RadMaster1000

&

H.E.R

Analysis and Report

Prepaired by :
Emma Mooney
Senior Energy Consultant
Tipperary Energy Agency
Craft Granary
Cahir,
Co. Tipperary

www.tea.ie

8th October 2004

Table of Contents

1. INTRODUCTION

The RadMaster is a multi zone heat distribution control system, which can offer up to 15 independently controlled zones within a heating space.

Tipperary Energy Agency were commissioned to carry out a Heat Energy Rating on a typical pre1980's semi detached house both before and after its upgrading, and then to asses what impact the addition of a RadMaster system would have on such a house. The upgrading of the house was to include increasing insulation in the attic space, insulating the wall cavity space and upgrading the heating system to a gas fired central heating system. There was also the possibility of upgrading the boiler used to a high efficiency condensing boiler and this was also to be investigated.

2. EXECUTIVE SUMMARY

The purpose of this report was to examine the potential impact of a number of energy saving measures and technologies. The ultimate aim of these measures was to reduce the energy use per square meter of a 'standard' pre 1980's house, by at least 50% and to below the Maximum Permitted Heat Energy Rating (MPHER) level, if possible.

In our calculations we see that through increasing the insulation levels, installing a gas central heating system including a condensing boiler and the RadMaster control system, the Heat Energy Rating reduces from 287kWh/m^2y in the original house without upgrade potentially to 68 kWh/m^2y.

From the tables below we can see a summary of the reduction in the Gross heat required and in Carbon Dioxide emissions from firstly the individual steps and then in the second table the impact of the different measures combined with the RadMaster .

Energy Saving Step	*Gross Reduction in Heat required kWh/y	*Gross Reduction in Heat required %	Reduction in CO2 Emissions kg/y
RadMaster 1000	15454	47%	6,912
Wall insulation	13925	42%	6,228
Attic Insulation	996	3%	446
Upgrade Heating system	4092	12%	1,830
Condensing Boiler	7338	22%	8503

* Gross heat requirement is 33,022kWh/y, based on a 70% system efficiency

Combined Energy Saving Steps	Reduction in Heat required kWh/y	Reduction in Heat required %	Reduction in CO2 Emissions kg/y	Cost €
RadMaster 1000	15454	47%	6,912	
RadMaster 1000 & Wall Insulation	24085	73%	10,772	
RadMaster 1000 & Attic Insulation	18034	55%	8,066	
RadMaster 1000 & Upgrade Heating System	19483	59%	8,714	
RadMaster 1000 & Condensing Boiler	21002	64%	11,276	
RadMaster 1000 & All upgrades	26365	80%	13,146	

3. METHODOLOGY

The method of assessing the potential impact of the proposed upgrades and changes on a standard pre 1980's house was to use the Heat Energy Rating (HER) SEI software and also the HER methods as outlined in the Building Regulations 2002 Technical Guidance Document L.

The key steps in carrying out the assessment and analysis were as follows:

- Determine 'standard' 1980's house.
- Carry out HER on 'standard' house.
- Apply building upgrades to 'standard' house and carryout HER.
- Assess the potential/likely use of the RadMaster in the 'standard' house.
- Model the impact of the RadMaster on the house.
- Compare a number of likely scenarios.

The results of these assessments were then analysed, and conclusions drawn up.

To Model the RadMaster we divided the house into zones, in this case each room was a zone, we then looked at how much heating each zone would require to achieve the desired temperature, without dropping below a minimum base temperature of $10^{o}C$ at any point in the house. Comparing this to the amount of heat required to heat the entire house to the desired temperature, as determined by the HER software gave us our potential additional saving due to the RadMaster.

4. RESULTS

Firstly we looked at the upgrading of the house and what impact these upgrades would have on the HER of the house, also keeping in mind what the Maximum permitted HER was for the house. The following table summarises these results and gives the percentage reduction for each step relative to the original 'standard' 1980's house. This does not include any reduction in use due to control systems.

(**Ref: 6.2 Appendix 2 HER Calculations**)

MPHER	96.46	[kWh/m2y]

HER Carried out	HER [kWh/m2y]	Reduction %
Original House	287	
Attic insulation upgraded	279	3%
Wall insulation upgraded	166	42%
Heating system upgraded	252	12%
Full House upgrade	132	54%

We then looked at the potential impact of the RadMaster on the house. As the RadMaster is a control system and is only as effective as its user determines we gave a number of scenarios of potential savings, we also looked at the use of a two-zone system to compare its potential savings to that of the RadMaster. The two most typical scenarios were *a)* the typical use for a family and *c)* a couple or single occupancy household. Details can be seen in section **6.3.1 Typical occupant usage scenarios**. The results of this analysis is summarised below:

(**Ref: 6.3 Appendix 3 Control System Analysis**)

Original no upgrade	HER [kWh/m2y]	Reduction %
RadMaster		
Scenario a	160	44%
Scenario c	146	49%
Average		*47%*
Two Zones		
Scenario a	265	8%
Scenario c	273	5%
Average		*6%*
Simple Timer		
Scenario a	287	0%
Scenario c	287	0%

Including upgrade	HER [kWh/m2y]	Reduction %
RadMaster		
Scenario a	74	43%
Scenario c	68	48%
Average		*46%*
Two Zones		
Scenario a	122	8%
Scenario c	125	5%
Average		*6%*
Simple Timer		
Scenario a	132	0%
Scenario c	132	0%

By looking at the likely fuel use, type and amount, of a standard pre 1980's house prior to upgrade and comparing it to the fuel use after the upgrade we can estimate the potential carbon dioxide savings due to the upgrade alone. This results in a potential saving of 5,600 kg a year a reduction of over 50%. (**Ref Section 6.3.3**)

When we looked at the impact of the RadMaster in addition to this saving, we looked at a number of scenarios, the first using a 70% efficient gas boiler, the second a 90% efficient condensing boiler and the third a 70% efficient oil boiler. We also looked at the impact the RadMaster would have using the same scenario but without upgrading the system.

Potential Carbon dioxide savings [kg/y]			
Upgraded	*70%, gas*	*90%, gas*	*70%, oil*
Timer	0	0	0
Two Zones	272	218	330
RadMaster	1538	1233	1867
Original	*70%, gas*	*90%, gas*	*70%, oil*
Timer	0	0	0
Two Zones	604	484	733
RadMaster	3419	2743	4150

This gives an additional Carbon dioxide saving of up to 1,867kg per annum on the upgraded system, and could save over 4,000kg per annum by itself on a 'standard' oil heated house with no upgrades.

From the table it can be seen that replacing the standard boiler with a condensing boiler gives an additional 20% in energy savings and similar reduction in Carbon Dioxide emissions.

This also highlights the potential impact of using the RadMaster when compared to the more typical 'two zone' heating system, potentially reducing the energy use and the carbon dioxide emissions by an additional 40%.

(**Ref Section 6.3.4**)

5. CONCLUSIONS

While all of the actions which we investigated make differences to the energy efficiency and ultimately the comfort levels of the house, the ultimate aim is to deliver a system that gives best value for money, both in an environmental and economic sense.

We would recommend that the best system that could be installed in this house would be one incorporating the building fabric upgrade, the condensing boiler and the RadMaster system. This would give a HER of approximately 70kWh/m2y, depending on the usage patterns of the household. This would be below the MPHER of 96.46 as recommended for the house. It would also result in Carbon Dioxide savings of over 7000kg per annum.

As the RadMaster is a control system and ultimately dependent on the way in which it is used, we would also recommend that some training in its use would take place for the homeowner to ensure maximum savings.

6. APPENDICES

6.1 Appendix 1 'Standard' pre 1980's house dimensions

The analysis is based on a standard two story semi-detached house. Standard house is pre 1980's build, with no wall insulation and a small amount of attic insulation, the windows are single glaze, and the heating system is solid fuel based with additional heating supplied by electrical heaters

House Dimensions					
	Width mm	Length mm	Height mm	Area m2	Volume m3
Kitchen / Dining	3800.0	3600.0	2475.0	13.7	33.9
Utility	1500.0	2000.0	2475.0	3.0	7.4
Sitting Room	3300.0	4100.0	2475.0	13.5	33.5
Hall	2000.0	5604.0	2475.0	11.2	27.7
Bedroom 1	3050.0	3850.0	2400.0	11.7	28.2
Bedroom 2	3050.0	3850.0	2400.0	11.7	28.2
Bedroom 3	2250.0	2900.0	2400.0	6.5	15.7
Bathroom	2250.0	1700.0	2400.0	3.8	9.2
Landing	2300.0	2250.0	2400.0	5.2	12.4
Total internal up	5400.0	7800.0	2400.0	39.0	93.6
Total internal down	5400.0	7804.0	2475.0	41.4	102.5
Total				80.4	196.1
Exposed Perimeter				19.2	
Area (A) [m2] to external				45.4	

Windows						
	Width mm	Height mm	Quantity	Area m2	Total Wall Area m2	% of Wall Area m2
North				5.0	27.0	18.7%
	1800	1200	1	2.2		
	1500	1200	1	1.8		
	900	1200	1	1.1		
South				4.6	27.0	17.0%
	1800	1200	1	2.2		
	1800	1350	1	2.4	42.0	0.0%
East						
West	650	1050	2	1.4	42.0	3.3%
Total external				11.0	96.0	11.45%
Total				11.0	138.0	7.97%

6.2 Appendix 2 HER Calculations

6.2.1 Original 'Standard' pre 1980's house HER

Overall dwelling dimensions

	Floor area [m^2]	Average storey height [m]	Volume [m^3]
Ground floor	41.42	2.48	102.51
First floor	39.01	2.40	93.62
Second floor	0.00	0.00	0.00
Additional parts	0.00		0.00
Floor area [m2]	80.43		
Volume [m3]	196.13		

Rate of heat loss through the building fabric

	Area [m^2]	U-value [W/m^2 K]	A*U [W/K]	Maximum elemental U-values (HE Element type	Compliance	Comment (
Roof (type 1)	39.01	0.42	16.38		No	-
Roof (type 2)	0.00	0.00	0.00		Yes	-
Wall (type 1)	96.00	1.59	152.64		No	-
Wall (type 2)	0.00	0.00	0.00		Yes	-
Ground floor (type 1)	41.42	0.86	35.62		No	-
Ground floor (type 2)	0.00	0.00	0.00		Yes	-
Other exposed floor	0.00	0.00	0.00			-
Element adj to unheated area (1)	0.00	0.00	0.00	Opening	Yes	-
Element adj to unheated area (2)	0.00	0.00	0.00	Opening	Yes	-
Rooflights	0.00	0.00	0.00			-
Window (type 1)	11.00	4.80	52.78			-
Window (type 2)	0.00	0.00	0.00			-
Door (type 1)	3.86	3.00	11.59			-
Door (type 2)	0.00	0.00	0.00			-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Compliance with maximum elemental U-values (HER)					No	
Area of external elements (At) [m^2]			191.29			
Rate of heat loss through elements [W/K]			269.01			
Rate of heat loss due to thermal bridging [W/K]			40.35			
Rate of heat loss through the fabric [W/K]			309.36			

Rate of heat loss due to ventilation

Basic air change rate			[ac/h]
Type of construction	Standard (masonry)		0.40
Number of storeys		2	0.10
Suspended timber floor?	No		0.00
Total basic air change rate			0.50
Infiltration due to flues, vents, fans, etc.			[m^3/h]
Number of large flues/chimneys		1	40
Number of small flues		1	20
Number of permanent vents		0	0
large (opening > 5000 mm^2)		0	0
small (opening < 5000 mm^2)		0	0
Number of passive vents		4	40
Number of fans		2	20
Number of ext. doors without draught lobby		0	0
Total due to flues, vents, etc. [ac/h]			0.61
Gross air change rate			1.11
Number of sides sheltered		2	0.95
Effective air change rate			0.95
Rate of heat loss due to ventilation [W/K]			61.27
Specific heat loss - fabric and infiltration [W/K]			370.63

Water heating

			[kWh/y]
Energy content of heated water			1391
Is hot water heated at point of use only?	No		232
Is hot water storage present?		Yes	
If yes:			
Hot water storage volume [litres]			120
Insulation type	Lagging jacket		
Insulation thickness [mm]			25
Does HW system have separate time control?		Yes	
Tank loss factor [kWh/litre y]			12.60
Storage losses [kWh/y]			1512

Solar and other energy gains

(a) Solar gains

Orientation	Window area [m^2]	Glazing type	Overshading	Flux [W/m^2]	Shading factor [-]	Solar gains [W]
North	5.00	Single glazed	Average	10	1.0	50.0
Northeast	0.00	Double glazed(low-e)	Average	9	1.0	0.0
East	0.00	Double glazed(low-e)	Average	14	1.0	0.0
Southeast	0.00	Double glazed(low-e)	Average	22	1.0	0.0
South	4.60	Single glazed	Average	34	1.0	156.4
Southwest	0.00	Double glazed(low-e)	Average	22	1.0	0.0
West	1.40	Single glazed	Average	20	1.0	28.0
Northwest	0.00	Double glazed(low-e)	Average	9	1.0	0.0
Rooflights	0.00	Double glazed(low-e)	Average	25	1.0	0.0
Totals	11.00					234.4

(b) Other energy gains	[W]
Water heating gains	248.9
Lights, appliances, cooking, occupants	431.9

Is the following heating / ventilation equipment present?

Central heating pump	No
Warm air heating system fan	No
Mechanical ventilation system	No

Gains from heating / ventilation equipment	0.0
Total other gains [W]	680.8
Total gains [W]	915.2
Gain/loss ratio [K]	2.47
Utilisation factor [-]	1.00
Useful gains [W]	914.6
Temperature rise from gains [K]	2.47

Space heating

Responsiveness	Solid-fuel based systems with boiler within heated space. Fan-assisted electric storage heat
Control category	Basic control, e.g. single room thermostat plus timer

Mean internal temperature [C]	19.35
Base temperature [C]	16.88
Degree days [C d]	2184
Energy to meet space heat demand [kWh/y]	19430

Is space heating distribution pipework/ductwork in floor void or attic?	No
Is space heating distribution pipework/ductwork embedded in ground floor?	No
Total area of ground (or lower) floor [m^2]	0
Distribution loss [kWh/y]	0

Equipment energy use [kWh/y]	0
Energy for space heating [kWh/y]	19430

Heat Energy Rating

Energy for space and water heating [kWh/y]	23115
Heat Energy Rating [kWh/m^2 y]	**287.40**
At/V	0.98
MPHER [kWh/m^2 y]	96.46
Compliance	Does not comply
HER as percentage of MPHER	298%

6.2.2 'Standard' pre 1980's house with Attic Insulation HER

Overall dwelling dimensions

	Floor area [m^2]	Average storey height [m]	Volume [m^3]
Ground floor	41.42	2.48	102.51
First floor	39.01	2.40	93.62
Second floor	0.00	0.00	0.00
Additional parts	0.00		0.00
Floor area [m2]	80.43		
Volume [m3]	196.13		

Rate of heat loss through the building fabric

	Area [m^2]	U-value [W/m^2 K]	A*U [W/K]	Maximum elemental U-values (HER) Element type	Compliance	Comment (optional)
Roof (type 1)	39.01	0.18	7.02		Yes	-
Roof (type 2)	0.00	0.00	0.00		Yes	-
Wall (type 1)	96.00	1.59	152.64		No	-
Wall (type 2)	0.00	0.00	0.00		Yes	-
Ground floor (type 1)	41.42	0.86	35.62		No	-
Ground floor (type 2)	0.00	0.00	0.00		Yes	-
Other exposed floor	0.00	0.00	0.00			-
Element adj to unheated area (1)	0.00	0.00	0.00	Opening	Yes	-
Element adj to unheated area (2)	0.00	3.00	0.00	Opening	Yes	-
Rooflights	0.00	0.00	0.00			-
Window (type 1)	11.00	4.80	52.78			-
Window (type 2)	0.00	0.00	0.00			-
Door (type 1)	3.86	3.00	11.59			-
Door (type 2)	0.00	0.00	0.00			-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Compliance with maximum elemental U-values (HER)					No	
Area of external elements (At) [m^2]			191.29			
Rate of heat loss through elements [W/K]			259.65			
Rate of heat loss due to thermal bridging [W/K]			38.95			
Rate of heat loss through the fabric [W/K]			298.60			

Rate of heat loss due to ventilation

Basic air change rate			[ac/h]
Type of construction	Standard (masonry)		0.40
Number of storeys		2	0.10
Suspended timber floor?	No		0.00
Total basic air change rate			0.50
Infiltration due to flues, vents, fans, etc.			[m^3/h]
Number of large flues/chimneys		1	40
Number of small flues		1	20
Number of permanent vents		0	0
large (opening > 5000 mm^2)		0	0
small (opening < 5000 mm^2)		0	0
Number of passive vents		4	40
Number of fans		2	20
Number of ext. doors without draught lobby		0	0
Total due to flues, vents, etc. [ac/h]			0.61
Gross air change rate			1.11
Number of sides sheltered		2	0.95
Effective air change rate			0.95
Rate of heat loss due to ventilation [W/K]			61.27
Specific heat loss - fabric and infiltration [W/K]			359.86

Water heating

			[kWh/y]
Energy content of heated water			1391
Is hot water heated at point of use only?	No		232
Is hot water storage present?		Yes	
If yes:			
Hot water storage volume [litres]			120
Insulation type	Lagging jacket		
Insulation thickness [mm]			25
Does HW system have separate time control?		Yes	
Tank loss factor [kWh/litre y]			12.60
Storage losses [kWh/y]			1512

Solar and other energy gains

(a) Solar gains

Orientation	Window area [m^2]	Glazing type	Overshading	Flux [W/m^2]	Shading factor [-]	Solar gains [W]
North	5.00	Single glazed	Average	10	1.0	50.0
Northeast	0.00	Double glazed(low-e)	Average	9	1.0	0.0
East	0.00	Double glazed(low-e)	Average	14	1.0	0.0
Southeast	0.00	Double glazed(low-e)	Average	22	1.0	0.0
South	4.60	Single glazed	Average	34	1.0	156.4
Southwest	0.00	Double glazed(low-e)	Average	22	1.0	0.0
West	1.40	Single glazed	Average	20	1.0	28.0
Northwest	0.00	Double glazed(low-e)	Average	9	1.0	0.0
Rooflights	0.00	Double glazed(low-e)	Average	25	1.0	0.0
Totals	11.00					234.4

(b) Other energy gains	[W]
Water heating gains	248.9
Lights, appliances, cooking, occupants	431.9

Is the following heating / ventilation equipment present?

Central heating pump	No
Warm air heating system fan	No
Mechanical ventilation system	No

Gains from heating / ventilation equipment	0.0
Total other gains [W]	680.8
Total gains [W]	915.2
Gain/loss ratio [K]	2.54
Utilisation factor [-]	1.00
Useful gains [W]	914.4
Temperature rise from gains [K]	2.54

Space heating

Responsiveness	Solid-fuel based systems with boiler within heated space. Fan-assisted electric storage heaters
Control category	Basic control, e.g. single room thermostat plus timer

Mean internal temperature [C]	19.35
Base temperature [C]	16.81
Degree days [C d]	2169
Energy to meet space heat demand [kWh/y]	18732

Is space heating distribution pipework/ductwork in floor void or attic?	No	
Is space heating distribution pipework/ductwork embedded in ground floor?	No	
Total area of ground (or lower) floor [m^2]		0
Distribution loss [kWh/y]		0

Equipment energy use [kWh/y]	0
Energy for space heating [kWh/y]	18732

Heat Energy Rating

Energy for space and water heating [kWh/y]	22418
Heat Energy Rating [kWh/m^2 y]	**278.73**
At/V	0.98
MPHER [kWh/m^2 y]	96.46
Compliance	Does not comply
HER as percentage of MPHER	289%

6.2.3 'Standard' pre 1980's house with Wall insulation HER

Overall dwelling dimensions

	Floor area [m^2]	Average storey height [m]	Volume [m^3]
Ground floor	41.42	2.48	102.51
First floor	39.01	2.40	93.62
Second floor	0.00	0.00	0.00
Additional parts	0.00		0.00
Floor area [m2]	80.43		
Volume [m3]	196.13		

Rate of heat loss through the building fabric

	Area [m^2]	U-value [W/m^2 K]	A*U [W/K]	Maximum elemental U-values (HER) Element type	Compliance	Comment (optional)
Roof (type 1)	39.01	0.42	16.38		No	-
Roof (type 2)	0.00	0.00	0.00		Yes	-
Wall (type 1)	96.00	0.22	21.12		Yes	-
Wall (type 2)	0.00	0.00	0.00		Yes	-
Ground floor (type 1)	41.42	0.86	35.62		No	-
Ground floor (type 2)	0.00	0.00	0.00		Yes	-
Other exposed floor	0.00	0.00	0.00			-
Element adj to unheated area (1)	0.00	0.00	0.00	Opening	Yes	-
Element adj to unheated area (2)	0.00	3.00	0.00	Opening	Yes	-
Rooflights	0.00	0.00	0.00			-
Window (type 1)	11.00	4.80	52.78			-
Window (type 2)	0.00	0.00	0.00			-
Door (type 1)	3.86	3.00	11.59			-
Door (type 2)	0.00	0.00	0.00			-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Compliance with maximum elemental U-values (HER)					No	
Area of external elements (At) [m^2]			191.29			
Rate of heat loss through elements [W/K]			137.49			
Rate of heat loss due to thermal bridging [W/K]			20.62			
Rate of heat loss through the fabric [W/K]			158.12			

Rate of heat loss due to ventilation

Basic air change rate			[ac/h]
Type of construction	Standard (masonry)		0.40
Number of storeys		2	0.10
Suspended timber floor?	No		0.00
Total basic air change rate			0.50
Infiltration due to flues, vents, fans, etc.			[m^3/h]
Number of large flues/chimneys		1	40
Number of small flues		1	20
Number of permanent vents		0	0
large (opening > 5000 mm^2)		0	0
small (opening < 5000 mm^2)		0	0
Number of passive vents		4	40
Number of fans		2	20
Number of ext. doors without draught lobby		0	0
Total due to flues, vents, etc. [ac/h]			0.61
Gross air change rate			1.11
Number of sides sheltered		2	0.95
Effective air change rate			0.95
Rate of heat loss due to ventilation [W/K]			61.27
Specific heat loss - fabric and infiltration [W/K]			219.38

Water heating

			[kWh/y]
Energy content of heated water			1391
Is hot water heated at point of use only?	No		232
Is hot water storage present?		Yes	
If yes:			
Hot water storage volume [litres]			120
Insulation type	Lagging jacket		
Insulation thickness [mm]			25
Does HW system have separate time control?		Yes	
Tank loss factor [kWh/litre y]			12.60
Storage losses [kWh/y]			1512

Solar and other energy gains

(a) Solar gains

Orientation	Window area [m^2]	Glazing type	Overshading	Flux [W/m^2]	Shading factor [-]	Solar gains [W]
North	5.00	Single glazed	Average	10	1.0	50.0
Northeast	0.00	Double glazed(low-e)	Average	9	1.0	0.0
East	0.00	Double glazed(low-e)	Average	14	1.0	0.0
Southeast	0.00	Double glazed(low-e)	Average	22	1.0	0.0
South	4.60	Single glazed	Average	34	1.0	156.4
Southwest	0.00	Double glazed(low-e)	Average	22	1.0	0.0
West	1.40	Single glazed	Average	20	1.0	28.0
Northwest	0.00	Double glazed(low-e)	Average	9	1.0	0.0
Rooflights	0.00	Double glazed(low-e)	Average	25	1.0	0.0
Totals	11.00					234.4

(b) Other energy gains	[W]
Water heating gains	248.9
Lights, appliances, cooking, occupants	431.9

Is the following heating / ventilation equipment present?

Central heating pump	No
Warm air heating system fan	No
Mechanical ventilation system	No

Gains from heating / ventilation equipment	0.0
Total other gains [W]	680.8
Total gains [W]	915.2
Gain/loss ratio [K]	4.17
Utilisation factor [-]	0.99
Useful gains [W]	902.9
Temperature rise from gains [K]	4.12

Space heating

Responsiveness	Solid-fuel based systems with boiler within heated space. Fan-assisted electric storage heaters
Control category	Basic control, e.g. single room thermostat plus timer

Mean internal temperature [C]	19.35
Base temperature [C]	15.23
Degree days [C d]	1839
Energy to meet space heat demand [kWh/y]	9682

Is space heating distribution pipework/ductwork in floor void or attic?	No
Is space heating distribution pipework/ductwork embedded in ground floor?	No
Total area of ground (or lower) floor [m^2]	0
Distribution loss [kWh/y]	0

Equipment energy use [kWh/y]	0
Energy for space heating [kWh/y]	9682

Heat Energy Rating

Energy for space and water heating [kWh/y]	13368
Heat Energy Rating [kWh/m^2 y]	**166.21**
At/V	0.98
MPHER [kWh/m^2 y]	96.46
Compliance	Does not comply
HER as percentage of MPHER	172%

6.2.4 'Standard' pre 1980's house with Heating System upgrade HER

Overall dwelling dimensions

	Floor area [m^2]	Average storey height [m]	Volume [m^3]
Ground floor	41.42	2.48	102.51
First floor	39.01	2.40	93.62
Second floor	0.00	0.00	0.00
Additional parts	0.00		0.00
Floor area [m2]	80.43		
Volume [m3]	196.13		

Rate of heat loss through the building fabric

	Area [m^2]	U-value [W/m^2 K]	A*U [W/K]	Maximum elemental U-values (HER) Element type	Compliance	Comment (optional)
Roof (type 1)	39.01	0.42	16.38		No	-
Roof (type 2)	0.00	0.00	0.00		Yes	-
Wall (type 1)	96.00	1.59	152.64		No	-
Wall (type 2)	0.00	0.00	0.00		Yes	-
Ground floor (type 1)	41.42	0.86	35.62		No	-
Ground floor (type 2)	0.00	0.00	0.00		Yes	-
Other exposed floor	0.00	0.00	0.00			-
Element adj to unheated area (1)	0.00	0.00	0.00	Opening	Yes	-
Element adj to unheated area (2)	0.00	3.00	0.00	Opening	Yes	-
Rooflights	0.00	0.00	0.00			-
Window (type 1)	11.00	4.80	52.78			-
Window (type 2)	0.00	0.00	0.00			-
Door (type 1)	3.86	3.00	11.59			-
Door (type 2)	0.00	0.00	0.00			-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Compliance with maximum elemental U-values (HER)					No	
Area of external elements (At) [m^2]			191.29			
Rate of heat loss through elements [W/K]			269.01			
Rate of heat loss due to thermal bridging [W/K]			40.35			
Rate of heat loss through the fabric [W/K]			309.36			

Rate of heat loss due to ventilation

Basic air change rate			[ac/h]
Type of construction	Standard (masonry)		0.40
Number of storeys		2	0.10
Suspended timber floor?	No		0.00
Total basic air change rate			0.50
Infiltration due to flues, vents, fans, etc.			[m^3/h]
Number of large flues/chimneys		1	40
Number of small flues		0	0
Number of permanent vents		0	0
large (opening > 5000 mm^2)		0	0
small (opening < 5000 mm^2)		0	0
Number of passive vents		4	40
Number of fans		2	20
Number of ext. doors without draught lobby		0	0
Total due to flues, vents, etc. [ac/h]			0.51
Gross air change rate			1.01
Number of sides sheltered		2	0.86
Effective air change rate			0.87
Rate of heat loss due to ventilation [W/K]			56.21
Specific heat loss - fabric and infiltration [W/K]			365.57

Water heating

			[kWh/y]
Energy content of heated water			1391
Is hot water heated at point of use only?	No		232
Is hot water storage present?		Yes	
If yes:			
Hot water storage volume [litres]			120
Insulation type		Factory-applied foam	
Insulation thickness [mm]			100
Does HW system have separate time control?		Yes	
Tank loss factor [kWh/litre y]			0.97
Storage losses [kWh/y]			116

Solar and other energy gains

(a) Solar gains

Orientation	Window area [m^2]	Glazing type	Overshading	Flux [W/m^2]	Shading factor [-]	Solar gains [W]
North	5.00	Single glazed	Average	10	1.0	50.0
Northeast	0.00	Double glazed(low-e)	Average	9	1.0	0.0
East	0.00	Double glazed(low-e)	Average	14	1.0	0.0
Southeast	0.00	Double glazed(low-e)	Average	22	1.0	0.0
South	4.60	Single glazed	Average	34	1.0	156.4
Southwest	0.00	Double glazed(low-e)	Average	22	1.0	0.0
West	1.40	Single glazed	Average	20	1.0	28.0
Northwest	0.00	Double glazed(low-e)	Average	9	1.0	0.0
Rooflights	0.00	Double glazed(low-e)	Average	25	1.0	0.0
Totals	11.00					234.4

(b) Other energy gains	[W]
Water heating gains	101.1
Lights, appliances, cooking, occupants	431.9

Is the following heating / ventilation equipment present?

Central heating pump	No
Warm air heating system fan	No
Mechanical ventilation system	No

Gains from heating / ventilation equipment	0.0
Total other gains [W]	533.0
Total gains [W]	767.4
Gain/loss ratio [K]	2.10
Utilisation factor [-]	1.00
Useful gains [W]	767.2
Temperature rise from gains [K]	2.10

Space heating

Responsiveness	Standard gas- or oil-fired radiator or warm-air systems; gas, oil or direct electric room heater systems
Control category	Basic control, e.g. single room thermostat plus timer

Mean internal temperature [C]	18.45
Base temperature [C]	16.35
Degree days [C d]	2073
Energy to meet space heat demand [kWh/y]	18186

Is space heating distribution pipework/ductwork in floor void or attic?	No
Is space heating distribution pipework/ductwork embedded in ground floor?	No
Total area of ground (or lower) floor [m^2]	0
Distribution loss [kWh/y]	0
Equipment energy use [kWh/y]	0
Energy for space heating [kWh/y]	18186

Heat Energy Rating

Energy for space and water heating [kWh/y]	20251
Heat Energy Rating [kWh/m^2 y]	**251.79**
At/V	0.98
MPHER [kWh/m^2 y]	96.46
Compliance	Does not comply
HER as percentage of MPHER	261%

6.2.5 'Standard' pre 1980's house with Full upgrade HER

Overall dwelling dimensions

	Floor area [m^2]	Average storey height [m]	Volume [m^3]
Ground floor	41.42	2.48	102.51
First floor	39.01	2.40	93.62
Second floor	0.00	0.00	0.00
Additional parts	0.00		0.00
Floor area [m2]	80.43		
Volume [m3]	196.13		

Rate of heat loss through the building fabric

	Area [m^2]	U-value [W/m^2 K]	A*U [W/K]	Maximum elemental U-values (HER) Element type	Compliance	Comment (optional)
Roof (type 1)	39.01	0.18	7.02		Yes	-
Roof (type 2)	0.00	0.00	0.00		Yes	-
Wall (type 1)	96.00	0.22	21.12		Yes	-
Wall (type 2)	0.00	0.00	0.00		Yes	-
Ground floor (type 1)	41.42	0.86	35.62		No	-
Ground floor (type 2)	0.00	0.00	0.00		Yes	-
Other exposed floor	0.00	0.00	0.00			-
Element adj to unheated area (1)	0.00	0.00	0.00	Opening	Yes	-
Element adj to unheated area (2)	0.00	0.00	0.00	Opening	Yes	-
Rooflights	0.00	0.00	0.00			-
Window (type 1)	11.00	4.80	52.78			-
Window (type 2)	0.00	0.00	0.00			-
Door (type 1)	3.86	3.00	11.59			-
Door (type 2)	0.00	0.00	0.00			-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Compliance with maximum elemental U-values (HER)					No	
Area of external elements (At) [m^2]			191.29			
Rate of heat loss through elements [W/K]			128.13			
Rate of heat loss due to thermal bridging [W/K]			19.22			
Rate of heat loss through the fabric [W/K]			147.35			

Rate of heat loss due to ventilation

Basic air change rate			[ac/h]
Type of construction	Standard (masonry)		0.40
Number of storeys		2	0.10
Suspended timber floor?	No		0.00
Total basic air change rate			0.50
Infiltration due to flues, vents, fans, etc.			[m^3/h]
Number of large flues/chimneys		1	40
Number of small flues		0	0
Number of permanent vents		0	0
large (opening > 5000 mm^2)		0	0
small (opening < 5000 mm^2)		0	0
Number of passive vents		4	40
Number of fans		2	20
Number of ext. doors without draught lobby		0	0
Total due to flues, vents, etc. [ac/h]			0.51
Gross air change rate			1.01
Number of sides sheltered		2	0.86
Effective air change rate			0.87
Rate of heat loss due to ventilation [W/K]			56.21
Specific heat loss - fabric and infiltration [W/K]			203.56

Water heating

		[kWh/y]
Energy content of heated water		1391
Is hot water heated at point of use only?	No	232
Is hot water storage present?	Yes	
If yes:		
Hot water storage volume [litres]		120
Insulation type	Factory-applied foam	
Insulation thickness [mm]		100
Does HW system have separate time control?	Yes	
Tank loss factor [kWh/litre y]		0.97
Storage losses [kWh/y]		116

Solar and other energy gains

(a) Solar gains

Orientation	Window area [m^2]	Glazing type	Overshading	Flux [W/m^2]	Shading factor [-]	Solar gains [W]
North	5.00	Single glazed	Average	10	1.0	50.0
Northeast	0.00	Double glazed(low-e)	Average	9	1.0	0.0
East	0.00	Double glazed(low-e)	Average	14	1.0	0.0
Southeast	0.00	Double glazed(low-e)	Average	22	1.0	0.0
South	4.60	Single glazed	Average	34	1.0	156.4
Southwest	0.00	Double glazed(low-e)	Average	22	1.0	0.0
West	1.40	Single glazed	Average	20	1.0	28.0
Northwest	0.00	Double glazed(low-e)	Average	9	1.0	0.0
Rooflights	0.00	Double glazed(low-e)	Average	25	1.0	0.0
Totals	11.00					234.4

(b) Other energy gains	[W]
Water heating gains	101.1
Lights, appliances, cooking, occupants	431.9

Is the following heating / ventilation equipment present?

Central heating pump	Yes
Warm air heating system fan	No
Mechanical ventilation system	No

Gains from heating / ventilation equipment	10.0
Total other gains [W]	543.0
Total gains [W]	777.4
Gain/loss ratio [K]	3.82
Utilisation factor [-]	0.99
Useful gains [W]	770.4
Temperature rise from gains [K]	3.78

Space heating

Responsiveness	Standard gas- or oil-fired radiator or warm-air systems; gas, oil or direct electric room heater systems
Control category	Basic control, e.g. single room thermostat plus timer

Mean internal temperature [C]	18.45
Base temperature [C]	14.67
Degree days [C d]	1721
Energy to meet space heat demand [kWh/y]	8406

Is space heating distribution pipework/ductwork in floor void or attic?	No
Is space heating distribution pipework/ductwork embedded in ground floor?	No
Total area of ground (or lower) floor [m^2]	0
Distribution loss [kWh/y]	0

Equipment energy use [kWh/y]	120
Energy for space heating [kWh/y]	8526

Heat Energy Rating

Energy for space and water heating [kWh/y]	10591
Heat Energy Rating [kWh/m^2 y]	**131.68**
At/V	0.98
MPHER [kWh/m^2 y]	96.46
Compliance	Does not comply
HER as percentage of MPHER	137%

6.3 Appendix 3 Control System Analysis

6.3.1 Typical occupant usage scenarios

a) Family Home; all rooms occupied, some additional heat required at night.

	Room	Desired Heating Programme							
		Usage period 1		*Usage period 2*		*Usage period 3*		*Usage period 4*	
		Start	*Finish*	*Start*	*Finish*	*Start*	*Finish*	*Start*	*Finish*
Zone 1	Kitchen / Dining			12:20	13:30	17:00	18:40		
	Utility			12:20	13:30	17:00	18:40		
	Sitting Room					18:00	23:00		
	Hall	7:40	8:40	12:20	13:30	17:00	17:40		
Zone 2	Master Bedroom	7:40	8:40			22:00	23:00		
	Bedroom 2	7:40	8:40			20:00	21:00	3:00	4:00
	Bedroom 3	7:40	8:40			20:00	22:00		
	Bathroom	7:40	8:40			17:00	17:40		
	Landing	7:40	8:40			17:00	18:40		

b) Careless users; controls in place but not being used properly

	Room	Desired Heating Programme							
		Usage period 1		*Usage period 2*		*Usage period 3*		*Usage period 4*	
		Start	*Finish*	*Start*	*Finish*	*Start*	*Finish*	*Start*	*Finish*
Zone 1	Kitchen / Dining	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
	Utility	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
	Sitting Room	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
	Hall	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
Zone 2	Master Bedroom	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
	Bedroom 2	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
	Bedroom 3	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
	Bathroom	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
	Landing	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00

c) Couple; not all rooms in the house used, no night heating.

	Room	Desired Heating Programme							
		Usage period 1		*Usage period 2*		*Usage period 3*		*Usage period 4*	
		Start	*Finish*	*Start*	*Finish*	*Start*	*Finish*	*Start*	*Finish*
Zone 1	Kitchen / Dining					17:00	18:40		
	Utility					17:00	18:40		
	Sitting Room					18:00	22:00		
	Hall	7:40	8:40			17:00	17:40		
Zone 2	Master Bedroom	7:40	8:40			22:00	23:00		
	Bedroom 2								
	Bedroom 3								
	Bathroom	7:40	8:40			17:00	17:40		
	Landing	7:40	8:40			17:00	18:40		

6.3.2 Comparison of control systems,

There are three control scenarios that we have examined here, these are:

Situation 1 Simple timer: heating system all on or all off.

Situation 2 Two Zones: upstairs and downstairs on different zones, with independent controls.

Situation 3 RadMaster: Each room independently zoned.

a) Occupancy scenario (a), original house, no upgrade.

Net Delivered Heat	Heat required (HER data) *[kWh/y]*	Saving *[kWh/y]*	Saving %	Heat Energy Rating *[kWh/m2y]*
Situation 1 Simple Timer	23,115	0	*0.0%*	287
Situation 2 Two Zones	21,308	1,807	*7.8%*	265
Situation 3 Rad Master	12,886	10,229	44.3%	160

b) Occupancy scenario (b), original house, no upgrade.

Net Delivered Heat	Heat required (HER data) *[kWh/y]*	Saving *[kWh/y]*	Saving %	Heat Energy Rating *[kWh/m2y]*
Situation 1 Simple Timer	23,115	0	*0.0%*	287
Situation 2 Two Zones	23,115	0	*0.0%*	287
Situation 3 Rad Master	23,115	0	0.0%	287

c) Occupancy scenario (c), original house, no upgrade.

Net Delivered Heat	Heat required (HER data) *[kWh/y]*	Saving *[kWh/y]*	Saving %	Heat Energy Rating *[kWh/m2y]*
Situation 1 Simple Timer	23,115	0	*0.0%*	287
Situation 2 Two Zones	21,988	1,127	*4.9%*	273
Situation 3 Rad Master	11,718	11,397	49.3%	146

a) Occupancy scenario (a), original house, upgrade.

Net Delivered Heat	Heat required [kWh/y]	Saving [kWh/y]	Saving %	Heat Energy Rating [kWh/m2y]
Situation 1 Simple Timer	10,591	0	*0.0%*	132
Situation 2 Two Zones	9,779	813	*7.7%*	122
Situation 3 Rad Master	5,991	4,600	43.4%	74

b) Occupancy scenario (b), original house, upgrade.

Net Delivered Heat	Heat required [kWh/y]	Saving [kWh/y]	Saving %	Heat Energy Rating [kWh/m2y]
Situation 1 Simple Timer	10,591	0	*0.0%*	132
Situation 2 Two Zones	10,591	0	*0.0%*	132
Situation 3 Rad Master	10,591	0	0.0%	132

c) Occupancy scenario (c), original house, upgrade.

Net Delivered Heat	Heat required [kWh/y]	Saving [kWh/y]	Saving %	Heat Energy Rating [kWh/m2y]
Situation 1 Simple Timer	10,591	0	*0.0%*	132
Situation 2 Two Zones	10,084	507	*4.8%*	125
Situation 3 Rad Master	5,465	5,126	48.4%	68

6.3.3 Potential Carbon Dioxide Savings with upgrade alone

Estimation of Carbon dioxide savings based on the fuels used as outlined below:

Fuel Type		Estimated percentage use
Peat	*Briquettes Baled*	20%
Brown Coal	*Nuggets*	0%
Coal	*Premium Coal*	0%
	Standard Coal	30%
Oil	*Gas Oil*	0%
	Kerosene	0%
LPG	*Bulk LPG*	0%
	Bottled Butane	10%
	Bottled Propane	0%
Natural Gas		0%
Electricity		40%
Total		100%

Original, based on **Net** heat requirement.

Net Delivered Heat	**Heat required** *[kWh/y]*	**CO2** **kg**	**Cost** **€**
Original house, pre upgrade	23,115	10,339	€1,886
Upgraded house, no radmaster	10,591	4,737	€ 864

6.3.4 Potential Cost and Carbon Dioxide Savings

Case 1a: Based on occupancy type a, Family home. Upgraded using natural gas and electricity to provide heat, standard 70% efficient gas boiler.

Gross Delivered Heat	Heat required *[kWh/y]*	Saving *[kWh/y]*	CO2 kg/y	Saving kg CO2/y	Cost €	Saving €
Situation 1 Simple Timer	14,508	0	3,540	0	€ 810	€ -
Situation 2 Two Zones	13,395	1,113	3,268	272	€ 747	€ 62
Situation 3 Rad Master	8,207	6,302	2,002	1,538	€ 458	€352

Case 1b: Based on occupancy type a, Family home. Upgraded using natural gas (90%) and electricity (10%) to provide heat, 90% efficient condensing gas boiler.

Gross Delivered Heat	Heat required *[kWh/y]*	Saving *[kWh/y]*	CO2 kg/y	Saving kg CO2/y	Cost €	Saving €
Situation 1 Simple Timer	11,639	0	2,840	0	€ 649	€ -
Situation 2 Two Zones	10,746	893	2,622	218	€ 600	€ 50
Situation 3 Rad Master	6,583	5,055	1,606	1,233	€ 367	€282

Case 2: Based on occupancy type a, Family home. Upgraded, using oil (90%) and electricity (10%) to provide heat, 70% efficient oil boiler.

Gross Delivered Heat	Heat required *[kWh/y]*	Saving *[kWh/y]*	CO2 kg/y	Saving kg CO2/y	Cost €	Saving €
Situation 1 Simple Timer	14,508	0	4,297	0	€ 748	€ -
Situation 2 Two Zones	13,395	1,113	3,968	330	€ 691	€ 57
Situation 3 Rad Master	8,207	6,302	2,431	1,867	€ 423	€325

Case 3a: Based on occupancy type a, Family home. Original using natural gas and electricity to provide heat, standard 70% efficient gas boiler.

Gross Delivered Heat	Heat required *[kWh/y]*	Saving *[kWh/y]*	CO2 kg	Saving kg CO2	Cost €	Saving €
Situation 1 Simple Timer	31,665	0	7,726	0	€1,767	€ -
Situation 2 Two Zones	29,190	2,475	7,122	604	€1,629	€138
Situation 3 Rad Master	17,653	14,012	4,307	3,419	€ 985	€782

Case 3b: Based on occupancy type a, Family home. Upgraded using natural gas (90%) and electricity (10%) to provide heat, 90% efficient condensing gas boiler.

Gross Delivered Heat	Heat required *[kWh/y]*	Saving *[kWh/y]*	CO2 kg	Saving kg CO2	Cost €	Saving €
Situation 1 Simple Timer	25,401	0	6,198	0	€1,417	€ -
Situation 2 Two Zones	23,416	1,985	5,713	484	€1,307	€111
Situation 3 Rad Master	14,161	11,240	3,455	2,743	€ 790	€627

Case 4: Based on occupancy type a, Family home. Original, using oil (90%) and electricity (10%) to provide heat, 70% efficient oil boiler.

Gross Delivered Heat	Heat required *[kWh/y]*	Saving *[kWh/y]*	CO2 kg	Saving kg CO2	Cost €	Saving €
Situation 1 Simple Timer	31,665	0	9,379	0	€1,633	€ -
Situation 2 Two Zones	29,190	2,475	8,646	733	€1,505	€128
Situation 3 Rad Master	17,653	14,012	5,229	4,150	€ 910	€723