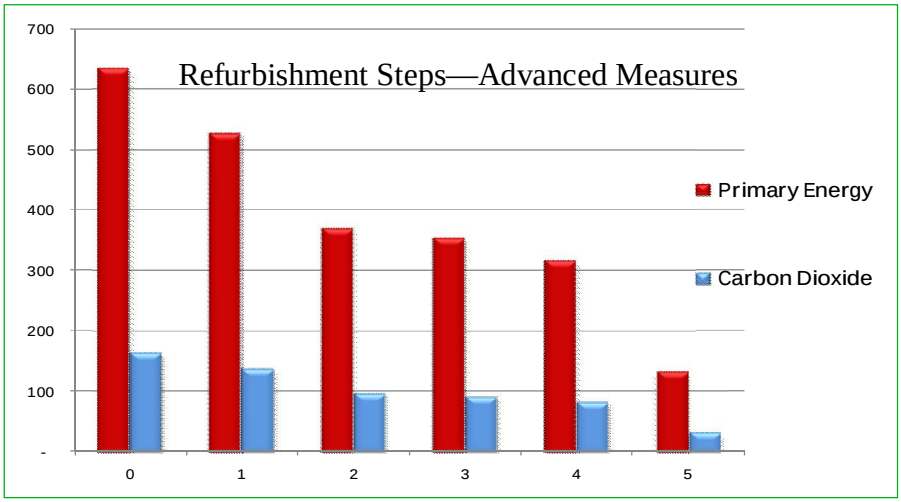
Heating system upgrade

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, 90% efficient

Refurbishment steps — advanced

				Expected U-values	Prim. energy kWh/m^2/y	Carbon Dioxide kgCO$_2$/m^2/y	Energy Rating
0	Building fabric upgrade steps:				**634** (actual state)	**162** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist	0.13	526	136	G
2	**Wall insulation**	Add	External wall insulation. Thickness : 90-150 mm	0.21	370	95	E2
3	**Flat roof**	Add	Insulation boards, rigid urethane/phenolic (100-110mm)	0.22	355	91	E2
4	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, argon filled, low-e windows	2.0 1.3	316	81	E1
	Systems upgrade:						
5	**Space and water heating system and controls**	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).		**132**	**31**	**B3**

* package also includes draughtstripping, 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	€ 1,340	1.9
Step 2	€ 13,130	10.5
Step 3	€ 830	7.5
Step 4	€ 7,000	24.8
Step 5	€ 11,100	7.6
Total:	**€ 33,400**	**9**

Advanced upgrade summary

Consumption of primary energy reduced by:	**502 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**131 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

4. End of terrace, solid brick walls, pre-1978

Description

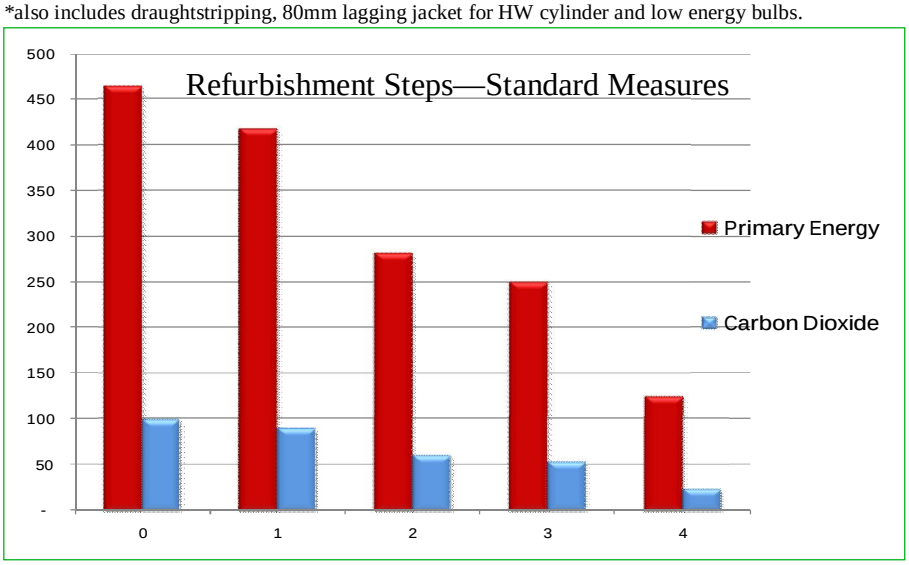
Solid brick fronted house with solid block walls to side and rear. Very common in older parts of Dublin, Limerick, Cork, etc. Built in the early 1900s and up to the 1940s. Suspended timber floors fitted in most of the property.

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 none	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, pipework uninsulated	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	**464** (actual state)	**99** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	418	89	F
2	**Wall insulation**	Add	82.5 mm of internal wall insulation+ vapour control layer.	0.27	282	60	D2
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap PVC/Timber frame doors.	2.0	250	53	D1
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**125**	**24**	**B3**

*also includes draughtstripping, 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**

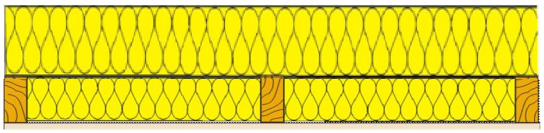
Measure	Estimated costs	Payback (y)
Step 1	€ 1,330	3.9
Step 2	€ 10,560	12.3
Step 3	€ 6,230	31.1
Step 4	€ 3,000	3.5
Total:	**€ 21,120**	**9.3**

Standard upgrade summary

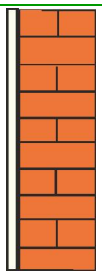
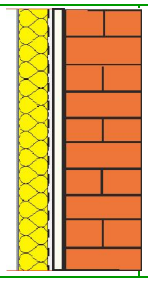
Consumption of primary energy reduced by:	**339 kWh/m²/y**
Emission of carbon dioxide reduced by:	**75 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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, uninsulated, U-value = 2.1 W/m^{2}K		Internal insulation added, urethane or phenolic boards, conductivity = 0.021 - 0.025 W/mK

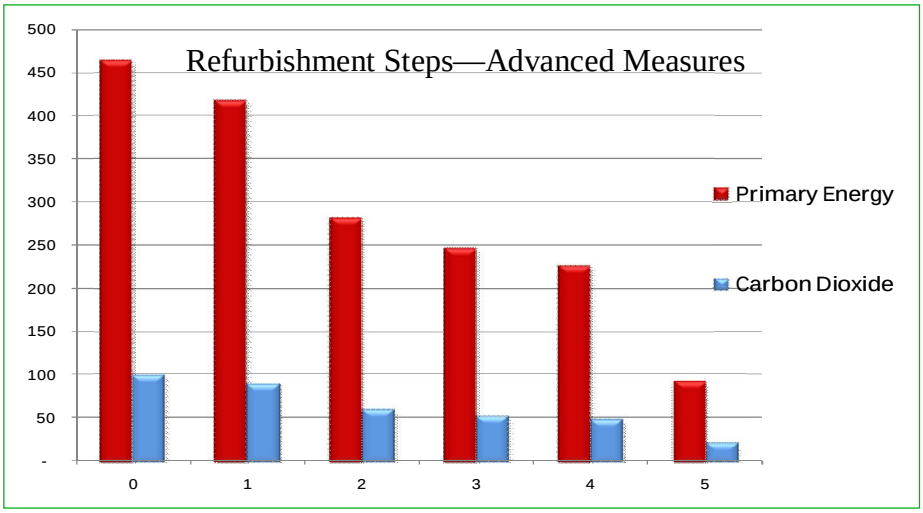
Heating system upgrade

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	MVHR, 88-90% 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	**464** (actual state)	**99** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist	0.13	418	89	F
2	**Wall insulation**	Add	82.5 mm of internal wall insulation+ vapour control layer.	0.27	282	60	D2
3	**Windows and Doors**	Add	Insulated PVC/wooden doors, Triple glazed, argon filled, low-e windows	2.0 1.3	246	52	D1
4	**Suspended floor**	Replace	Insulate the suspended wooden floor with 70-100mm phenolic/urethane boards	0.25	226	48	C3
	Systems upgrade:						
5	**Space and water heating system and controls**	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).		**93**	**22**	**B1**

* package also includes draughtstripping, 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	€ 1,330	3.9
Step 2	€ 10,560	12.3
Step 3	€ 8,350	36.9
Step 4	€ 2,130	18.4
Step 5	€ 13,100	18.8
Total:	**€ 35,470**	**15.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**371 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**77 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

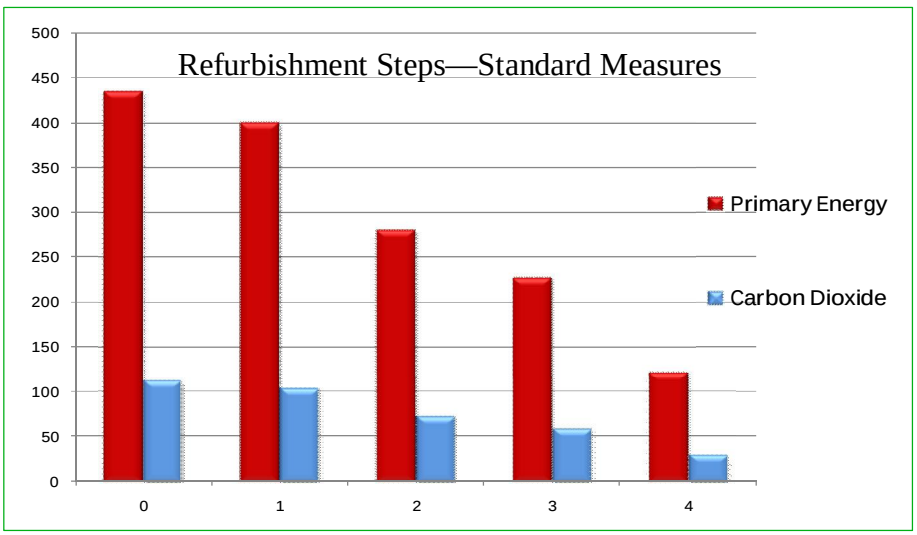
5. Detached house, solid brick walls, pre-1978

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, pipework uninsulated	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	**436** (actual state)	**112** (actual state)	**F**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	401	104	F
2	**Wall insulation**	Add	Internal drylining. 77.5 mm phenolic / urethane boards	0.27	281	72	D2
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors	2.0	228	59	D1
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**123**	**30**	**B2**

*also includes draughtstripping, 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**

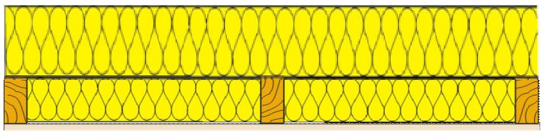
Measure	Estimated costs	Payback (y)
Step 1	€ 1,560	3.1
Step 2	€ 16,100	8.5
Step 3	€ 13,000	15.5
Step 4	€ 3,500	2.2
Total:	**€ 34,160**	**7.1**

Standard upgrade summary

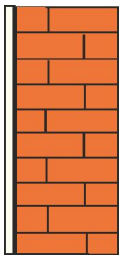
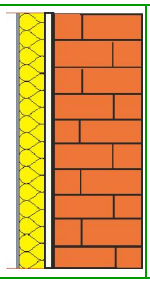
Consumption of primary energy reduced by:	**313 kWh/m²/y**
Emission of carbon dioxide reduced by:	**82 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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, uninsulated, U-value = 2.1 W/m^{2}K		Internal insulation added, (on dabs or timber battens)- urethane or phenolic boards, conductivity = 0.021 - 0.025 W/mK

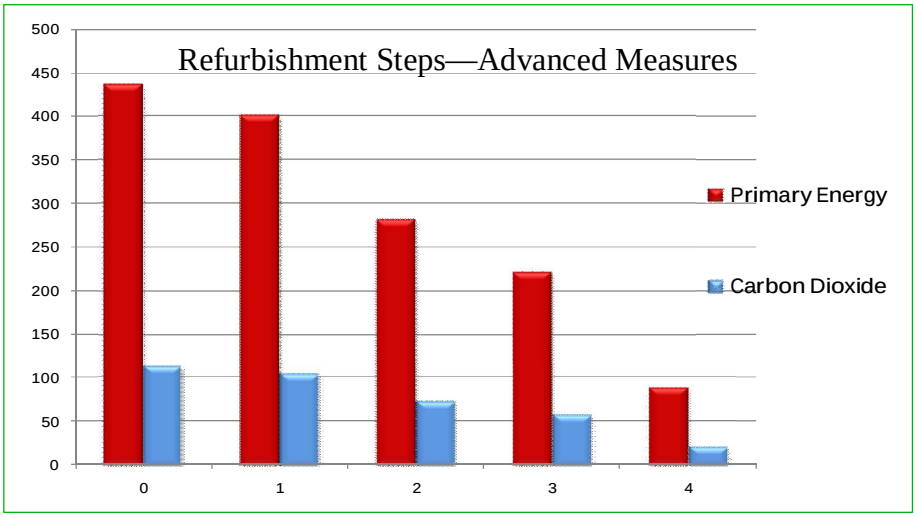
Heating system upgrade

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, 90% 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	**436** (actual state)	**112** (actual state)	**F**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist	0.13	401	104	F
2	**Wall insulation**	Add	Internal drylining. 77.5 mm phenolic / urethane boards	0.27	281	72	D2
3	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, argon filled, low-E windows	2.0 1.3	222	57	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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. Mechanical ventilation with heat recovery (MVHR).	**88**	**21**	**B1**

* package also includes draughtstripping, 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	€ 1,560	3.1
Step 2	€ 16,100	8.5
Step 3	€ 13,025	13.7
Step 4	€ 18,100	7.9
Total:	**€ 48,785**	**8.66**

Advanced upgrade summary

Consumption of primary energy reduced by:	**348 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**91 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

6. Terraced house, solid brick wall, pre-1978

Description

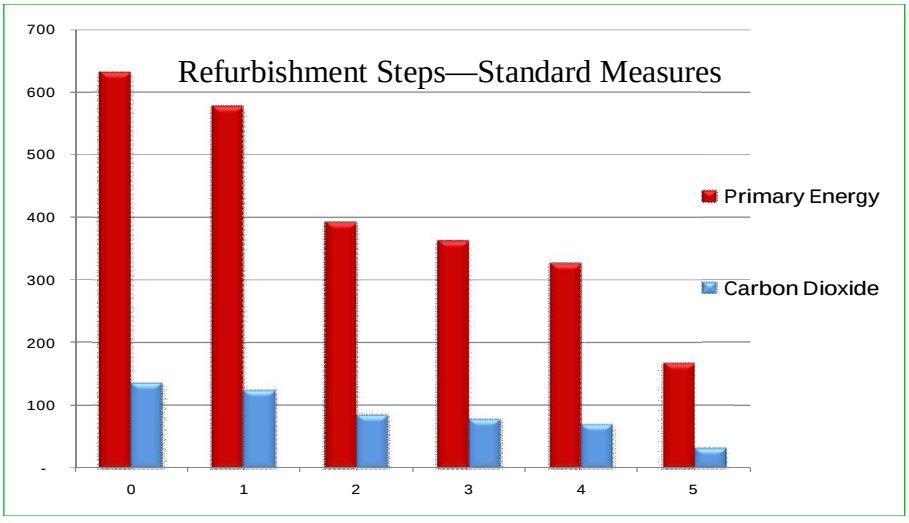
Typical redbrick house found in Dublin, Cork, Limerick etc from late 1800s up to 1930s. Often includes a flat roof extension to rear. Suited to a mix of internal and external wall insulation. Suspended timber floors are common that can be retrofitted with insulation.

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, pipework uninsulated	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	**632** (actual state)	**134** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	577	123	G
2	**Wall insulation**	Add	Internal drylining. 77.5 mm phenolic boards, extension walls externally insulated.	0.27	393	83	F
3	**Flat roof**	Add	Flat roof drylined or externally insulated	0.22	363	77	E2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors	2.0	328	70	E1
	Systems upgrade:						
5	**Space and water heating system and controls**	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.		**169**	**32**	**C1**

*also includes draughtstripping, 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**

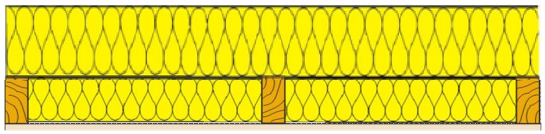
Measure	Estimated costs	Payback (y)
Step 1	€ 1,140	4.4
Step 2	€ 12,900	17.4
Step 3	€ 1,230	10.1
Step 4	€ 4,600	32.8
Step 5	€ 3,000	4.3
Total:	**€ 22,870**	**11.7**

Standard upgrade summary

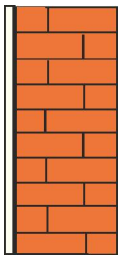
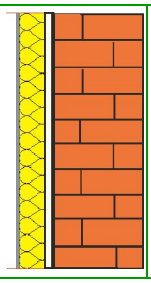
Consumption of primary energy reduced by:	**463 kWh/m²/y**
Emission of carbon dioxide reduced by:	**102 kg CO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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, uninsulated, U-value = 2.1 W/m^{2}K		Internal insulation added, (on dabs or timber battens)- urethane or phenolic boards, conductivity = 0.021 - 0.025 W/mK

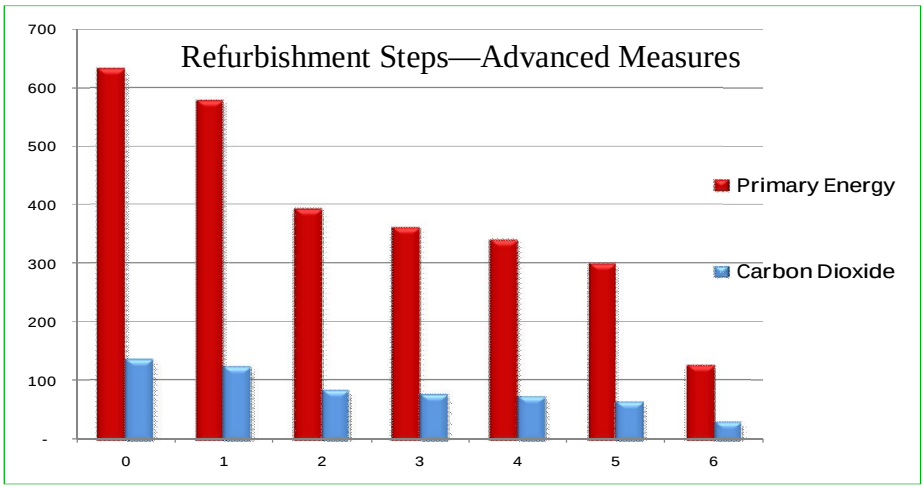
Heating system upgrade

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	MVHR, 90% 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	**632** (actual state)	**134** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	577	123	G
2	**Wall insulation**	Add	Main wall: Internal drylining. 77.5 mm phenolic / urethane boards Extension: external insulation 100 –150mm.	0.27 0.21	392	83	F
3	**Flat roof**	Add	Flat roof drylined or externally insulated	0.22	361	77	E2
4	**Suspended floor**	Add	Insulation boards between the floor joists, 70-100 mm	0.25	340	72	D2
5	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, argon filled, low-e windows	2.0 1.3	300	64	D2
	Systems upgrade:						
6	**Space and water heating system and controls**	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).		**124**	**30**	**B2**

* package also includes draughtstripping, 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	€ 1,140	4.4
Step 2	€ 20,620	27.6
Step 3	€ 1,230	10.1
Step 4	€ 1,650	19.2
Step 5	€ 6,100	38.0
Step 6	€ 11,100	19.6
Total:	**€ 41,840**	**15.6**

Advanced upgrade summary

Consumption of primary energy reduced by:	**508 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**104 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

7. Detached bungalow, mass concrete, pre-1978

Description

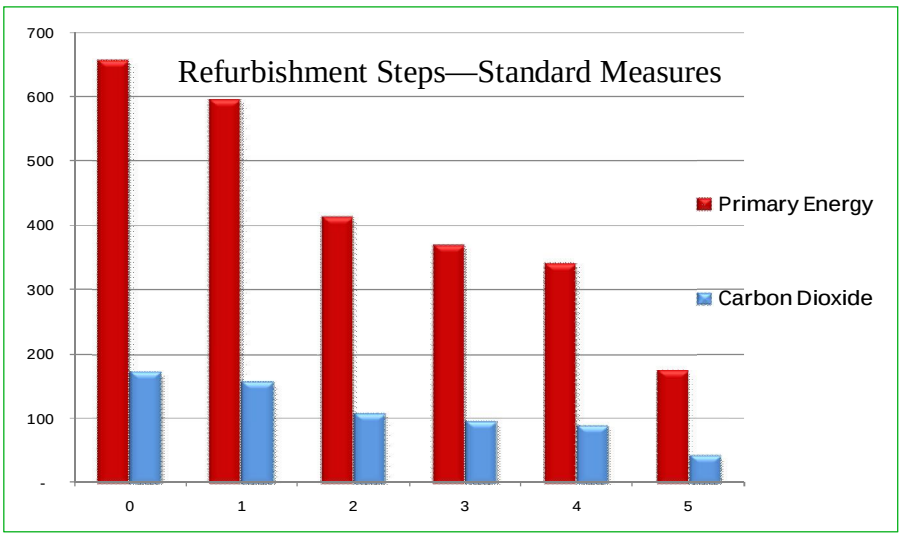
This house type very common in rural areas and towns in 1940s and 1950s. Mass concrete walls have good thermal mass and is suited for external insulation. Flat roof often in kitchen annex.

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, pipework uninsulated	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		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**657** (actual state)	**171** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	596	156	G
2	**Wall insulation**	Add	External wall insulation. Thickness: 70-100 mm	0.27	414	107	F
3	**Flat roof**	Add	Flat roof drylined or externally insulated, 80-110 mm	0.22	369	96	E2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors	2.0	341	88	E2
	Systems upgrade:						
5	**Space and water heating system and controls**	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.		**174**	**43**	**C1**

*also includes draughtstripping, 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**

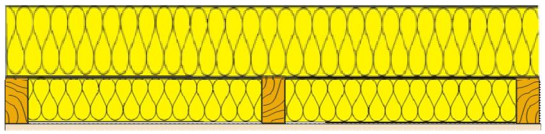
Measure	Estimated costs	Payback (y)
Step 1	€ 1,670	7.7
Step 2	€ 15,800	9.3
Step 3	€ 2,700	6.6
Step 4	€ 5,230	19.8
Step 5	€ 3,000	2.0
Total:	**€ 28,400**	**7.0**

Standard upgrade summary**

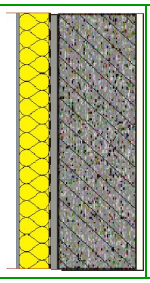
Consumption of primary energy reduced by:	**483 kWh/m²/y**
Emission of carbon dioxide reduced by:	**128 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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 uninsulated, U-value = 2.2 W/m^{2}K		External insulation added, EPS, urethane or phenolic boards, conductivity = 0.021 - 0.031 W/mK

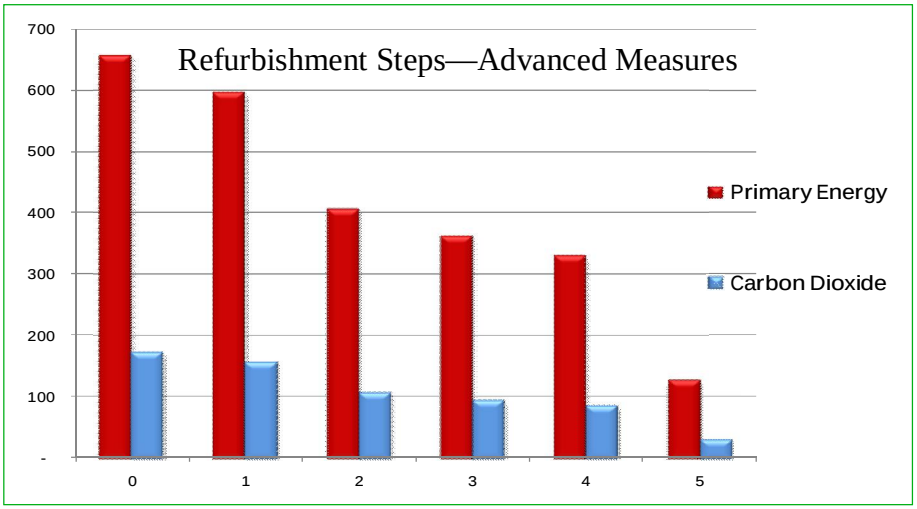
Heating system upgrade

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, 90% 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	**657** (actual state)	**171** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	596	156	G
2	**Wall insulation**	Add	External wall insulation, Thickness: 90-150 mm	0.21	407	106	F
3	**Flat roof**	Add	Flat roof drylined or externally insulated	0.22	363	94	E2
4	**Windows and Doors**	Replace	Insulated PVC/wooden doors Triple glazed, argon filled, low-e windows	2.0 1.3	331	85	E1
	Systems upgrade:						
5	**Space and water heating system and controls**	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. Mechanical ventilation with heat recovery (MVHR).		**128**	**30**	**B**

* package also includes draughtstripping, 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	€ 1,670	7.7
Step 2	€ 17,400	9.9
Step 3	€ 2,700	6.6
Step 4	€ 7,450	24.7
Step 5	€ 16,100	7.9
Total:	**€ 45,320**	**9.6**

Advanced upgrade summary**

Consumption of primary energy reduced by:	**529 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**141 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

8. Terraced house, mass concrete, pre-1978

Description

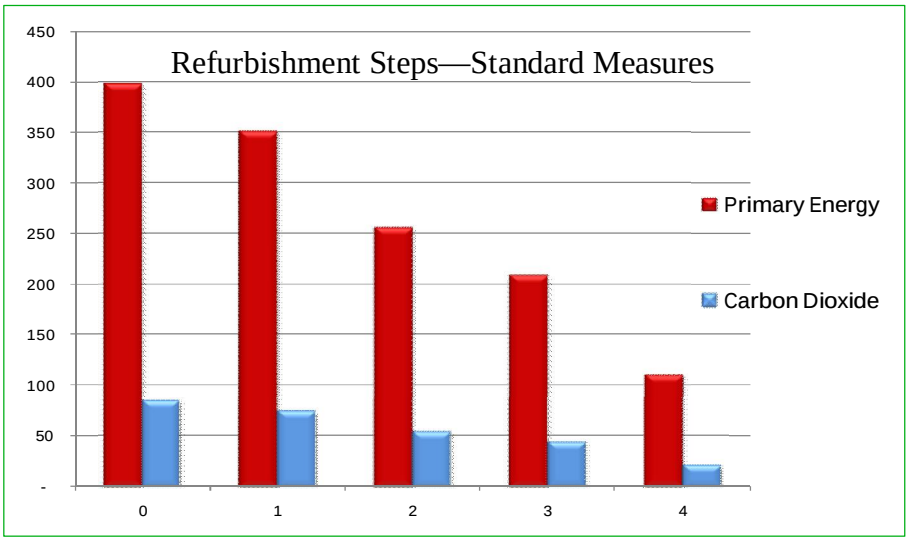
Terraced house, very common in Dublin in 1930s and 1940s. Originally built by Dublin Corporation with mass concrete walls and solid floors. This house type is an ideal candidate for external wall insulation as space is limited internally.

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, pipework uninsulated	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	**398** (actual state)	**85** (actual state)	**F**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	351	75	E2
2	**Wall insulation**	Add	External wall insulation. Thickness: 70-100 mm	0.27	257	55	D1
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors	2.0	209	44	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**112**	**22**	**B2**

*also includes draughtstripping, 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**

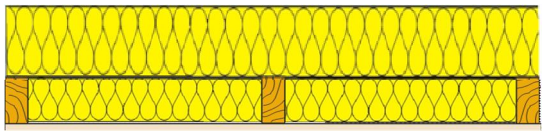
Measure	Estimated costs	Payback (y)
Step 1	€ 750	3.4
Step 2	€ 5,280	14.6
Step 3	€ 4,930	27.2
Step 4	€ 3,000	7.1
Total:	**€ 13,960**	**11.8**

Standard upgrade summary

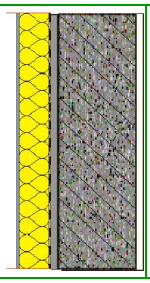
Consumption of primary energy reduced by:	**286 kWh/m²/y**
Emission of carbon dioxide reduced by:	**63 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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 uninsulated, U-value = 2.2 W/m^{2}K		External insulation added, EPS, urethane or phenolic boards, conductivity = 0.021 - 0.031 W/mK

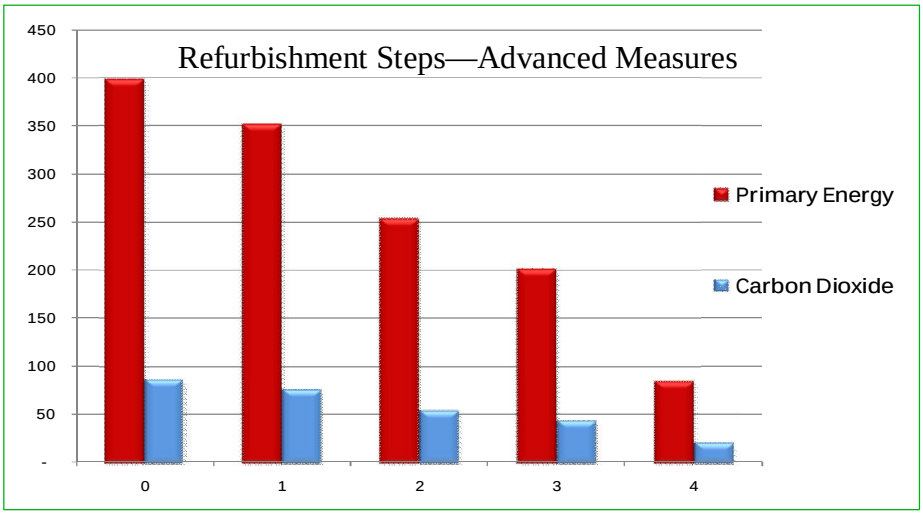
Heating system upgrade

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, 90% 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	**398** (actual state)	**85** (actual state)	**F**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	351	75	E2
2	**Wall insulation**	Add	External wall insulation. Thickness: 90-150 mm	0.21	254	54	D1
3	**Windows and Doors**	Replace	Insulated PVC/wooden doors Triple glazed, argon filled, low-e windows	2.0 1.3	201	43	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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).		**85**	**20**	**B1**

* package also includes draughtstripping, 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	€ 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**

Advanced upgrade summary

Consumption of primary energy reduced by:	**313 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**65 kg CO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

9. Bungalow, hollow block, pre-1978

Description

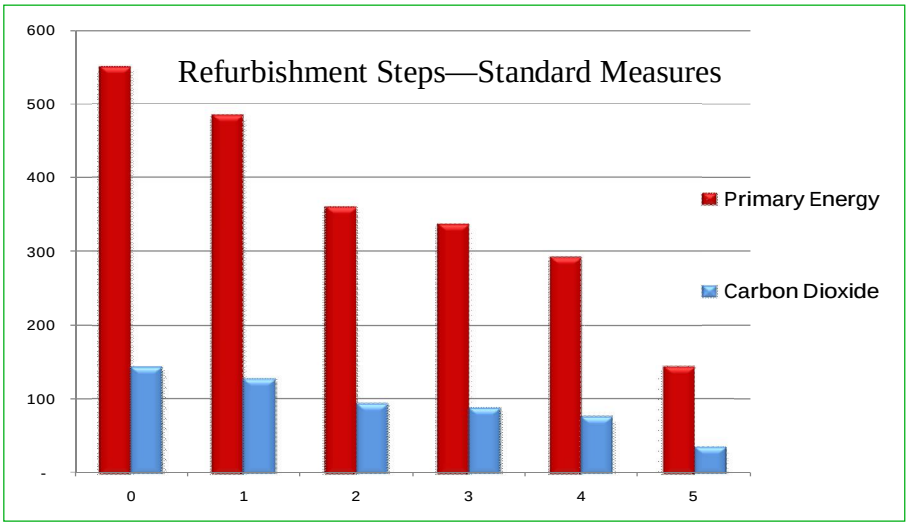
1950s detached bungalow with uninsulated 9 inch (225mm) hollow block walls, uninsulated suspended timber floors and a standard pitched roof insulated at ceiling level between the attic joists. This house type is located in the Dublin and east coast areas in particular.

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, pipework uninsulated.	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	**549** (actual state)	**142** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists.	0.13	485	126	G
2	**Wall insulation**	Add	70-100 mm external insulation, main and extension walls (phenolic/urethane/EPS)	0.24-0.27	360	93	E2
3	**Flat roof insulation**	Add	External insulation or drylining boards (urethane/ phenolic) , 100-110 mm	0.22	337	87	E1
4	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap, Insulated doors.	2.0	292	75	D2
	Systems upgrade:						
5	**Space and water heating system and controls**	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.		**143**	**35**	**B3**

*also includes draughtstripping, 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**

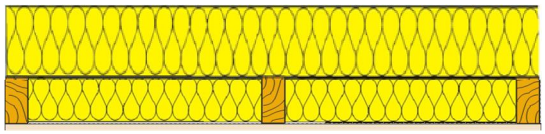
Measure	Estimated costs	Payback (y)
Step 1	€ 2,360	3.1
Step 2	€ 13,050	8.5
Step 3	€ 1,900	6.7
Step 4	€ 9,150	16.5
Step 5	€ 3,500	2.0
Total:	**€ 29,960**	**6.1**

Standard upgrade summary

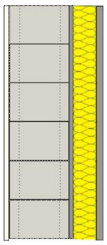
Consumption of primary energy reduced by:	**406 kWh/m²/y**
Emission of carbon dioxide reduced by:	**107 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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)

Before		After	
	Concrete hollow block with render outside and plasterwork inside, uninsulated. U-value =2.4 W/m^{2}K		External insulation added, 70 - 120 mm thick EPS, phenolic or urethane boards with conductivity = 0.021-0.035 W/mK

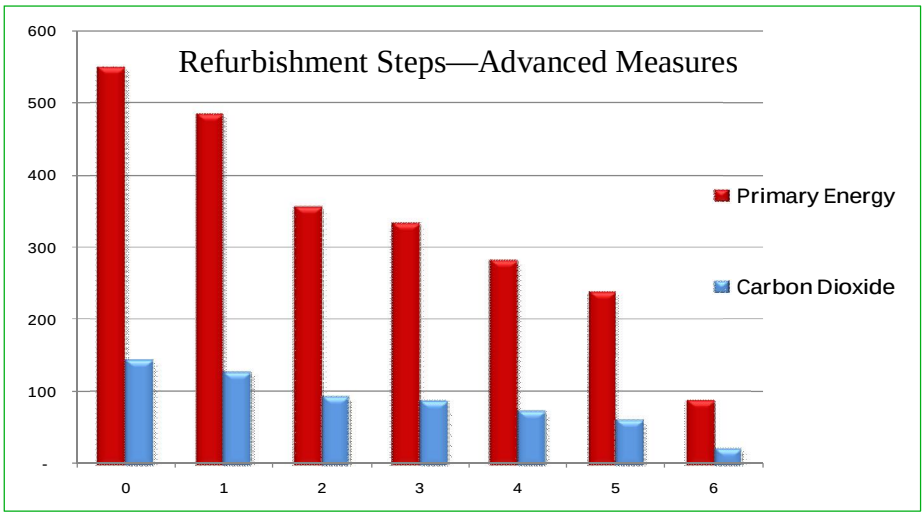
Heating system upgrade

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, 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, 90% 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	**549** (actual state)	**142** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists.	0.13	485	126	G
2	**Wall insulation**	Add	External wall insulation. Thickness: 90-150 mm	0.21	356	92	E2
3	**Flat roof insulation**	Add	External urethane/phenolic insulation, 100-110 mm	0.22	333	86	E1
4	**Windows and Doors**	Replace	Triple glazed, argon filled low-e windows, Insulated doors.	1.3 2.0	283	73	D2
5	**Floors**	Add	Add insulation between the floor joists 70-100mm	0.25	239	61	D1
	Systems upgrade:						
6	**Space and water heating system and controls**	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. Mechanical ventilation with heat recovery (MVHR).		**89**	**21**	**B1**

* package also includes draughtstripping, 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	€ 2,360	3.1
Step 2	€ 14,400	9.1
Step 3	€ 1,900	6.6
Step 4	€ 12,400	20.0
Step 5	€ 6,800	12.8
Step 6	€ 18,100	9.2
Total	**€ 55.960**	**9.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**460 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**121 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

10. Semi detached, hollow block walls, pre-1978

Description

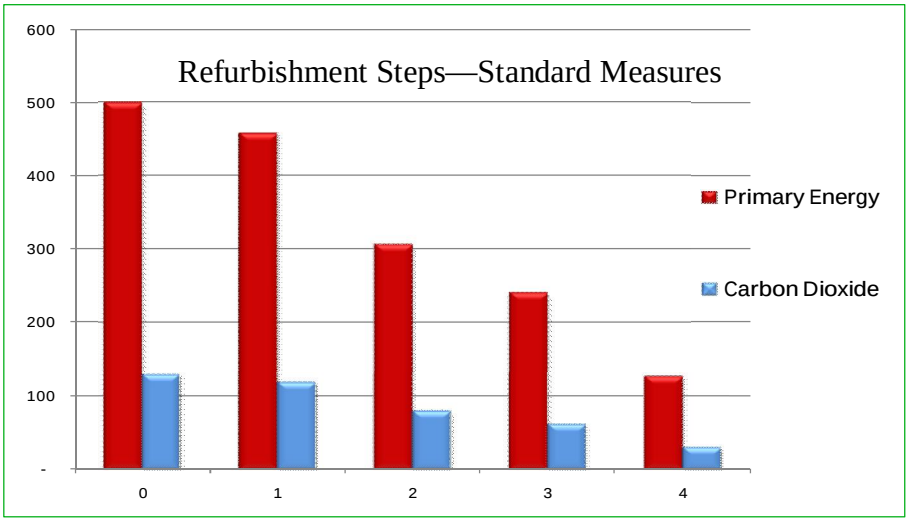
Semi-detached house with a brick-cavity-block front wall and hollow block walls to side & rear. All walls would be uninsulated. This construction was common from the 1950s up to the end of the 1970s in Dublin and along the East Coast but can be found in Cork too.

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, pipework uninsulated	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		

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**499** (actual state)	**129** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	458	119	G
2	**Wall insulation**	Add	Gable and rear– internal drylining, 82.5 mm urethane/ phenolic boards Front - cavity fill, 60mm	0.27 0.48	308	79	E1
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated doors.	2.0	242	62	D1
	Systems upgrade:						
4	**Space and water heating system and controls**	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**	**31**	**B3**

*also includes draughtstripping, 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**

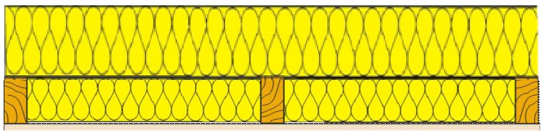
Measure	Estimated costs	Payback (y)
Step 1	€ 1,280	3.3
Step 2	€ 7,400	4.7
Step 3	€ 9,430	13.8
Step 4	€ 3,500	3.1
Total:	**€ 21,610**	**5.7**

Standard upgrade summary

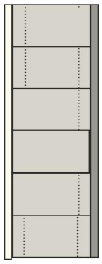
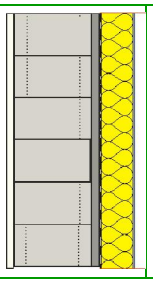
Consumption of primary energy reduced by:	**371 kWh/m²/y**
Emission of carbon dioxide reduced by:	**98 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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, 90 - 120 mm thick EPS, phenolic or urethane boards with conductivity = 0.021-0.035W/mK

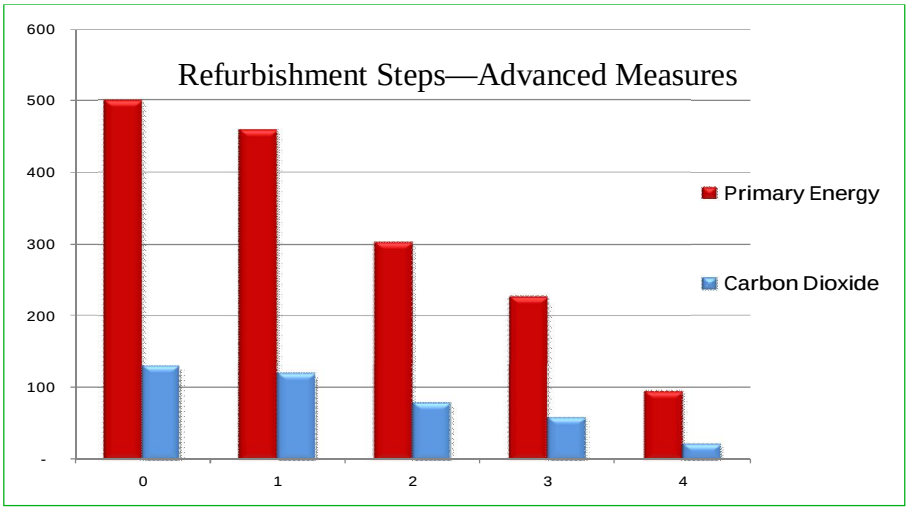
Heating system upgrade

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, 90% 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	**499** (actual state)	**129** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	458	119	G
2	**Wall insulation**	Add	Gable and rear– external insulation, 90-150 mm Front - cavity fill, 60mm	0.21 0.48	303	78	E1
3	**Windows and Doors**	Add	Insulated PVC/wooden doors Triple glazed, argon filled, low-e windows	2.0 1.3	228	58	D1
	Systems upgrade:						
4	**Space and water heating system and controls**	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).		**94**	**22**	**B1**

* package also includes draughtstripping, 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	€ 1,280	3.3
Step 2	€ 12,800	6.4
Step 3	€ 13,050	30.6
Step 4	€ 13,100	8.7
Total:	**€ 40,230**	**9.3**

Advanced upgrade summary

Consumption of primary energy reduced by:	**405 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**107 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

11. Terraced house, hollow block walls pre-1978

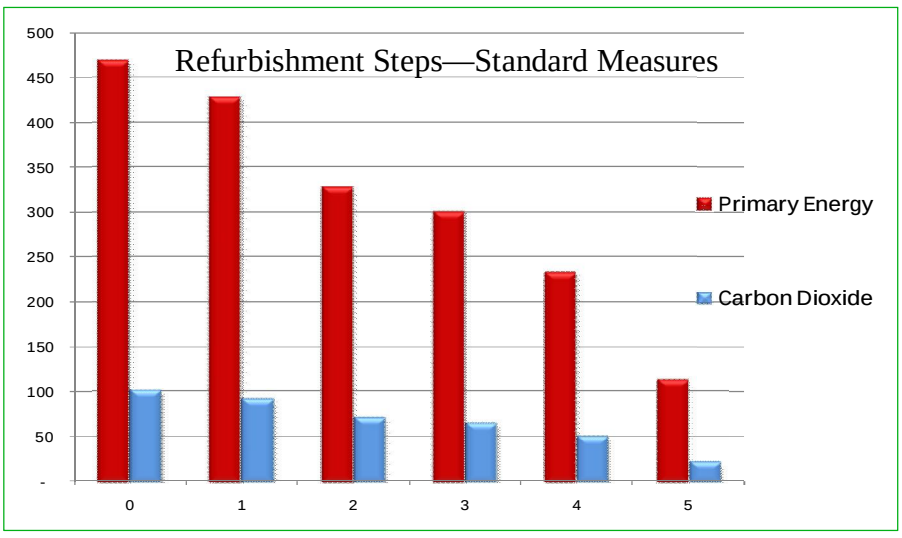
Description

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. Uninsulated 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, pipework uninsulated	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	**468** (actual state)	**100** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joists	0.13	428	91	F
2	**Wall insulation**	Add	Hollow block walls– internal drylining, 82.5 mm urethane/phenolic boards Front - cavity fill, 60mm	0.27 0.48	328	70	E1
3	**Flat roof and floor over the garage**	Add	Phenolic / urethane drylining boards, 70-100 mm	0.22	301	64	E1
4	**Windows and Doors**	Replace	Double glazed, low-e windows and doors, air filled, 16mm gap	2.0	233	50	D1
	Systems upgrade:						
5	**Space and water heating system and controls**	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.		**114**	**22**	**B2**

*also includes draughtstripping, 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**

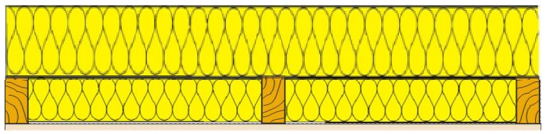
Measure	Estimated costs	Payback (y)
Step 1	€ 1,360	4.4
Step 2	€ 6,400	10.2
Step 3	€ 2,200	12.5
Step 4	€ 11,400	26.6
Step 5	€ 3,000	3.7
Total:	**€ 24,360**	**10.3**

Standard upgrade summary

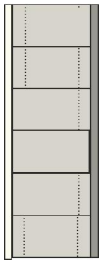
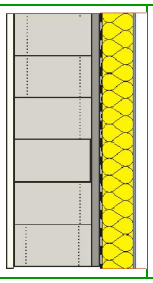
Consumption of primary energy reduced by:	**354 kWh/m²/y**
Emission of carbon dioxide reduced by:	**78 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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, 90 - 120 mm thick EPS, phenolic or urethane boards with conductivity = 0.021-0.035 W/mK

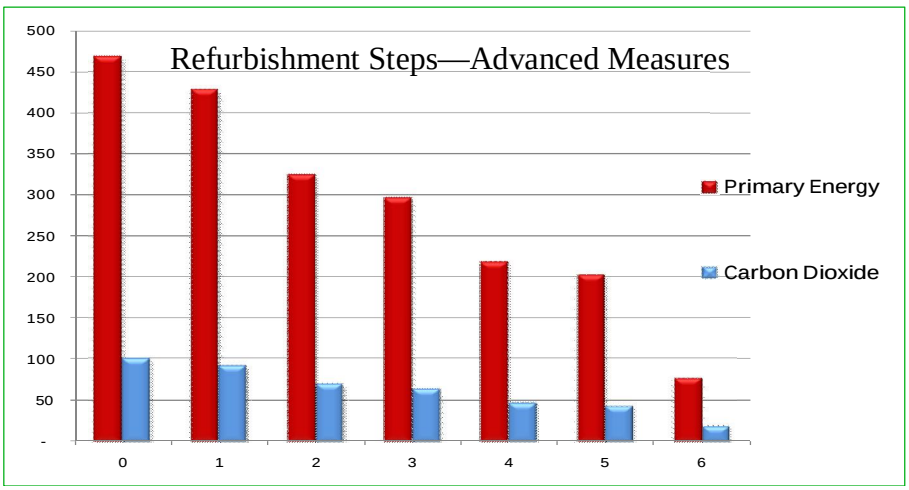
Heating system upgrade

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, 90% 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	**468** (actual state)	**100** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm of mineral wool between and over the ceiling joist	0.13	428	91	F
2	**Wall insulation**	Add	All walls: external insulation. Thickness 90-150 mm	0.21	325	69	E1
3	**Flat roof and floor over the garage**	Add	Phenolic / urethane drylining boards, 70-100 mm	0.22	297	63	D2
4	**Windows and Doors**	Replace	Insulated PVC/wooden doors, Triple glazed, argon filled, low-e windows	2.0 1.3	219	47	C3
5	**Suspended floor**	Add	70-100 mm of insulation boards between the floor joists	0.25	203	43	C3
	Systems upgrade:						
6	**Space and water heating system and controls**	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).	**77**	**18**	**B1**

* package also includes draughtstripping, 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	€ 1,360	4.4
Step 2	€ 12,200	18,7
Step 3	€ 2,220	12.6
Step 4	€ 16,000	32.7
Step 5	€ 3,630	36.4
Step 6	€ 13,100	18.9
Total:	**€ 48,510**	**20**

Advanced upgrade summary

Consumption of primary energy reduced by:	**391 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**82 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

12. Detached Bungalow, cavity walls pre-1978

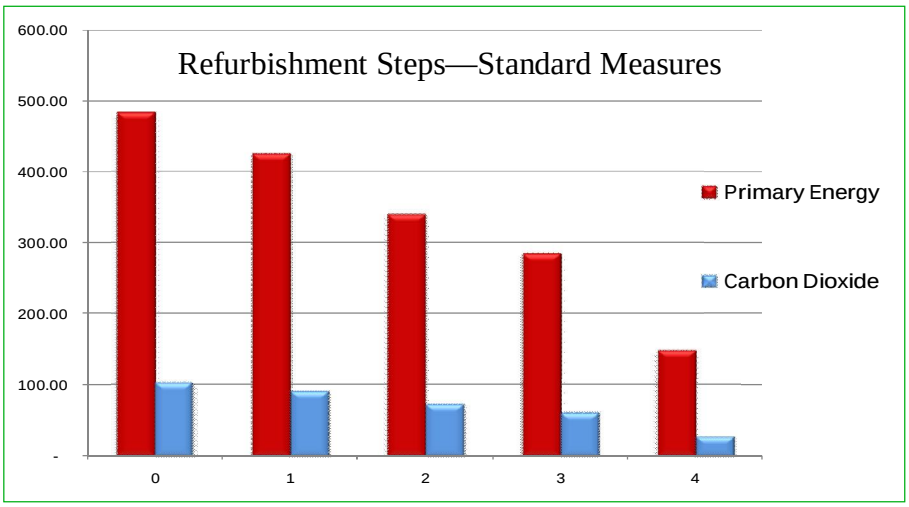
Description: Very common house construction in most of rural Ireland during 1960s and 1970s. Typically has 100mm empty cavity in walls that can be pumped with insulation beads.

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, pipework uninsulated	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		

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)	**102** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists	0.13	425	90	F
2	**Wall insulation**	Add	100mm cavity filled with beads.	0.32	340	72	E2
3	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated Doors	2.0	286	60	D2
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**149**	**28**	**B3**

*also includes draughtstripping, 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**

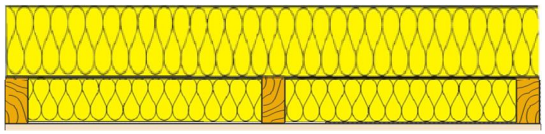
Measure	Estimated costs	Payback (y)
Step 1	€1,600	2.9
Step 2	€900	1.1
Step 3	€9,425	16.9
Step 4	€3,000	2.2
Total:	**€14,925**	**4.5**

Standard upgrade summary

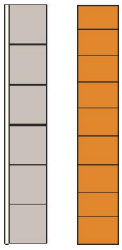
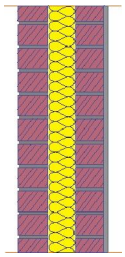
Consumption of primary energy reduced by:	**334 kWh/m²/y**
Emission of carbon dioxide reduced by:	**74 kg CO_2/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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)

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

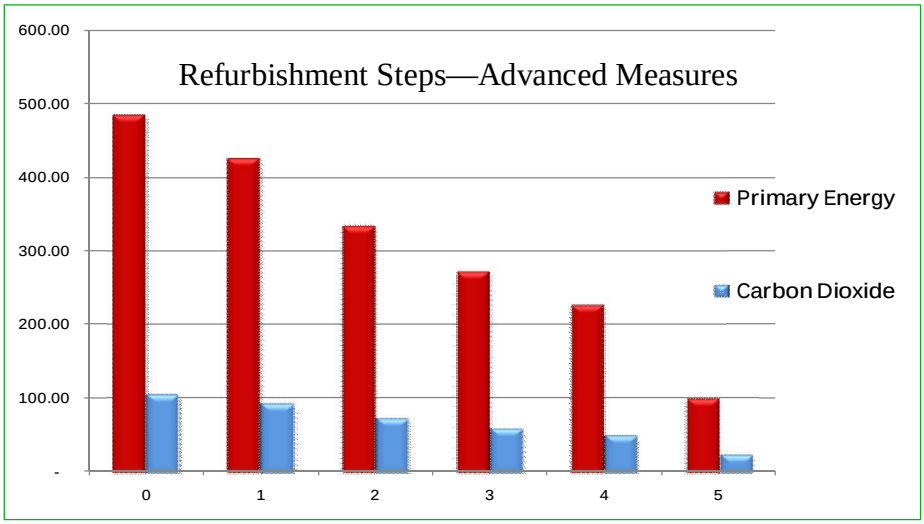
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	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, 90% 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)	**103** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists	0.13	425	90	F
2	**Wall insulation**	Add	Cavity walls filled with beads with combination of external wall insulation	0.21	334	70	E1
3	**Windows and Doors**	Replace	Triple glazed, low-e windows, argon filled	1.3	271	57	D2
4	**Floors**	Add	Insulation boards between the floor joists	0.25	226	47	D1
	Systems upgrade:						
5	**Space and water heating system and controls**	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).		**98**	**23**	**B1**

* package also includes draughtstripping, 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	€1,600	2.9
Step 2	€11,500	12.3
Step 3	€13,050	20.5
Step 4	€2,750	6.0
Step 5	€11,100	7.8
Total:	**€40,000**	**10**

Advanced upgrade summary

Consumption of primary energy reduced by:	**385 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**80 kg CO$_2$/m^2 /y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

INTELLIGENT ENERGY EUROPE

13. End of terrace house, cavity walls, pre-1978

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 Flat roof - 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

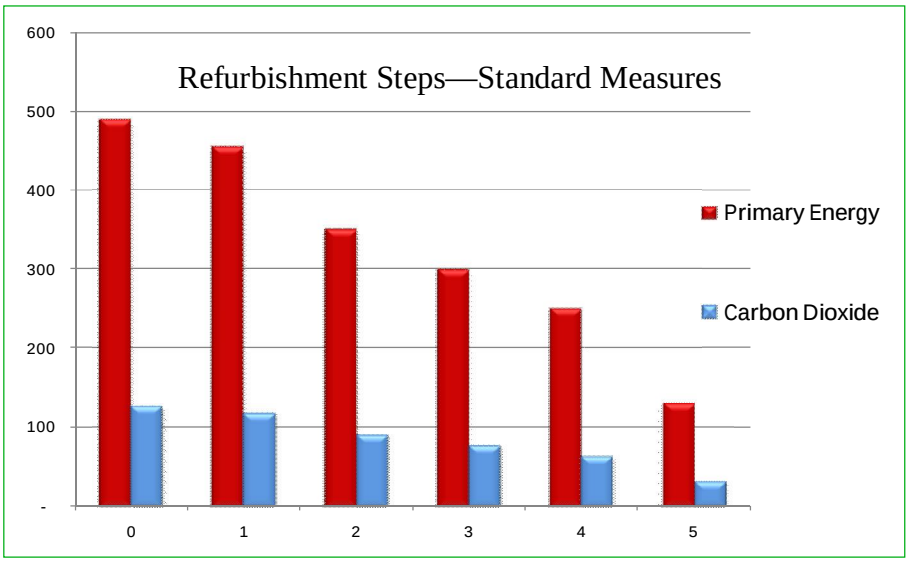
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipework uninsulated.	Heating oil	65%
Secondary	Open fire in grate	Solid, smoke-less	30%
Hot water	From primary heating system. Electric immersion heater is used in summer.		
Cylinder	No thermostat, insulated with 25mm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

Description

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

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**489** (actual state)	**126** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists.	0.13	455	118	G
2	**Wall insulation**	Add	100 mm cavity fill (beads)	0.32	352	91	E2
3	**Flat roof insulation**	Add	110 mm rigid urethane/phenolic boards	0.22	301	77	E1
4	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap, PVC/wooden doors, insulated.	2.0	251	64	D1
	Systems upgrade:						
5	**Space and water heating system and controls**	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.		**131**	**32**	**B3**

*also includes draughtstripping, 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	€ 780	2.6
Step 2	€ 990	0.9
Step 3	€ 3,400	6.7
Step 4	€ 9,750	19.1
Step 5	€ 3,000	2.6
Total:	**€ 17,920**	**5.1**

Standard upgrade summary

Consumption of primary energy reduced by:	**358 kWh/m²/y**
Emission of carbon dioxide reduced by:	**94 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

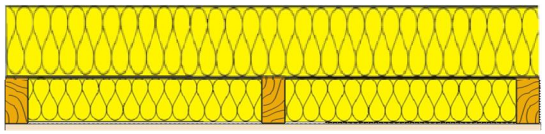
Typical roof upgrade (standard/advanced)

50mm of mineral wool between ceiling joists

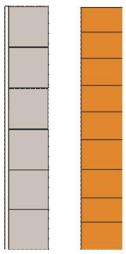
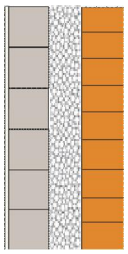
Before:

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

After:



Typical wall upgrade (standard)

Before		After	
	Empty cavity walls, outer brick and inner block with plaster-work, uninsulated. 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

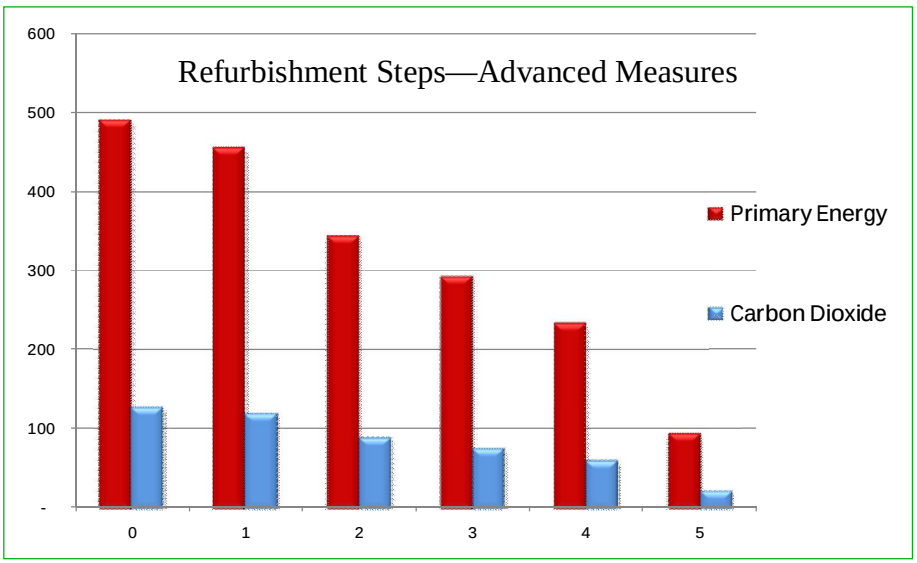
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular 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, 90% 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	**490** (actual state)	**126** (actual state)	**G**
1	**Roof insulation and standard package***	Add	250 mm mineral wool between and over the ceiling joists.	0.13	455	118	G
2	**Wall insulation**	Add	Cavity fill with combination of external insulation or drylining (50-80 mm)	0.21	344	88	E2
3	**Flat roof insulation**	Add	110 mm rigid urethane/phenolic boards	0.22	293	75	D2
4	**Windows and Doors**	Replace	Triple glazed low-e windows, argon filled, 16mm gap. PVC or wooden doors.	1.3 2.0	233	59	D1
	Systems upgrade:					
5	**Space and water heating system and controls**	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)		**93**	**22**	**B1**

* package also includes draughtstripping, 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	€ 780	2.6
Step 2	€ 12,500	11.0
Step 3	€ 3,400	6.6
Step 4	€ 13,500	22.5
Step 5	€ 11,100	7.3
Total:	**€ 41,280**	**10.1**

Advanced upgrade summary

Consumption of primary energy reduced by:	**397 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**104 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

14. Top floor apartment, solid brick / concrete wall, pre 1978

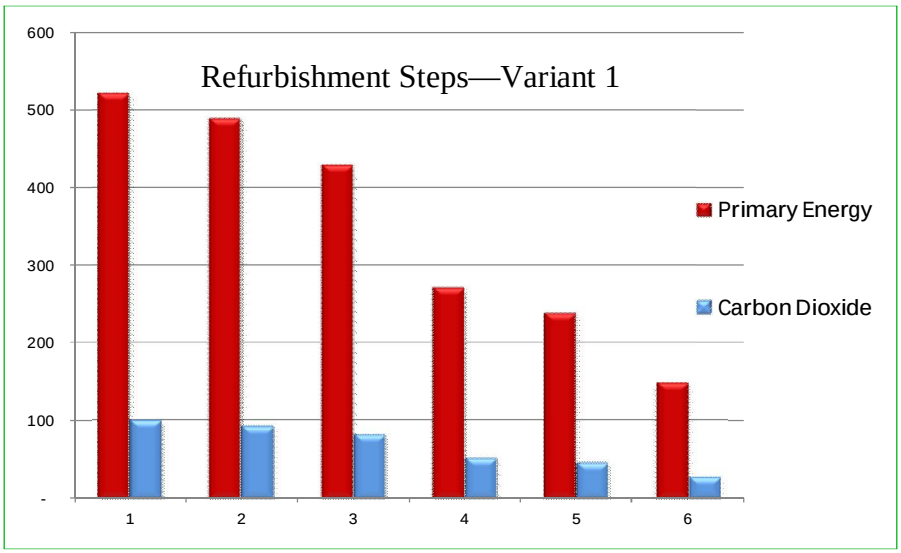
Description

Top floor flat of 1940s 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.

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

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	**522** (actual state)	**99** (actual state)	**G**
1	**Basic measures**	Add	100% Draughtstripping, Replacing all bulbs with CFLs, Installing 80 mm lagging jacket on the cylinder	n.a.	490	92	G
2	**Wall insulation**	Add	Internal drylining. 52.5 mm thick phenolic /urethane boards	0.5	430	81	F
3	**Roof insulation**	Add	Internal drylining. 52.5 mm thick phenolic /urethane boards	0.5	272	52	D2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated solid doors	1.6 2.0	239	46	D1
	Systems upgrade:						
5	**Space and water heating system and controls**	Replace	Condensing boiler 90% efficient with room thermostat and TRVs, independent water heating. Hot water cylinder insulated with 50 mm spray foam.		**149**	**28**	**B3**



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

Estimated costs and payback time*

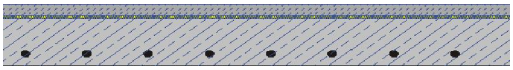
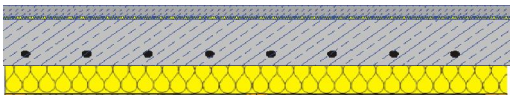
Measure	Estimated costs	Payback (y)
Step 1	€ 140	1.4
Step 2	€ 1,625	12.3
Step 3	€ 2,990	8.7
Step 4	€ 2,450	33.8
Step 5	€ 3,000	12.4
Total:	**€ 10,205**	**11.5**

Standard upgrade summary

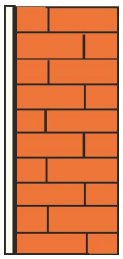
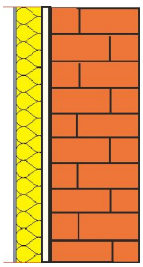
Consumption of primary energy reduced by:	**373 kWh/m²/y**
Emission of carbon dioxide reduced by:	**71 kg CO_2/m²/y**

*Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade

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

Typical wall upgrade

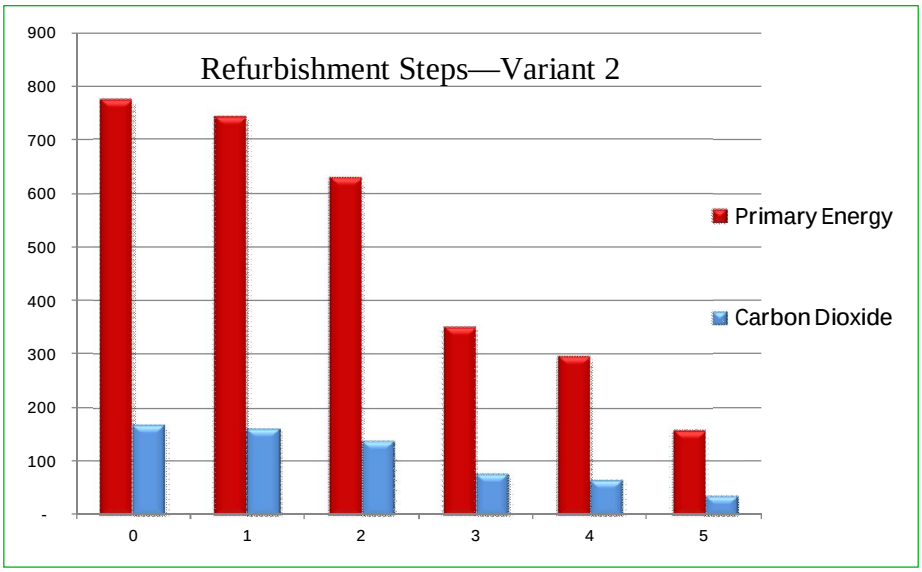
Before		After	
	Solid brick wall 325 mm, uninsulated, U-value = 2.1 W/m^{2}K		Internal insulation added, (on dabs or timber battens)- urethane or phenolic boards, conductivity = 0.021 - 0.025 W/mK

Heating system upgrade

Feature:	Variant 1—gas	Variant 2—electric
Heat generator	Regular condensing boiler	Air to air heat pump
Efficiency:	90%	360%
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:	Natural	Natural

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	**772** (actual state)	**166** (actual state)	**G**
1	**Basic measures**	Add	100% Draughtstripping, Replacing all bulbs with CFLs, Installing 80 mm lagging jacket on the cylinder	n.a.	742	160	G
2	**Wall insulation**	Add	Internal drylining. 52.5 mm thick phenolic /urethane boards	0.5	628	135	G
3	**Roof insulation**	Add	Internal drylining. 52.5 mm thick phenolic /urethane boards	0.5	351	76	E2
4	**Windows and Doors**	Replace	Double glazed, low-e windows, air filled, 16mm gap Insulated solid doors	1.6 2.0	297	64	D2
	Systems upgrade:						
5	**Space and water heating system and controls**	Replace	Air to air heat pump, 250% efficient, individual temperature controls for each room. High efficiency hot water cylinder, heated by the immersion heater.		**156**	**34**	**C1**



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	€ 140	1.9
Step 2	€ 1,625	7.6
Step 3	€ 2,990	5.8
Step 4	€ 2,450	24.1
Step 5	€ 4,300	22
Total:	**€ 11,505**	**10.4**

Advanced upgrade summary

Consumption of primary energy reduced by:	**616 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**132 kgCO$_2$/m^2/y**

*Note: 1. Costs are indicative only, based on typical prices (2011). 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

15. Detached house, cavity walls, 1978-1982

Description

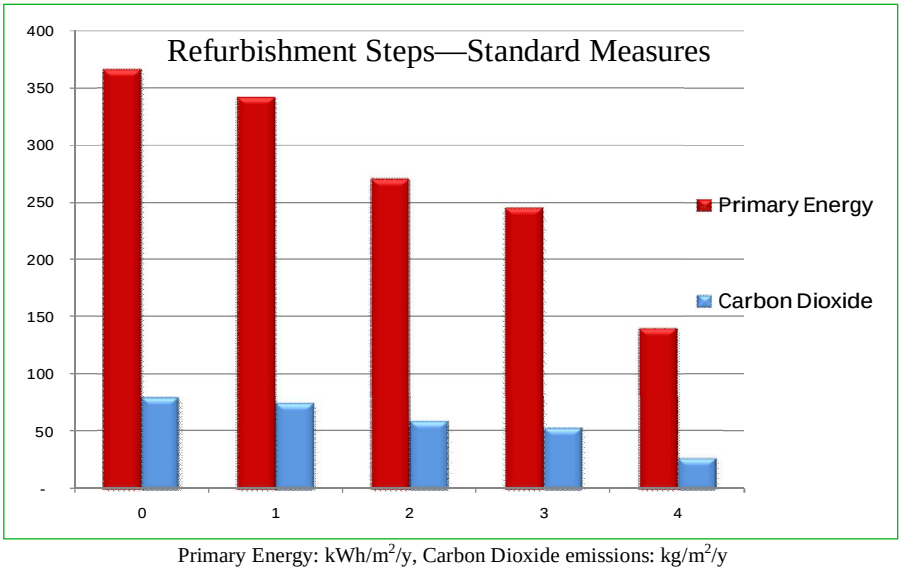
Red-brick fronted detached house with cavity wall construction, i.e. wall contains a 100mm cavity part-filled with a 50mm insulation board. More commonly found outside of Dublin and neighbouring counties.

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, pipework uninsulated.	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		

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**366** (actual state)	**79** (actual state)	**E2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	341	73	E2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads	0.41 (for 50mm)	270	58	D2
3	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap. Insulated PVC/wooden doors.	2.0	245	52	D1
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**140**	**27**	**B3**

*also includes draughtstripping, 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**

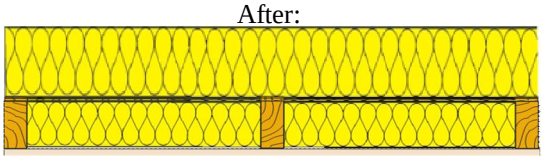
Measure	Estimated costs	Payback (y)
Step 1	€ 830	4.3
Step 2	€ 1,600	3.8
Step 3	€ 8,200	55.6
Step 4	€ 3,000	4.5
Total:	**€ 13,630**	**9.5**

Standard upgrade summary

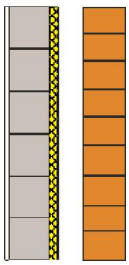
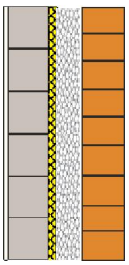
Consumption of primary energy reduced by:	**226 kWh/m²/y**
Emission of carbon dioxide reduced by:	**52 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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 roof 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

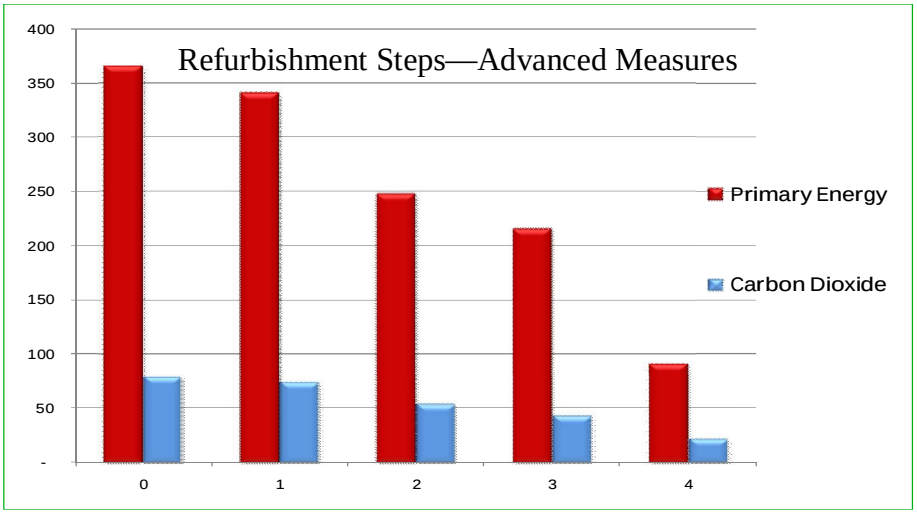
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Ground source heat pump
Efficiency:	90%	400%
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, 90% 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	**366** (actual state)	**79** (actual state)	**E2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	341	73	E2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads, with combination of drylining (front) and external wall insulation (sides and rear). Thickness: 50-100 mm	0.21	248	53	D1
3	**Windows and Doors**	Replace	Triple glazed low-e windows, argon filled, 16mm gap Insulated doors.	1.3 2.0	216	43	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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).	**92**	**22**	**B1**

* package also includes draughtstripping, 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	€ 830	4.3
Step 2	€ 20,100	37.1
Step 3	€ 11,050	59.2
Step 4	€ 18,100	30.8
Total:	**€ 50,080**	**33.2**

Advanced upgrade summary

Consumption of primary energy reduced by:	**274 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 (2011). 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

16. Terraced house, cavity walls, 1978-1982

Description

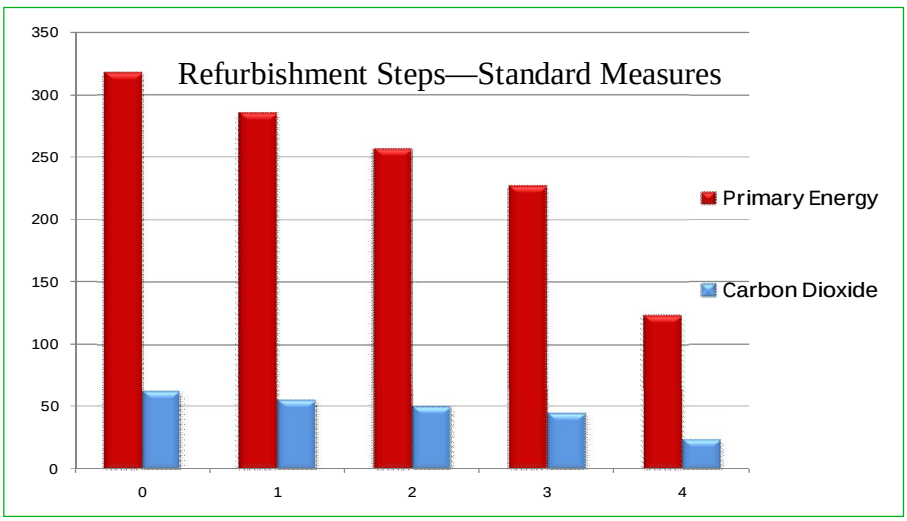
Terraced house with cavity walls containing 25mm insulation boards. This one was found in Dublin but it could be anywhere in Ireland. This house is a perfect candidate for cavity wall insulation. Solid floors were standard for this period and so floor insulation options are limited.

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, pipework uninsulated.	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	**318** (actual state)	**62** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	286	55	D2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads	0.41 (for 50mm)	257	50	D1
3	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap, Insulated doors	2.0	227	44	D1
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**124**	**24**	**B2**

*also includes draughtstripping, 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**

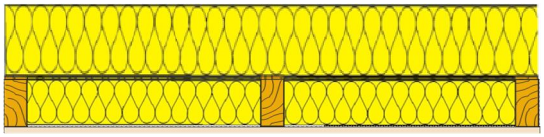
Measure	Estimated costs	Payback (y)
Step 1	€ 620	3.8
Step 2	€ 460	3.9
Step 3	€ 5,850	18.3
Step 4	€ 3,000	11.4
Total:	**€ 9,930**	**11.5**

Standard upgrade summary

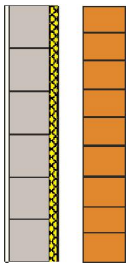
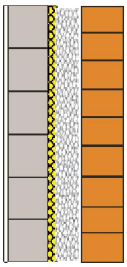
Consumption of primary energy reduced by:	**194 kWh/m²/y**
Emission of carbon dioxide reduced by:	**38 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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 roof 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

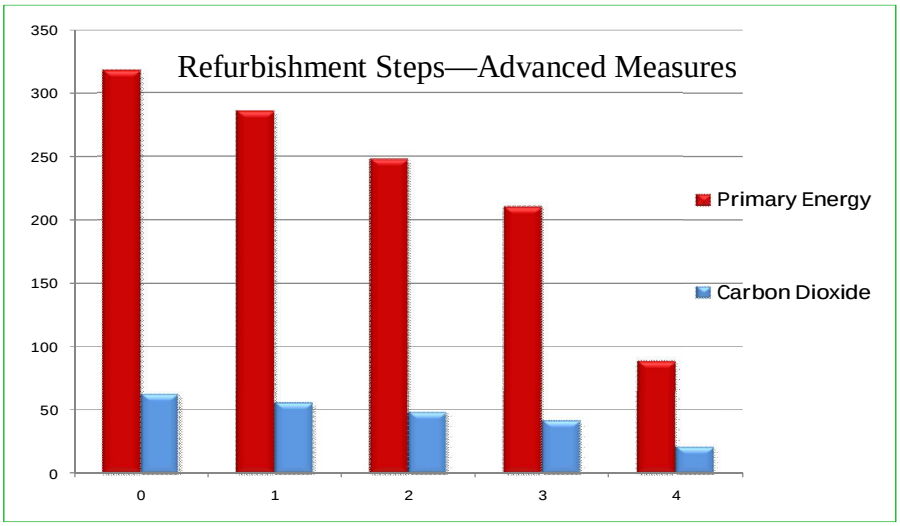
Heating system upgrade

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, 90% 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	**318** (actual state)	**62** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	286	55	D2
2	**Wall insulation**	Add	50-80 mm of remaining cavity filled with beads, with combination of drylining (front) and external wall insulation (rear). Thickness: 50-100 mm	0.21	248	48	D1
3	**Windows and Doors**	Replace	Triple glazed low-e windows and doors, argon filled, 16mm gap.	1.3	210	41	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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).		**89**	**21**	**B1**

* package also includes draughtstripping, 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	€ 620	3.8
Step 2	€ 4,720	31.2
Step 3	€ 8,100	54.1
Step 4	€ 11,100	27.0
Total:	**€ 24,540**	**28.1**

Advanced upgrade summary

Consumption of primary energy reduced by:	**229 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**41 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

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

Description

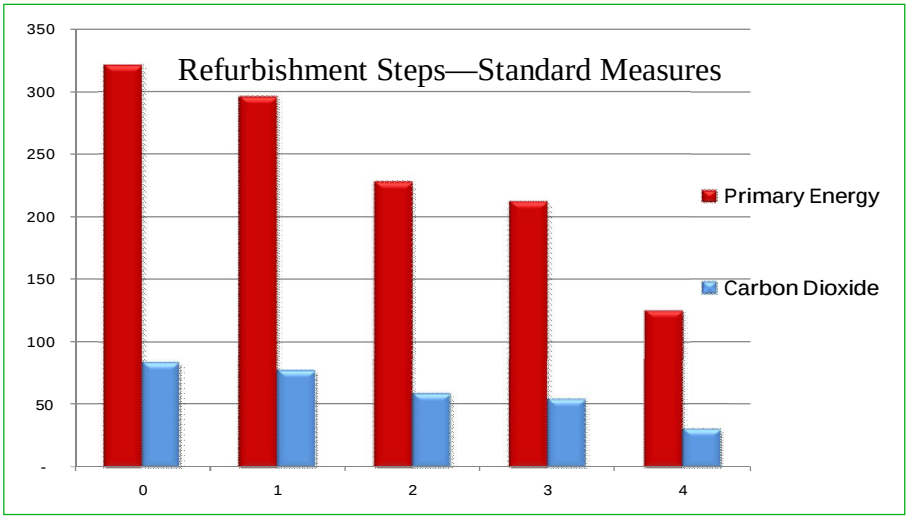
Detached house with hollow block walls. These walls would be dry-lined internally with perhaps 25mm of insulation board on timber battens or else 50mm of fibre insulation may be placed between the battens.

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	Efficiency
Primary	Central heating boiler, pipework uninsulated.	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	**322** (actual state)	**83** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	296	77	D2
2	**Wall insulation**	Replace insulation	Walls re-drylined with 82.5mm phenolic/urethane boards.	0.27	228	59	D1
3	**Windows and Doors**	Replace	Double glazed low-e windows and doors, air filled, 16mm gap	2.0	212	55	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**126**	**31**	**B3**

*also includes draughtstripping, 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**

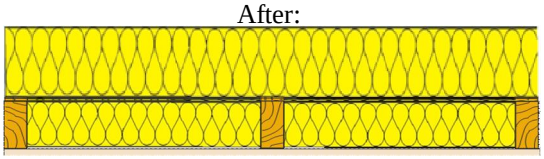
Measure	Estimated costs	Payback (y)
Step 1	€ 1,060	3.9
Step 2	€ 14,780	17.3
Step 3	€ 6,250	11.9
Step 4	€ 3,500	5.0
Total:	**€ 25,590**	**10.9**

Standard upgrade summary

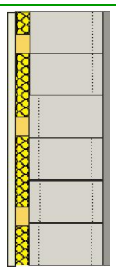
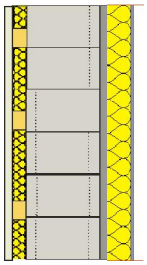
Consumption of primary energy reduced by:	**196 kWh/m²/y**
Emission of carbon dioxide reduced by:	**52 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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 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 walls, drylined insulation between the timber battens, U-value =1.1 W/m^{2}K		External wall insulation added, urethane, phenolic or EPS boards, thickness: 80-120mm, conductivity = 0.021—0.031 W/mK

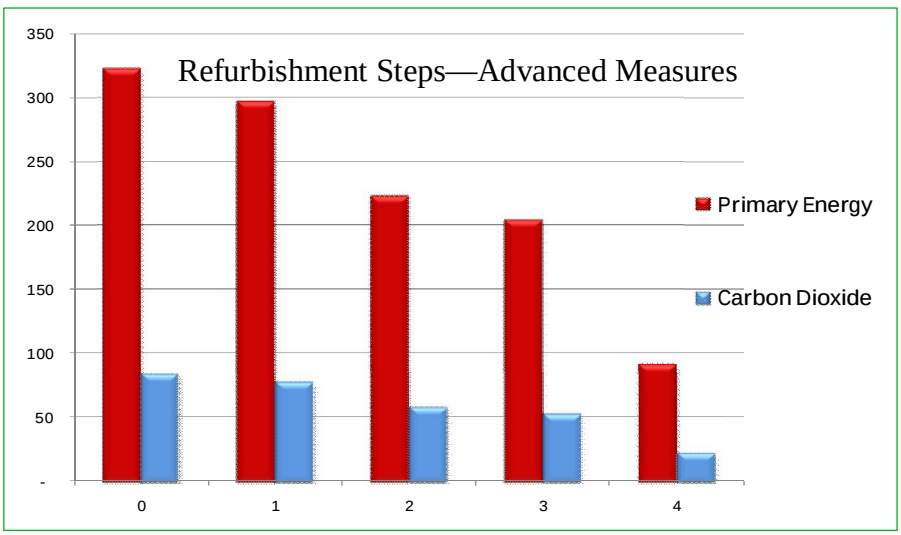
Heating system upgrade

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, 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, 90% 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	**322** (actual state)	**83** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	296	77	D2
2	**Wall insulation**	Add	Walls insulated externally with 80-120 mm thick insulation boards	0.21	223	57	C3
3	**Windows and Doors**	Replace	Triple glazed low-e windows and doors, argon filled, 16mm gap	1.3	204	52	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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. Mechanical ventilation with heat recovery (MVHR).		**92**	**22**	**B1**

* package also includes draughtstripping, 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	3.9
Step 2	€ 19,800	21.5
Step 3	€ 8,250	34.7
Step 4	€ 18,100	11.8
Total:	**€ 47,210**	**12.2**

Advanced upgrade summary

Consumption of primary energy reduced by:	**230 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**55 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

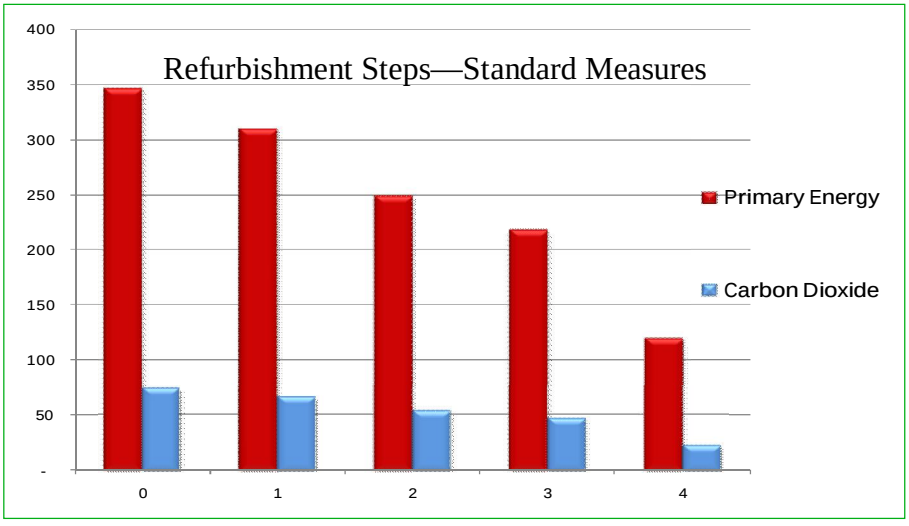
18. Terraced house, hollow block, 1978-1982

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 drylined with 25mm polystyrene board or with 50mm of insulation fibre between battens.

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, pipework uninsulated.	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.		

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**346** (actual state)	**74** (actual state)	**E2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	310	66	E1
2	**Wall insulation**	Replace insulation	Walls re-drylined with 82.5mm phenolic/urethane boards.	0.27	249	53	D1
3	**Windows and Doors**	Replace	Double glazed low-e windows, air filled, 16mm gap Insulated doors.	2.0	218	46	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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.		**120**	**23**	**B2**

*also includes draughtstripping, 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**

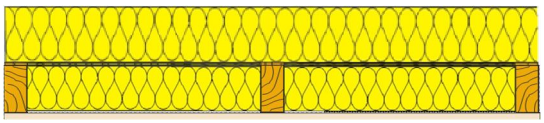
Measure	Estimated costs	Payback (y)
Step 1	€ 680	3.8
Step 2	€ 6,160	25.9
Step 3	€ 7,200	59.6
Step 4	€ 3,000	6.8
Total:	**€ 17,040**	**17.5**

Standard upgrade summary

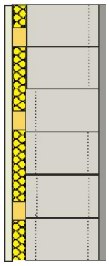
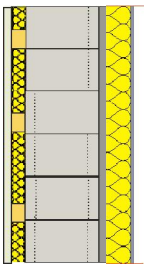
Consumption of primary energy reduced by:	**226 kWh/m²/y**
Emission of carbon dioxide reduced by:	**51 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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 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 walls, drylined insulation between the timber battens, U-value =1.1 W/m^{2}K		External wall insulation added, urethane, phenolic or EPS boards, thickness: 80-120mm, conductivity = 0.021—0.031 W/mK

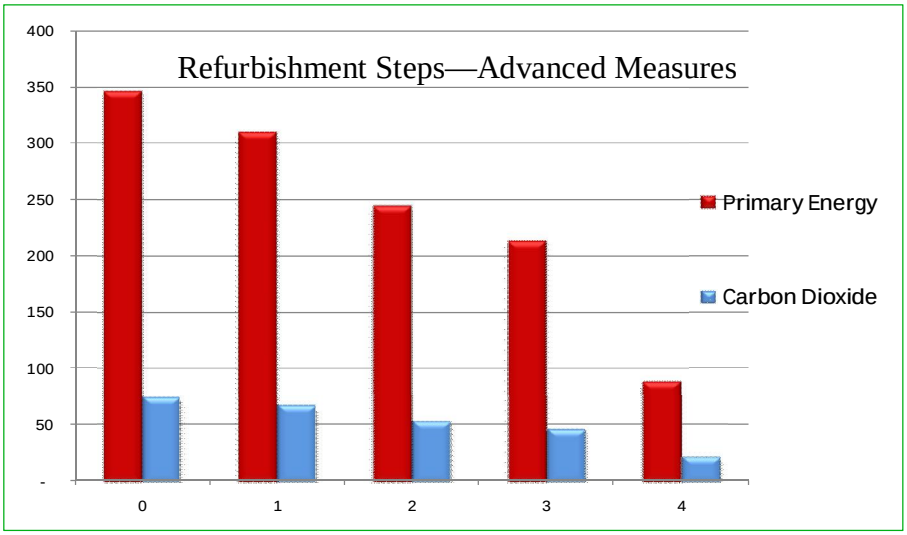
Heating system upgrade

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, 90% 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	**346** (actual state)	**74** (actual state)	**E2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	310	66	E1
2	**Wall insulation**	Add	Walls insulated externally with 80-120 mm thick insulation boards	0.21	244	52	D1
3	**Windows and Doors**	Replace	Triple glazed low-e windows, argon filled, 16mm gap PVC/wooden doors, insulated	1.3 2.0	213	45	C3
	Systems upgrade:						
4	**Space and water heating system and controls**	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).		**88**	**21**	**B1**

* package also includes draughtstripping, 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	€ 680	3.8
Step 2	€ 8,260	32.3
Step 3	€ 9,350	76.9
Step 4	€ 11,100	26.5
Total:	**€ 29,390**	**30.2**

Advanced upgrade summary

Consumption of primary energy reduced by:	**258 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**53 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

19. Detached bungalow, cavity walls, 1983-1993

Description

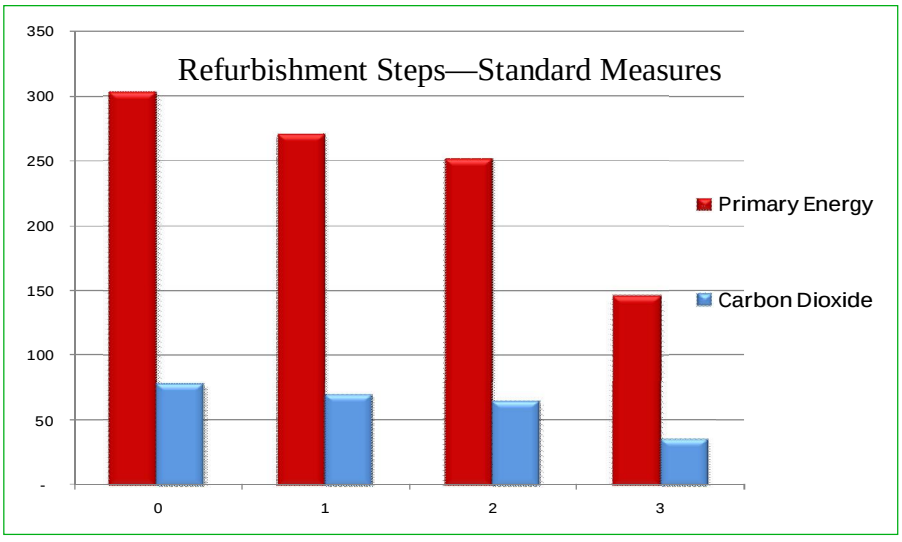
Very typical rural bungalow from the 1980s. 50mm of polystyrene wall insulation was normally fitted during construction. The part-filled cavity can be full-filled by pumping in additional insulation beads.

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, pipework uninsulated.	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	**303** (actual state)	**78** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	271	70	D2
2	**Wall insulation**	Add	Remaining cavity (50mm) filled with insulation beads	0.27	252	65	E1
	Systems upgrade:						
3	**Space and water heating system and controls**	Replace	Condensing boiler 90% efficient, two separated heating zones with time and thermostatic control, independent water heating.		**146**	**36**	**B3**

*also includes draughtstripping, 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**

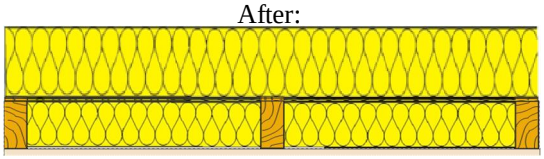
Measure	Estimated costs	Payback (y)
Step 1	€ 1,940	5.3
Step 2	€ 1,270	5.2
Step 3	€ 3,500	2.8
Total	**€ 6,710**	**3.6**

Standard upgrade summary

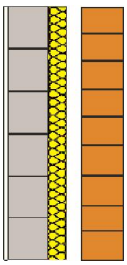
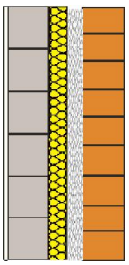
Consumption of primary energy reduced by:	**157 kWh/m²/y**
Emission of carbon dioxide reduced by:	**42 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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 roof upgrade includes topping the attic insulation up to 300 mm. Conductivity = 0.04 W/mK	After: 

Typical wall upgrade (standard)

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

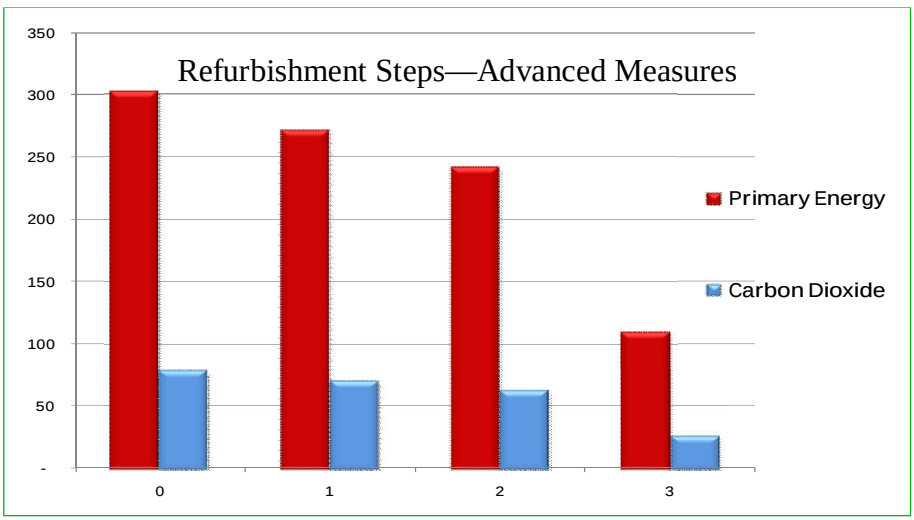
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	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, 90% 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	**303** (actual state)	**78** (actual state)	**E1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	271	70	D2
2	**Wall insulation**	Add	Remaining cavity (50mm) filled with insulation beads, walls insulated internally with 50 mm phenolic/urethane drylining boards	0.21	242	62	D1
	Systems upgrade:						
3	**Space and water heating system and controls**	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).	**110**	**26**	**B2**

* package also includes draughtstripping, 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	€ 1,940	5.3
Step 2	€ 11,400	30.9
Step 3	€ 18,100	9.8
Total:	**€ 31,440**	**12.2**

Advanced upgrade summary

Consumption of primary energy reduced by:	**193 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**52 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

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

Description

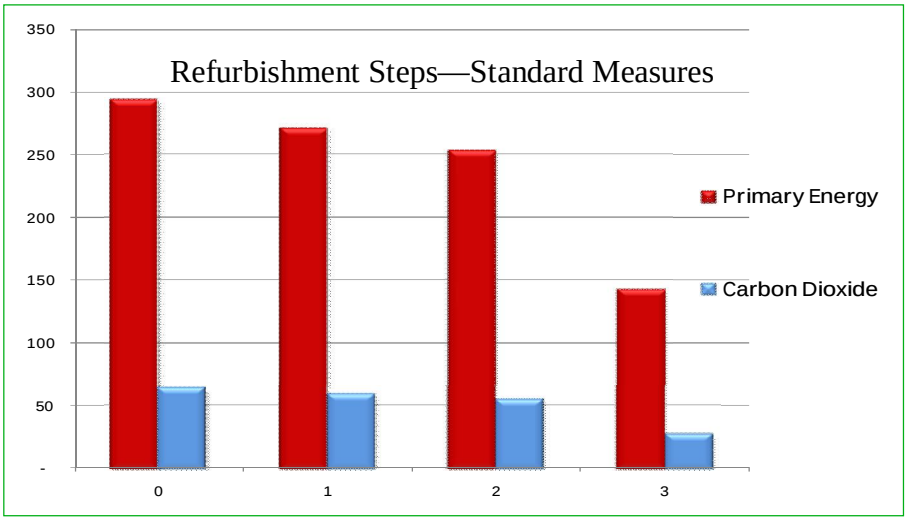
Semi-detached house with part-filled cavity walls and solid floors. The part-filled cavity can be full-filled by pumping in additional insulation beads. This house type is common throughout Ireland during the 1980s.

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, pipework uninsulated.	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.		

Refurbishment steps — standard					Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:			Expected U-values	**294** (actual state)	**63** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	271	58	D2
2	**Wall insulation**	Add	Remaining cavity (50mm) filled with insulation beads	0.27	253	54	D1
	Systems upgrade:						
3	**Space and water heating system and controls**	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.		**143**	**27**	**B3**

*also includes draughtstripping, 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**

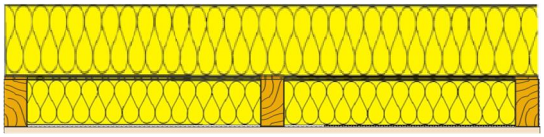
Measure	Estimated costs	Payback (y)
Step 1	€ 760	5.4
Step 2	€ 870	10.6
Step 3	€ 3,000	5.3
Total:	**€ 4,630**	**5.9**

Standard upgrade summary

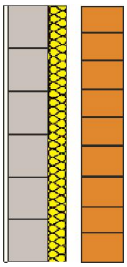
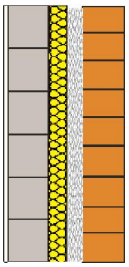
Consumption of primary energy reduced by:	**151 kWh/m²/y**
Emission of carbon dioxide reduced by:	**36 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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 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, 25-50 mm thick. U-value = 0.6 W/m^{2}K		Remaining cavity filled with insulation beads, conductivity = 0.033 W/mK

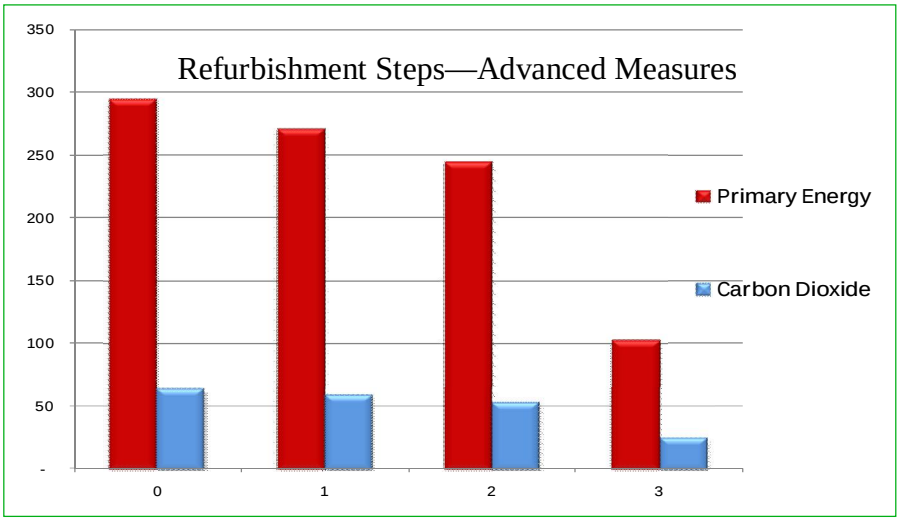
Heating system upgrade

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, 90% 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	**294** (actual state)	**63** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	271	58	D2
2	**Wall insulation**	Add	Remaining cavity (50mm) filled with insulation beads, walls insulated internally with 50 mm phenolic / urethane drylining boards	0.21	244	53	D1
	Systems upgrade:						
3	**Space and water heating system and controls**	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).	**103**	**25**	**B2**

* package also includes draughtstripping, 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	€ 760	5.4
Step 2	€ 7,800	64.5
Step 3	€ 13,100	24.7
Total:	**€ 21,660**	**27.4**

Advanced upgrade summary

Consumption of primary energy reduced by:	**191 kWh/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 (2011). 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

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

Description

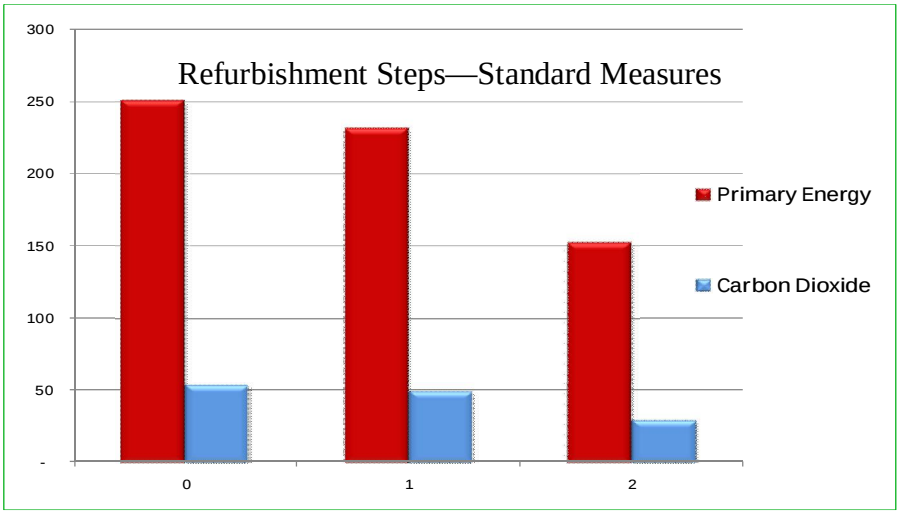
This house was found in Dublin and had hollow block walls with internal dry-lining. If it was located outside Dublin, cavity wall construction would be more likely. The room in the roof at first floor level would have had modest fibre insulation at the time of construction and could be much improved.

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, pipework uninsulated.	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	**251** (actual state)	**54** (actual state)	**D1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	232	49	D1
Walls are insulated, but the thickness of the insulation is below the current standards. One of the possible measures is re-drylining or installing external wall insulation to achieve a U-value of 0.27 W/m²/K. Usually, when the walls are uninsulated, the payback time for installing external wall insulation is around 10-15 years. But in this case, where the walls are partially insulated, the payback time would be around 80 years. Therefore it is not recommended on economic grounds. Replacement of double glazed windows to achieve current standards is also possible, but due to long payback times, this step is not generally recommended either.							
Systems upgrade:							
2	**Space and water heating system and controls**	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.		**153**	**29**	**C1**

*also includes draughtstripping, 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**

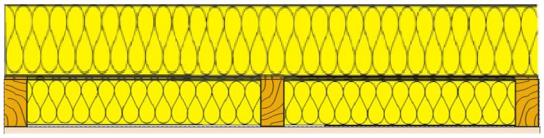
Measure	Estimated costs	Payback (y)
Step 1	€ 1,020	5.8
Step 2	€ 3,000	5.6
Total:	**€ 4,020**	**5.6**

Standard upgrade summary

Consumption of primary energy reduced by:	**98 kWh/m²/y**
Emission of carbon dioxide reduced by:	**25 kgCO₂/m²/y**

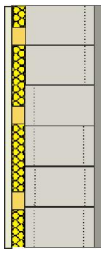
**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

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

Typical wall construction

Concrete hollow block, insulated



Concrete hollow block, internally drylined. 25-50mm thick insulation between the wooden battens, 12.5 mm thick plasterboards. U value = 0.6 W/m^{2}K

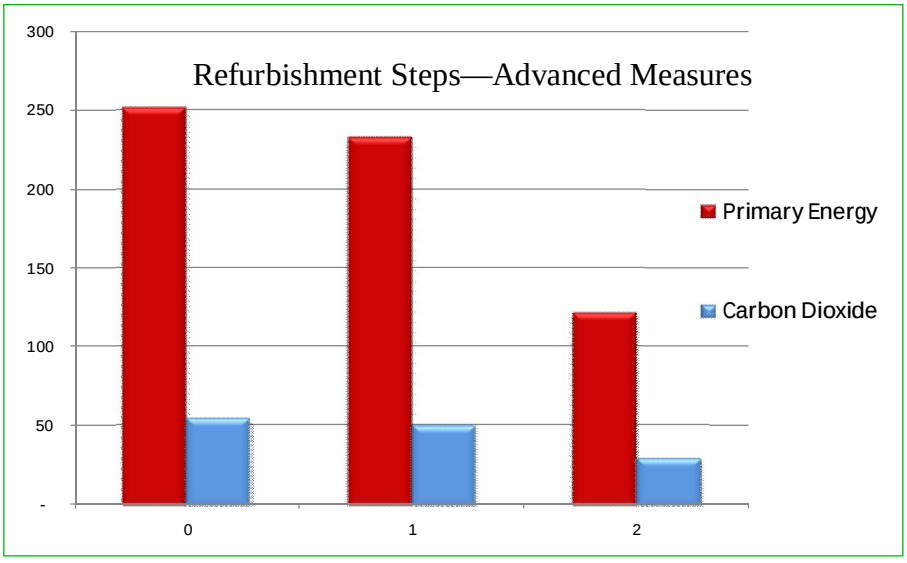
Heating system upgrade

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, 90% 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	**251** (actual state)	**54** (actual state)	**D1**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	232	49	D1
	Systems upgrade:					
2	**Space and water heating system and controls**	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).	**122**	**29**	**B2**

* package also includes draughtstripping, 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	€ 1,020	5.8
Step 2	€ 13,100	31.0
Total:	**€ 14,120**	**23.6**

Advanced upgrade summary

Consumption of primary energy reduced by:	**129 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**25 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

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

Description

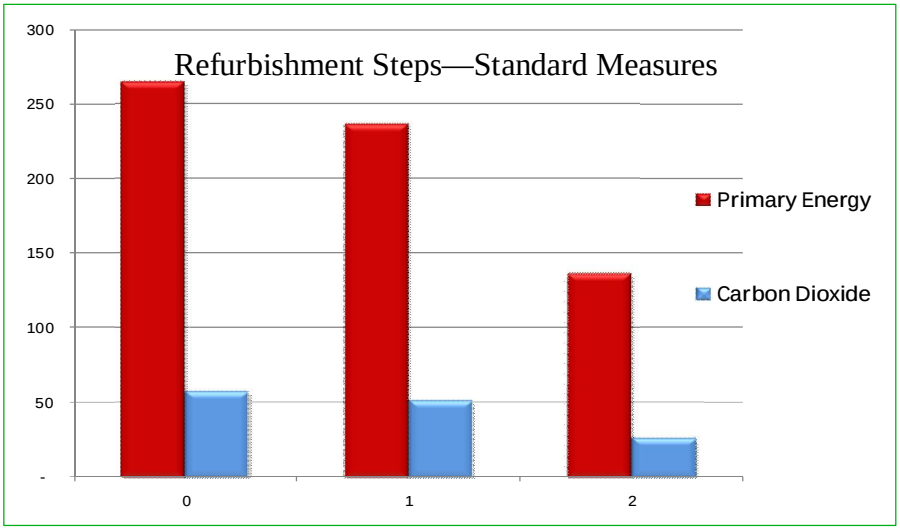
Very typical house built in Dublin and east coast area during the 1980s with hollow block walls that were dry-lined internally with 50mm of fibre insulation between wooden battens fixed to the walls. See notes on wall insulation options below. Solid floors are common with this house type.

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, pipework uninsulated.	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	**265** (actual state)	**57** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	237	51	D1
Walls are insulated, but the thickness of the insulation is below the current standards. One of the possible measures is re-drylining or installing external wall insulation to achieve a U-value of 0.27 W/m²/K. Usually, when the walls are uninsulated, the payback time for installing external wall insulation is around 10-15 years. But in this case, where the walls are partially insulated, the payback time would be around 80 years. Therefore it is not recommended on economic grounds. Replacement of double glazed windows to achieve current standards is also possible, but due to long payback times, it is not recommended either.							
Systems upgrade:							
2	**Space and water heating system and controls**	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.		**136**	**26**	**B3**

*also includes draughtstripping, 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**

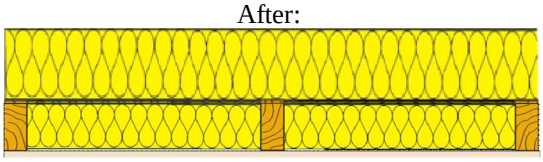
Measure	Estimated costs	Payback (y)
Step 1	€ 570	4.7
Step 2	€ 3,000	7.6
Total:	**€ 3,570**	**6.9**

Standard upgrade summary

Consumption of primary energy reduced by:	**129 kWh/m²/y**
Emission of carbon dioxide reduced by:	**31 kgCO₂/m²/y**

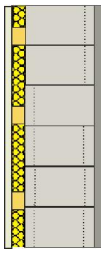
**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

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

Typical wall construction

Concrete hollow block, insulated



Concrete hollow block, internally drylined. 25-50mm thick insulation between the wooden battens, 12.5 mm thick plasterboards. U value = 0.6 W/m^{2}K

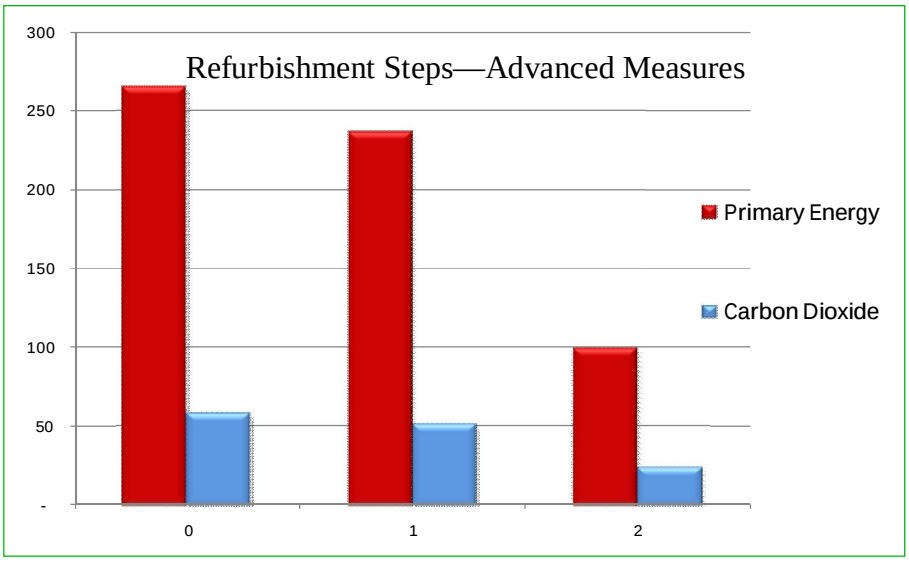
Heating system upgrade

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, 90% 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	**265** (actual state)	**57** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	200 mm mineral wool over the existing insulation.	0.13	237	51	D2
	Systems upgrade:						
2	**Space and water heating system and controls**	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).		**100**	**24**	**B1**

* package also includes draughtstripping, 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	€ 570	4.7
Step 2	€ 11,100	28.2
Total:	**€ 11,670**	**22.6**

Advanced upgrade summary

Consumption of primary energy reduced by:	**165 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**33 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

23. 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

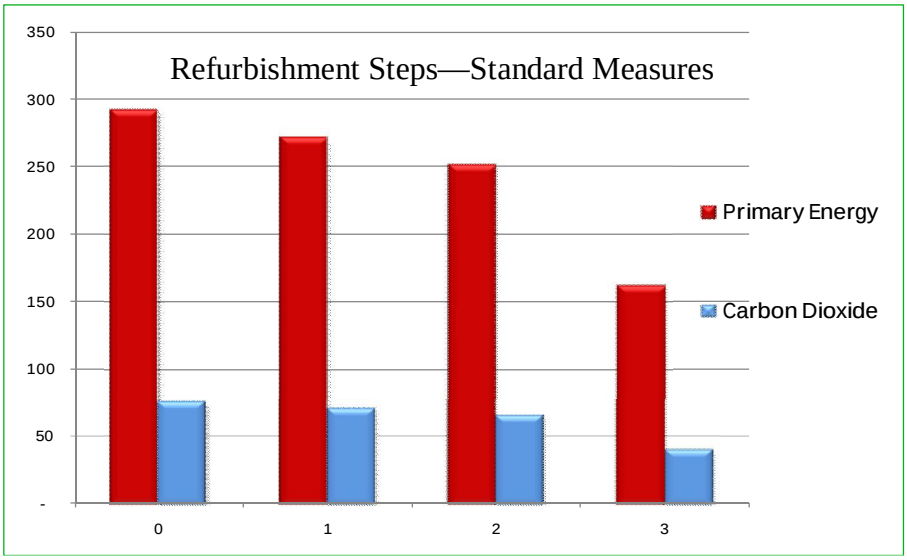
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipework uninsulated.	Heating oil	75%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Separated time controls,.		
Cylinder	Insulated with loose jacket, 50 mm, no cylinder thermostat		
Controls	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	**292** (actual state)	**75** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation	0.13	271	70	D2
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.	0.32	251	65	D1
	Systems upgrade:						
3	**Space and water heating system and controls**	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.		**162**	**40**	**C1**

*also includes draughtstripping, 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**

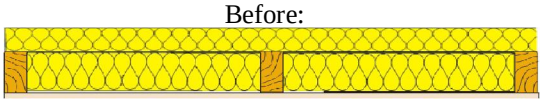
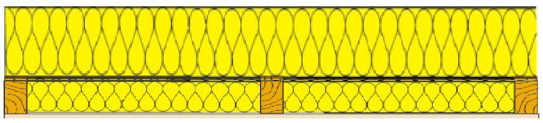
Measure	Estimated costs	Payback (y)
Step 1	€ 1,030	8.5
Step 2	€ 800	6.0
Step 2	€ 3,500	5.9
Total:	**€ 5,330**	**6.3**

Standard upgrade summary

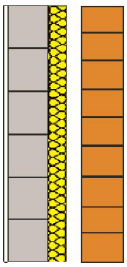
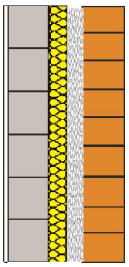
Consumption of primary energy reduced by:	**130 kWh/m²/y**
Emission of carbon dioxide reduced by:	**35 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

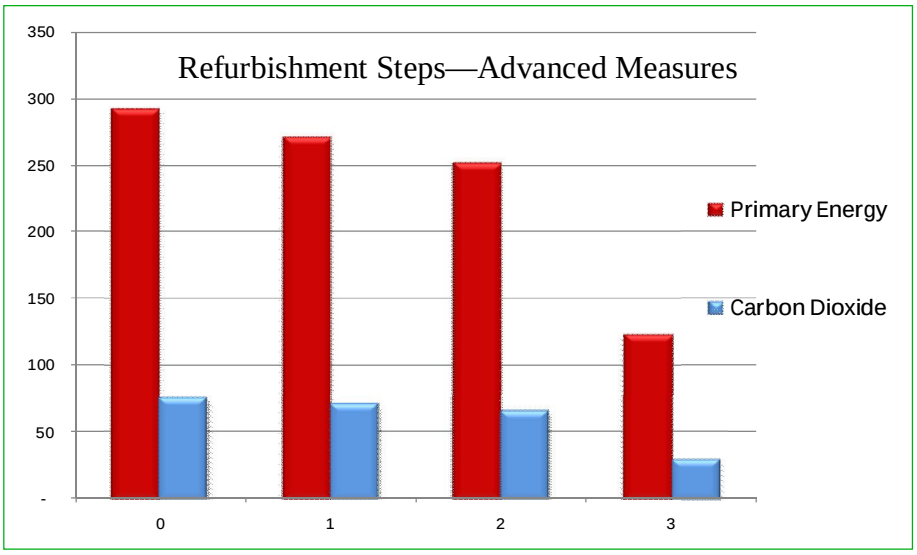
Heating system upgrade

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, 90% 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	**292** (actual state)	**75** (actual state)	**D2**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation.	0.13	271	70	D2
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.	0.32	251	65	D1
	Systems upgrade:						
2	**Space and water heating system and controls**	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).	**124**	**29**	**B2**

* package also includes draughtstripping, 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	€ 1,030	8.5
Step 2	€ 800	6.0
Step 3	€ 11,100	11.2
Total:	**€ 12,930**	**10.4**

Advanced upgrade summary

Consumption of primary energy reduced by:	**168 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 (2011). 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

24. 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	Not applicable	2.8
Doors	Solid wooden	none	3

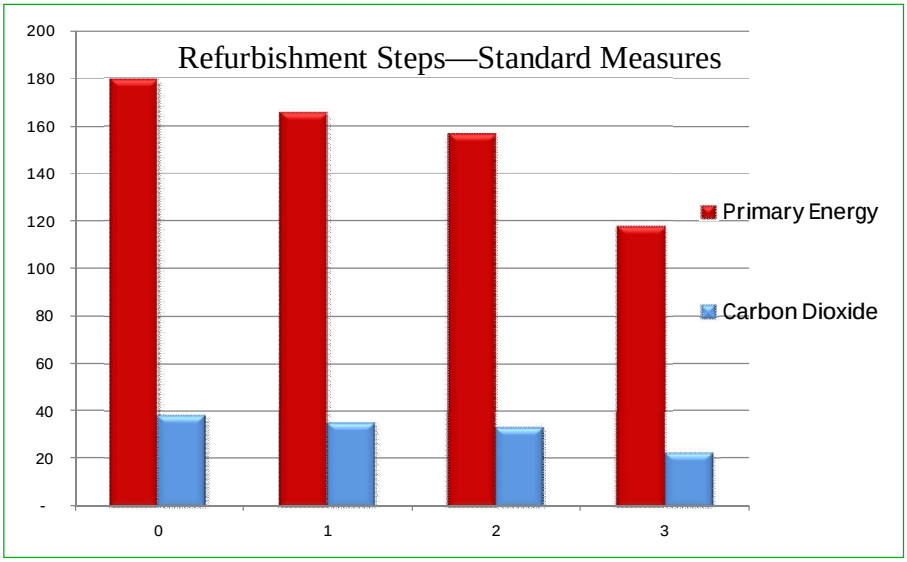
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, pipework uninsulated.	Heating oil	80%
Secondary	Open fire in grate	Smokeless	30%
Hot water	From primary heating system. Independent time control of space & water heating.		
Cylinder	Factory insulated, 35 mm spray foam, 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 were insulated during construction.

Refurbishment steps — standard				Prim. energy kWh/m²/y	Carbon Dioxide kgCO₂/m²/y	Energy Rating
0	Building fabric upgrade steps:		Expected U-values	**180** (actual state)	**38** (actual state)	**C2**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation	0.13	166	35	C1
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.	0.32	157	33	C1
	Systems upgrade:						
3	**Space and water heating system and controls**	Replace	Condensing boiler 90% efficient, additional heating zone		**118**	**23**	**B2**

*also includes draughtstripping, 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**

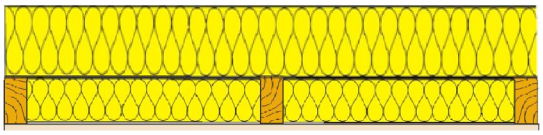
Measure	Estimated costs	Payback (y)
Step 1	€ 520	8.0
Step 2	€ 400	13.0
Step 2	€ 2,050	16.7
Total:	**€ 2,970**	**13.6**

Standard upgrade summary

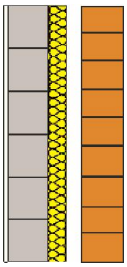
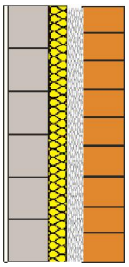
Consumption of primary energy reduced by:	**62 kWh/m²/y**
Emission of carbon dioxide reduced by:	**15 kgCO₂/m²/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

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

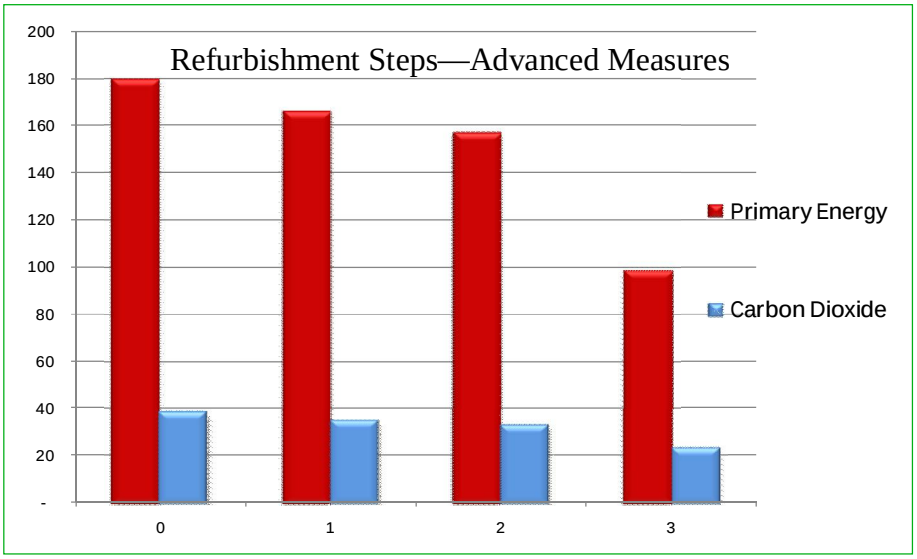
Heating system upgrade

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, 90% 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	**180** (actual state)	**38** (actual state)	**C2**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation.	0.13	166	35	C1
2	**Wall insulation**	Add	Remaining cavity filled with insulation beads.	0.32	157	33	C1
	Systems upgrade:						
3	**Space and water heating system and controls**	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).		**99**	**23**	**B1**

* package also includes draughtstripping, 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	€ 520	8.0
Step 2	€ 400	13.0
Step 3	€ 11,100	160.4
Total	**€ 12,020**	**73.4**

Advanced upgrade summary

Consumption of primary energy reduced by:	**81 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 (2011). 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

25. 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

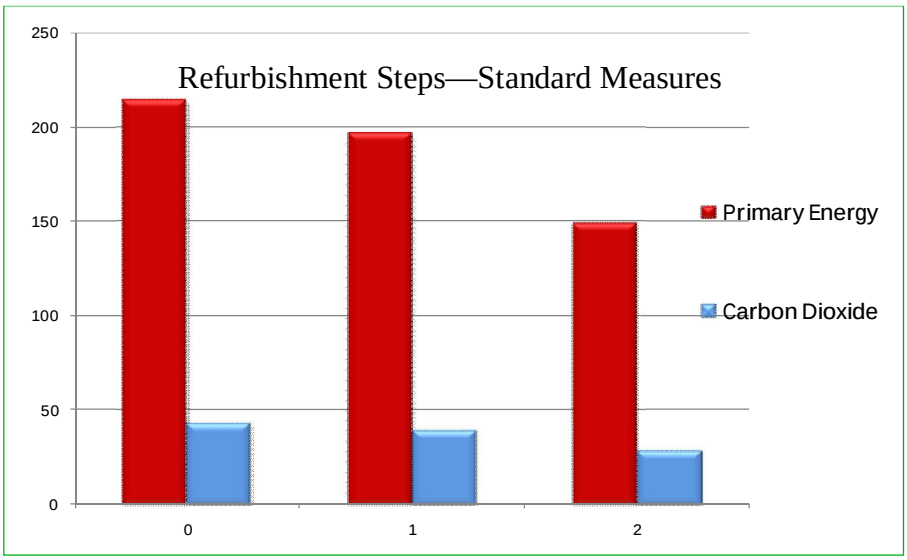
Heating systems characteristics:		Fuel	Efficiency
Primary	Central heating boiler, primary pipework uninsulated.	Gas	80%
Secondary	Electric heaters	Electricity	100%
Hot water	From primary heating system. Separated time controls,.		
Cylinder	Insulated with 35mm spray foam, cylinder thermostat		
Controls	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	**215** (actual state)	**43** (actual state)	**C3**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation	0.13	197	39	C2
	Systems upgrade:						
3	**Space and water heating system and controls**	Replace	Condensing gas boiler 90% efficient, additional space heating zone	**150**	**29**	**B3**

*also includes draughtstripping, 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**

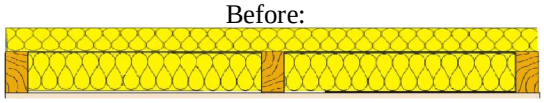
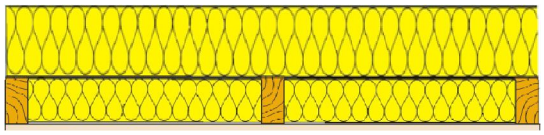
Measure	Estimated costs	Payback (y)
Step 1	€ 950	8.6
Step 2	€ 2,060	7.6
Total:	**€ 3,010**	**7.9**

Standard upgrade summary

Consumption of primary energy reduced by:	**65 kWh/m²/y**
Emission of carbon dioxide reduced by:	**14 kgCO₂/m²/y**

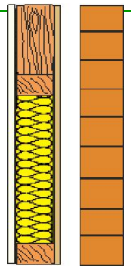
**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

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

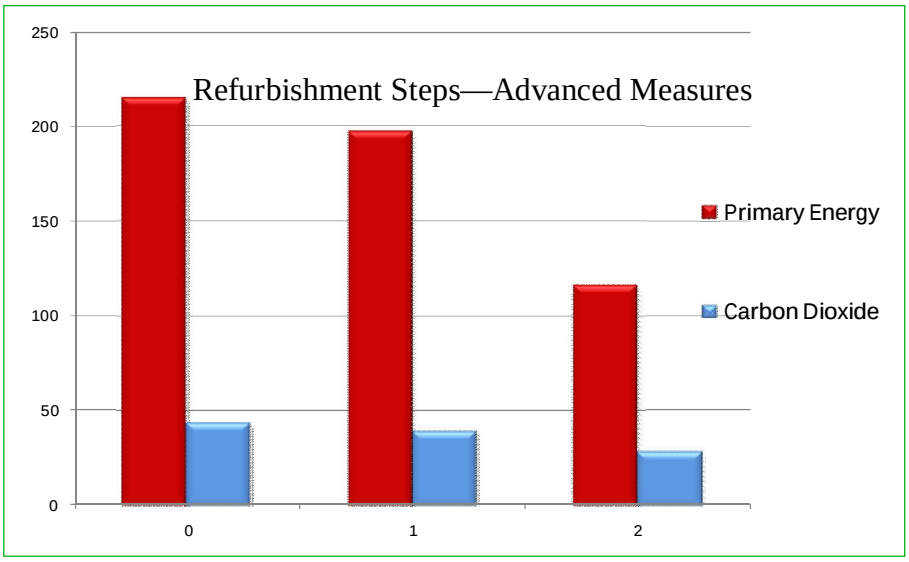
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	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, 90% 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	**215** (actual state)	**43** (actual state)	**C3**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation.	0.13	197	39	C2
	Systems upgrade:						
2	**Space and water heating system and controls**	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).	**117**	**28**	**B2**

* package also includes draughtstripping, 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	€ 950	8.6
Step 2	€ 11,100	50.6
Total:	**€ 12,050**	**36.5**

Advanced upgrade summary

Consumption of primary energy reduced by:	**98 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 (2011). 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

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

Description

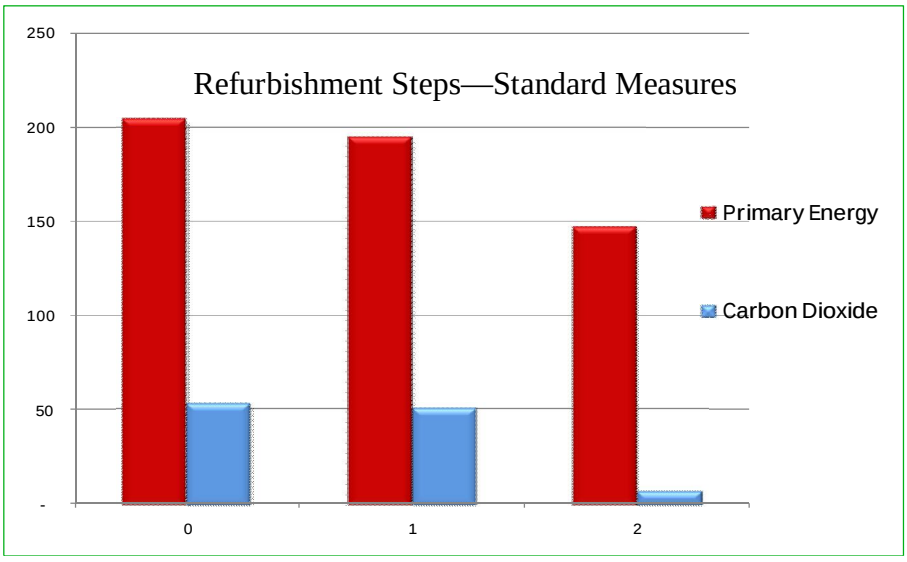
Timber frame construction started to become increasingly popular in the late 1990s and has made up more than 10% of the market from 2000 onwards. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

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 pipework uninsulated.	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	**204** (actual state)	**53** (actual state)	**C3**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation	0.13	194	50	C2
	Systems upgrade:					
2	**Space and water heating system and controls**	Replace	Wood pellet boiler 90% efficient, additional space heating zone, secondary heating removed	**147**	**7**	**B3**

*also includes draughtstripping, 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**

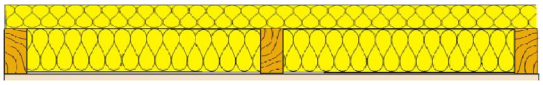
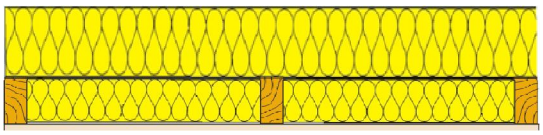
Measure	Estimated costs	Payback (y)
Step 1	€ 570	11.4
Step 2	€ 7,500	38.9
Total:	**€ 8,070**	**33.2**

Standard upgrade summary

Consumption of primary energy reduced by:	**57 kWh/m²/y**
Emission of carbon dioxide reduced by:	**46 kgCO₂/m²/y**

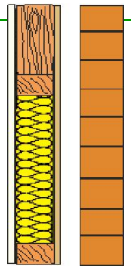
**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

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

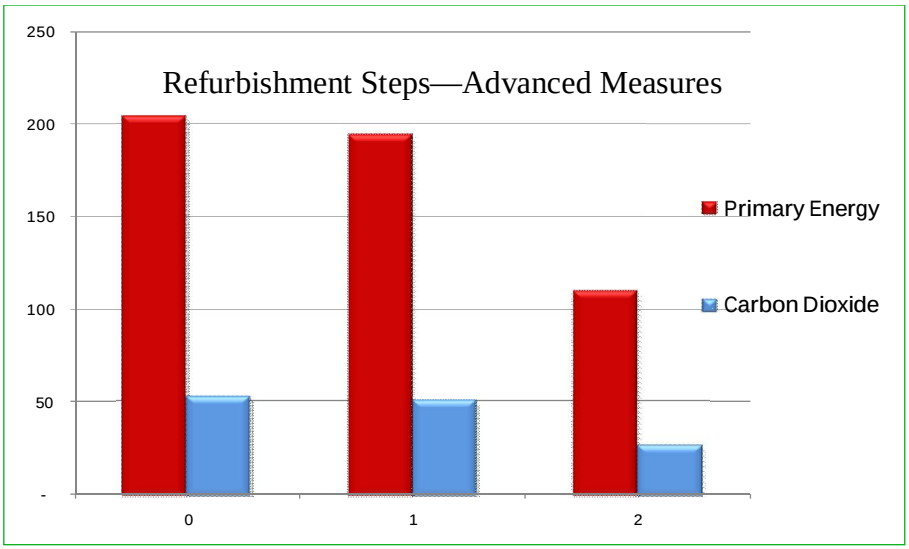
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	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, 90% 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	**204** (actual state)	**53** (actual state)	**C3**
1	**Roof insulation and standard package***	Add	150 mm of mineral wool over the existing insulation.	0.13	194	50	C2
	Systems upgrade:						
2	**Space and water heating system and controls**	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).	**110**	**26**	**B2**

* package also includes draughtstripping, 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	€ 570	11.4
Step 2	€ 11,100	63.5
Total:	**€ 11,670**	**51.9**

Advanced upgrade summary

Consumption of primary energy reduced by:	**94 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**27 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

27. Detached house, cavity walls, 2005 - onwards

Description

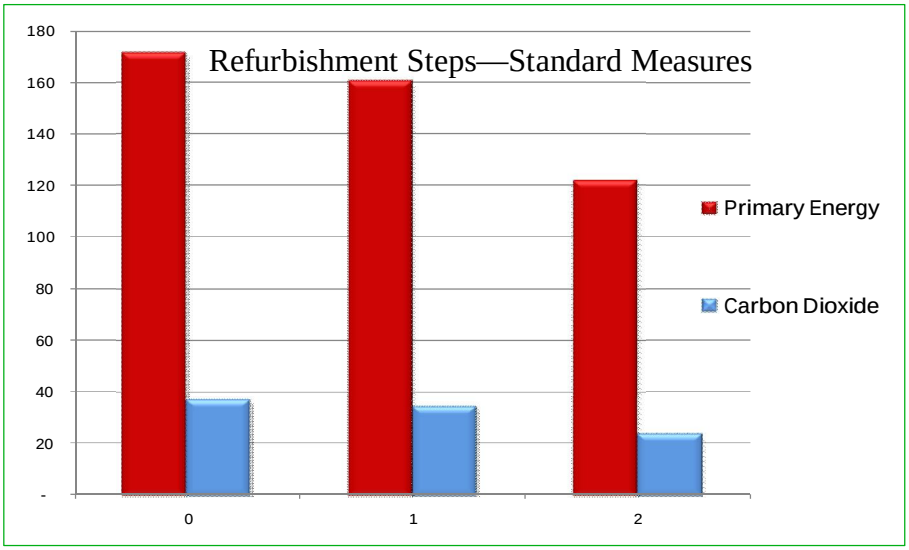
The cavity walls of this house are well insulated with U values as low as 0.27 W/m^{2}K and the floors are well insulated. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

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 pipework 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		

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	**171** (actual state)	**37** (actual state)	**C1**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation	0.13	160	34	C1
	Systems upgrade:						
3	**Space and water heating system and controls**	Add/ replace	Gas condensing boiler 90% efficient, additional space heating zone, secondary heating removed		**122**	**23**	**B2**

*also includes draughtstripping (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**

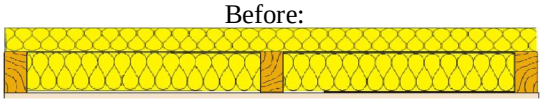
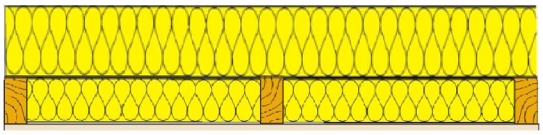
Measure	Estimated costs	Payback (y)
Step 1	€ 540	6.4
Step 2	€ 2,200	11.7
Total:	**€ 2,740**	**10**

Standard upgrade summary

Consumption of primary energy reduced by:	**49 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**14 kgCO$_2$/m^2/y**

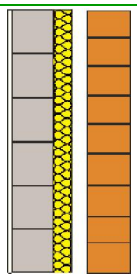
**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

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

Typical wall construction

Cavity walls, partially filled



Cavity walls, partially filled with the expanded polystyrene boards, U-value = 0.37 W/m^{2}K

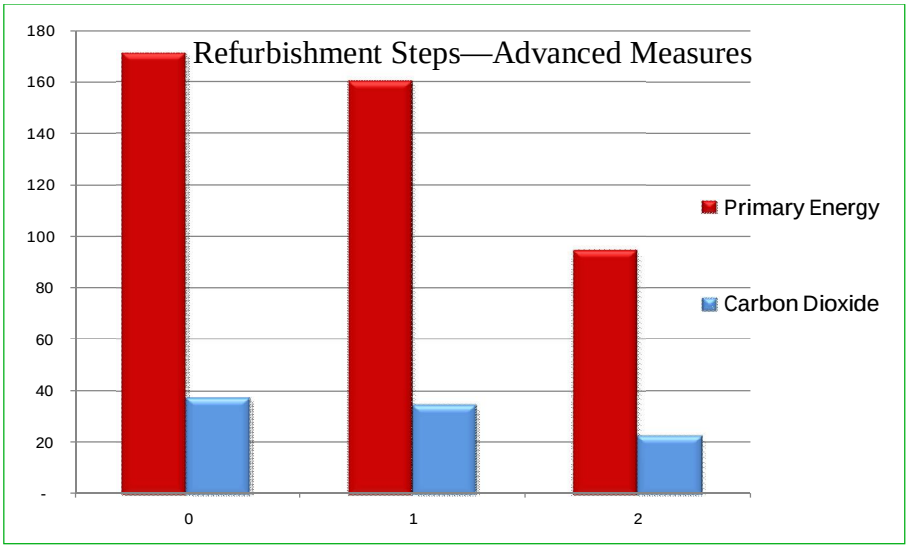
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	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, 90% 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	**171** (actual state)	**37** (actual state)	**C1**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation.	0.13	160	34	C1
	Systems upgrade:						
2	**Space and water heating system and controls**	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).		**95**	**23**	**B1**

* package also includes draughtstripping, 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	€ 540	6.4
Step 2	€ 13,100	87.9
Total:	**€ 13,640**	**58.3**

Advanced upgrade summary

Consumption of primary energy reduced by:	**76 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**14 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

28. Terraced house, cavity walls, 2005 - onwards

Description

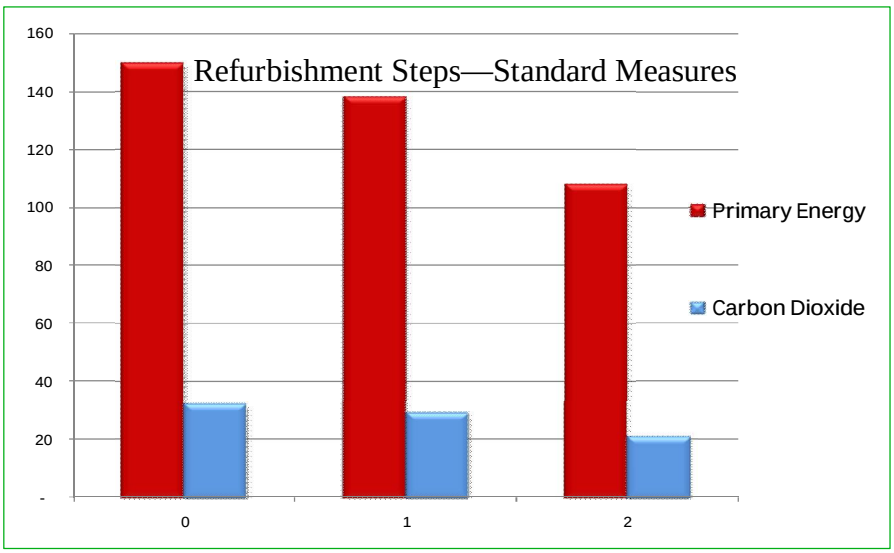
The cavity walls of this house are well insulated with U values as low as 0.27 W/m^2/K and the floors are well insulated. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

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 pipework 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		

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	**150** (actual state)	**32** (actual state)	**B3**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation	0.13	138	29	B3
	Systems upgrade:						
3	**Space and water heating system and controls**	Add/ replace	Gas condensing boiler 90% efficient, additional space heating zone, secondary heating removed		**108**	**21**	**B2**

*also includes draughtstripping (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**

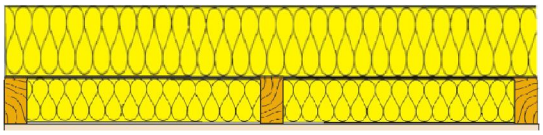
Measure	Estimated costs	Payback (y)
Step 1	€ 560	5.7
Step 2	€ 2,200	14.2
Total:	**€ 2,760**	**10.9**

Standard upgrade summary

Consumption of primary energy reduced by:	**42 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**11 kgCO$_2$/m^2/y**

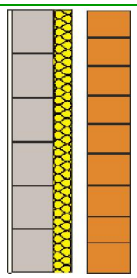
**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

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

Typical wall construction

Cavity walls, partially filled



Cavity walls, partially filled with expanded polystyrene boards, U-value = 0.37 W/m^{2}K

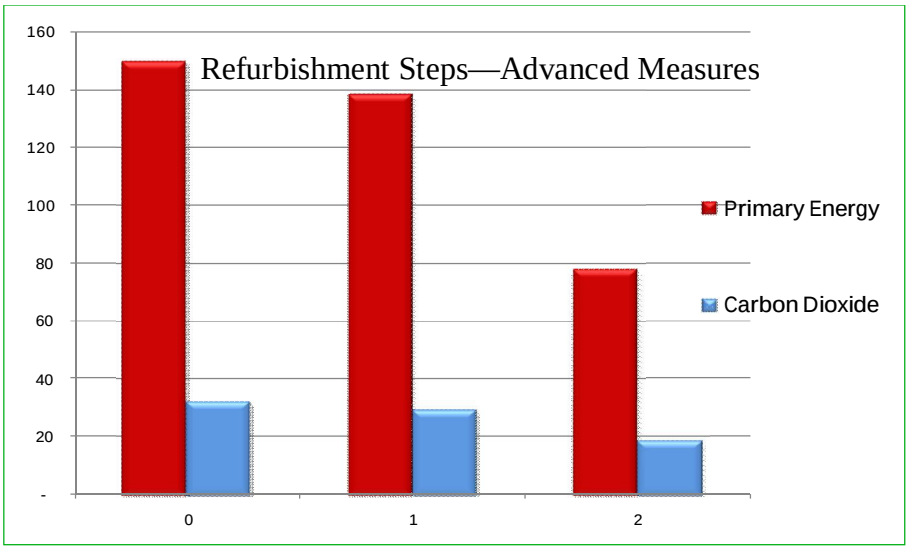
Heating system upgrade

Feature:	Standard	Advanced
Heat generator	Regular condensing boiler	Air source heat pump
Efficiency:	90%	380%
Fuel:	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, 90% 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	**150** (actual state)	**32** (actual state)	**B3**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation.	0.13	138	29	B3
	Systems upgrade:						
2	**Space and water heating system and controls**	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).	**78**	**19**	**B1**

* package also includes draughtstripping, 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	€ 560	5.7
Step 2	€ 13,100	76.5
Total:	**€ 13,660**	**50.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**72 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**13 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

29. Detached house, timber frame, 2005 - onwards

Description

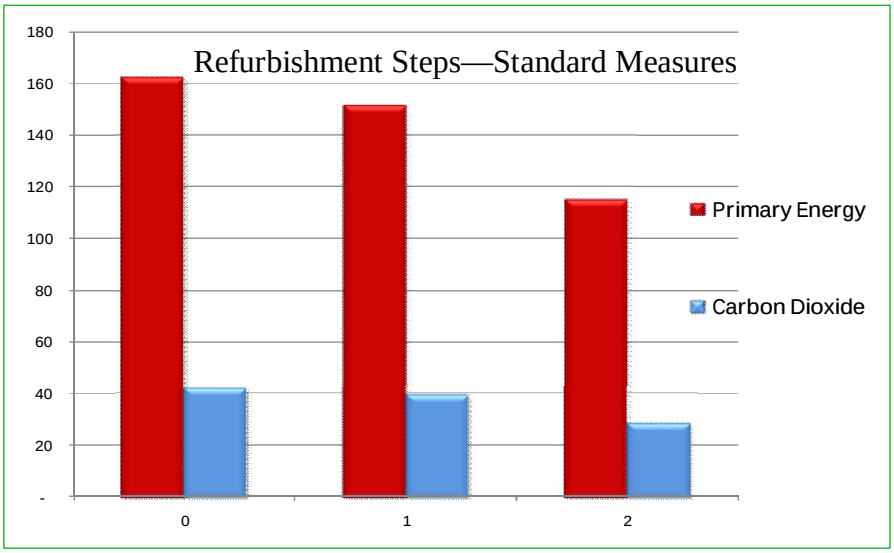
Timber frame construction accounted for more than 10% of the new house market from 2000 onwards. The walls are well insulated with U values as low as 0.27 W/m^{2}K and the floors are well insulated. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & 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 pipework 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	**162** (actual state)	**42** (actual state)	**C1**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation	0.13	152	39	C1
	Systems upgrade:						
2	**Space and water heating system and controls**	Add / Replace	Condensing boiler 90% efficient, additional heating zone, secondary heating removed.		**115**	**28**	**B2**

*also includes draughtstripping (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**

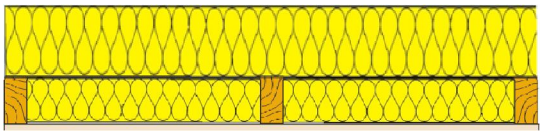
Measure	Estimated costs	Payback (y)
Step 1	€ 800	6.7
Step 2	€ 2,700	5.5
Total:	**€ 3,500**	**5.8**

Standard upgrade summary

Consumption of primary energy reduced by:	**47 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**14 kgCO$_2$/m^2/y**

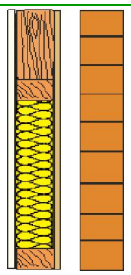
**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

200 mm of mineral wool between and above the ceiling joists	Before: 
Typical roof 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

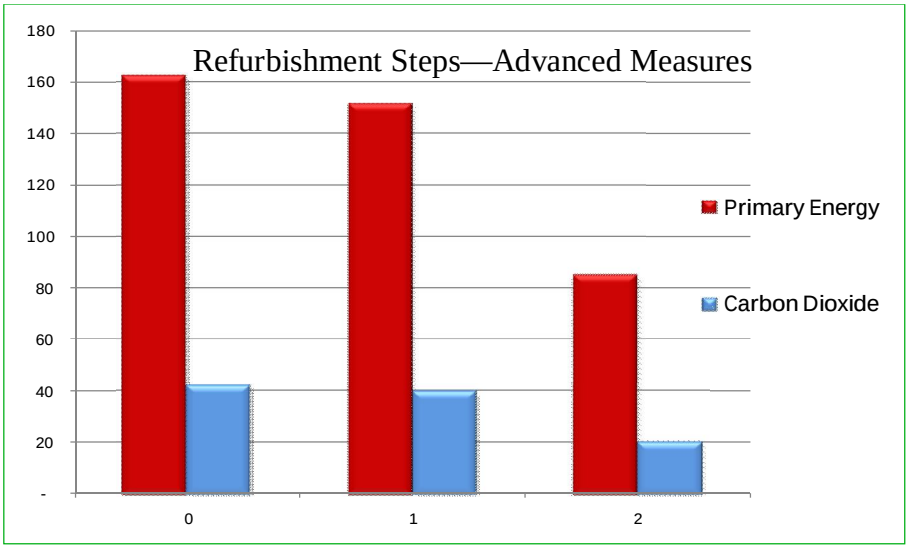
Heating system upgrade

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, 90% 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	**162** (actual state)	**42** (actual state)	**C1**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation.	0.13	152	39	C1
	Systems upgrade:						
2	**Space and water heating system and controls**	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).		**85**	**20**	**B1**

* package also includes draughtstripping, 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	€ 800	6.7
Step 2	€ 18,100	16.6
Total:	**€ 18,900**	**15.6**

Advanced upgrade summary

Consumption of primary energy reduced by:	**77 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**22 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

30. Semi detached house, timber frame, 2005 - onwards

Description

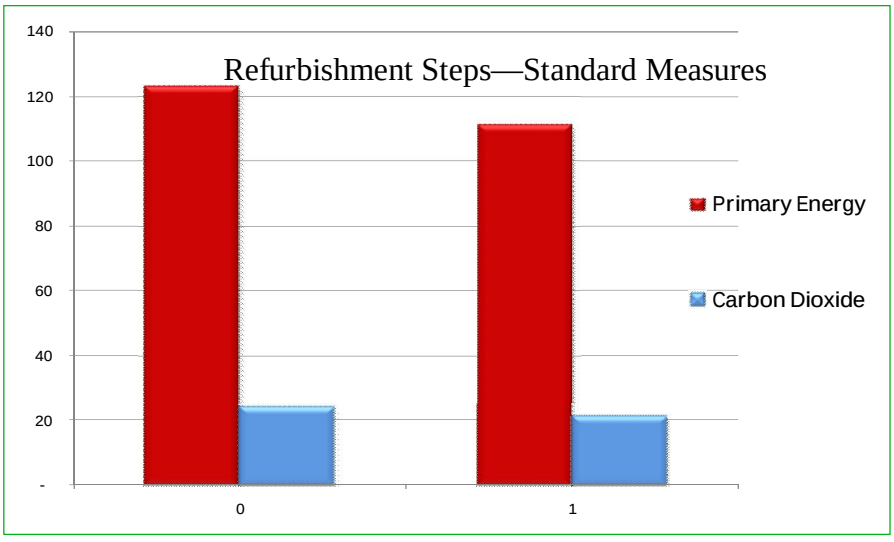
The walls of this timber frame house are well insulated with U values as low as 0.27 W/m^{2}K and the floors are well insulated. Apart from adding additional roof insulation, the focus for retrofit would be on upgrading the space & water heating systems.

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 pipework 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	**123** (actual state)	**24** (actual state)	**B2**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation	0.13	111	21	B2
	Systems upgrade:						
2	**Space and water heating system and controls**	n.a.	Heating system meets all current requirements		**n.a.**	**n.a**	**n.a.**

*also includes draughtstripping (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**

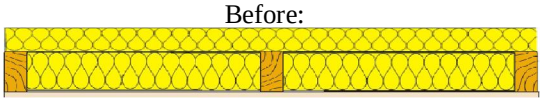
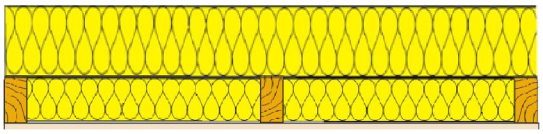
Measure	Estimated costs	Payback (y)
Step 1	€ 500	6.0
Total:	**€ 500**	**6.0**

Standard upgrade summary

Consumption of primary energy reduced by:	**12 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**3 kgCO$_2$/m^2/y**

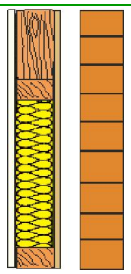
**Note: 1. Costs are indicative only, based on typical prices (2011). 2. Measures analysed are one of many options, especially for the renewable heating systems.

Typical roof upgrade (standard/advanced)

200 mm of mineral wool between and above the ceiling joists	Before: 
Typical roof 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

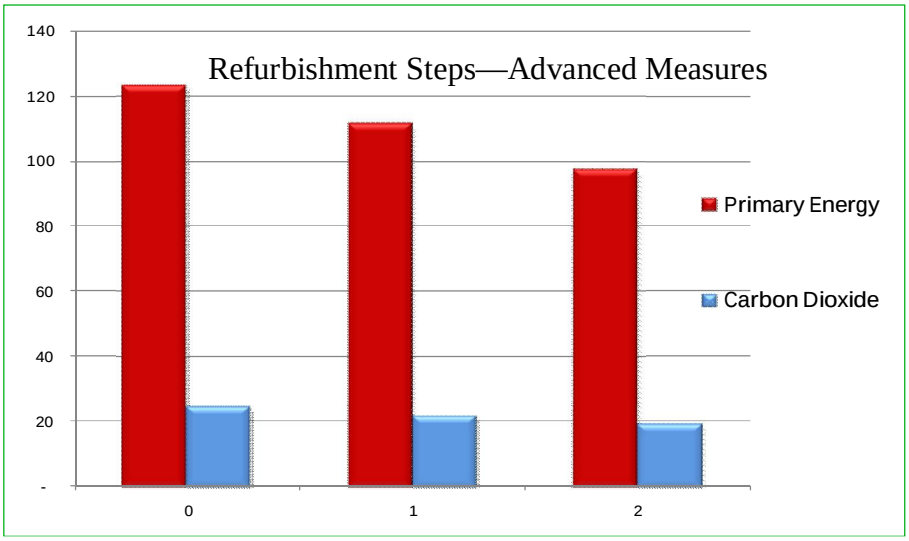
Heating system upgrade

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	**123** (actual state)	**24** (actual state)	**B2**
1	**Roof insulation and standard package***	Add	100 mm of mineral wool over the existing insulation.	0.13	111	21	B2
	Systems upgrade:						
2	**Space and water heating system and controls**	Replace/ add	Solar thermal panels providing 50% of hot water demand	**98**	**19**	**B1**

* package also includes draughtstripping, 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	€ 500	6.0
Step 2	€ 3000	47.4
Total:	€ 3500	**23.8**

Advanced upgrade summary

Consumption of primary energy reduced by:	**25 kWh/m^2/y**
Emission of carbon dioxide reduced by:	**5 kgCO$_2$/m^2/y**

**Note: 1. Costs are indicative only, based on typical prices (2011). 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

A

Air Source Heat Pump They draw their heat from the ambient environment, that is, from the air, from water, or from the ground. By compressing and decompressing liquids circulating within the heat pump system, they can be used to transfer heat from the environment into a dwelling. Heat is circulated inside the dwelling either via warmed water in radiator s or underfloor distribution networks, or by warmed air being pushed into the dwelling.

C

Cavity Wall A wall constructed in two separate thicknesses with an air space between; provides thermal insulation.

Condensing 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

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

Dry Lining The application of an insulation layer (in most cases) and plasterboard layer to the internal surface of an exposed wall.

E

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 in the form of mineral glass fibre or rock wool is used between joists or rafters in roof construction or between timber studs in wall constructions.

G

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

H

Hollow-block A 9 inch masonry block containing hollowed sections.

HW controls water heating controls such as cylinder thermostat.

I

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 the wall is broken open for any reason.

J

Joists A length of timber or steel supporting part of the structure of a building, typically arranged in parallel series to support a floor or ceiling

L

Lagging Jacket An insulation covering for a hot water cylinder or cold water storage tank located in an attic space

M

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 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.

R

Retrofit To install or fit (a device or system, for example) for use in or on an existing structure, especially an older dwelling

S

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

T

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) 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%.