

# RadMaster1000 & H.E.R

# Analysis and Report

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# **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<sup>2</sup>y in the original house without upgrade potentially to 68 kWh/m<sup>2</sup>y.

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	*Gross Reduction in Heat required	Reduction in CO2 Emissions
	kWh/y	%	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	Reduction in Heat required	Reduction in CO2 Emissions	Cost
	kWh/y	%	kg/y	€
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°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	Reduction
HER Carried out	[kWh/m2y]	%
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	HER	Reduction	Including	HER	Red
upgrade	[kWh/m2y]	%	upgrade	[kWh/m2y]	Q
RadMaster			RadMaster		
Scenario a	160	44%	Scenario a	74	43
Scenario c	146	49%	Scenario c	68	48
Average		47%	Average		46
Two Zones			Two Zones		
Scenario a	265	8%	Scenario a	122	8
Scenario c	273	5%	Scenario c	125	59
Average		6%	Average		69
Simple Timer			Simple Timer		
Scenario a	287	0%	Scenario a	132	0
Scenario c	287	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]					
		90%,			
Upgraded	70%, gas	gas	70%, oil		
Timer	0	0	0		
Two Zones	272	218	330		
RadMaster	1538	1233	1867		
		90%,			
Original	70%, gas	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 80.4 196.2							
Exposed Perimeter 19.2							
Area (A) [m2] to exte	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%	
l otal 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 d	imensions		
	Floor area	Average storey	Volume
	[m <sup>2</sup> ]	height [m]	[m <sup>3</sup> ]
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 build			A *! !		elemental L	
	Area	U-value	A*U	Element	Compliance	Comment
Deef (hare 4)	[m <sup>2</sup> ]	[W/m <sup>2</sup> K] 0.42	[W/K]	type	Nie	
Roof (type 1)	39.01 0.00	0.42	16.38		No Yes	-
Roof (type 2)	96.00	0.00 1.59	0.00 152.64		res	-
Wall (type 1) Wall (type 2)	96.00	0.00	0.00		Yes	-
Ground floor (type 1)	41.42	0.00	35.62		No	-
Ground floor (type 2)	0.00	0.00	0.00		Yes	-
Other exposed floor	0.00	0.00	0.00		163	-
Element adj to unheated area (1)	0.00	0.00		Opening	Yes	-
Element adj to unheated area (1)	0.00	0.00		Opening	Yes	_
Rooflights	0.00	0.00	0.00	opening	100	-
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		Opening	Yes	-
Other	0.00	0.00		Opening	Yes	-
Other	0.00	0.00		Opening	Yes	-
Other	0.00	0.00		Opening	Yes	-
Compliance with maximum elementa	al U-value	s (HER)			No	
Area of external elements (At) [m <sup>2</sup> ]			191.29			
Rate of heat loss through elements [	W/K]		269.01			
Rate of heat loss due to thermal brid	ging [W/K	1	40.35			
Rate of heat loss through the fabric [	[W/K]	-	309.36			
Rate of heat loss due to ventilation	n					
Basic air change rate				[ac/h]		
Type of construction		Standard (m	nasonry)	0.40		
Number of storeys			2	0.10		
Suspended timber floor?		I	No	0.00		
Total basic air change rate				0.50		
Infiltration due to flues, vents, fans, e	etc.			[m <sup>3</sup> /h]		
Number of large flues/chimneys			1	40		
Number of small flues			1	20		
Number of permanent vents			0	0		
large (opening > 5000 n	nm²)		0	0		
small (opening < 5000 r			0	0		
Number of passive vents	,		4	40		
Number of fans			2			
Number of ext. doors without draugh	t lobby		0	20		
Total due to flues, vents, etc. [ac/h]			Ū	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/K1			61.27		
Specific heat loss - fabric and infiltra				370.63		
Water heating				[kWh/y]		
Energy content of heated water				1391		
Is hot water heated at point of use or	nly?	I	No	232		
Is hot water storage present? If yes:				Yes		
Hot water storage volume	e [litres]			120		
Insulation type	- []	1	Lagging jac			
Insulation thickness [mm	1			25		
Does HW system have s		me control?		Yes		
Tank loss factor [kWh/litr				12.60		

### Solar and other energy gains

(a) Solar gains						
Orientation Window Glazing type	Overshading		Flux	Shading	Solar gains	
area [m <sup>2</sup> ]	0		[W/m <sup>2</sup> ]	factor [-]	ſŴĨ	
North 5.00 Single glazed	Average		10	1.0		
Northeast 0.00 Double glazed(low-e)			9	1.0		
East 0.00 Double glazed(low-e)			14	1.0		
Southeast 0.00 Double glazed(low-e)			22	1.0		
South 4.60 Single glazed	Average		34	1.0		
Southwest 0.00 Double glazed(low-e)			22	1.0		
West 1.40 Single glazed	Average		20	1.0		
Northwest 0.00 Double glazed(low-e)	0		20	1.0		
Rooflights 0.00 Double glazed(low-e)	-		25	1.0		
Totals 11.00	Average		20	1.0	234.4	
10tais 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 equipmen						
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 syste	ms with boiler w	within hea	ited space.	Fan-assist	ed electric s	torage heat
Control category Basic control, e.g. sing	gle room thermo	ostat 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/ductwo	ork in floor void	or attic?			No	
Is space heating distribution pipework/ductwo	ork embedded i	n ground	floor?		No	
Total area of ground (or lower) floor [m <sup>2</sup> ]		0			0	
Distribution loss [kWh/y]					0	
					0	
Equipment operaty use [k]/h/h/d		0				
Equipment energy use [kWh/y]						
Energy for space heating [kWh/y]		19430				
Heat Energy Bating						
Heat Energy Rating		00445				
Energy for space and water heating [kWh/y]		23115				
Heat Energy Rating [kWh/m <sup>2</sup> y]		287.40				
At/V		0.98				
MPHER [kWh/m <sup>2</sup> y]		96.46				
Compliance	Do	es not co	mply			
HER as percentage of MPHER		298%				
-						

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

Overall dwelling dimensions							
	Floor area	Average storey	Volume				
	[m <sup>2</sup> ]	height [m]	[m <sup>3</sup> ]				
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 buil	Area	U-value	A*U	Element		J-values (HER) Comment (optiona
	[m <sup>2</sup> ]	[W/m <sup>2</sup> K]	[W/K]	type		
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		Opening	Yes	-
Other	0.00	0.00		Opening	Yes	-
Other	0.00	0.00		Opening	Yes	-
Other	0.00	0.00	0.00	Opening	Yes	-
Compliance with maximum element	al U-value	s (HER)			No	
Area of external elements (At) [m <sup>2</sup> ]			191.29			
Rate of heat loss through elements			259.65			
Rate of heat loss due to thermal brid	0 0 1	]	38.95			
Rate of heat loss through the fabric	[W/K]		298.60			
Rate of heat loss due to ventilatio	n					
Basic air change rate				[ac/h]		
Type of construction		Standard (m	asonry)	0.40		
Number of storeys			2	0.10		
Suspended timber floor?		I	No	0.00		
Total basic air change rate				0.50		
5						
Infiltration due to flues, vents, fans,	etc.			[m <sup>3</sup> /h]		
Number of large flues/chimneys			1	40		
Number of small flues			1	20		
Number of permanent vents			0	0		
large (opening > 5000	mm <sup>2</sup> )		0	0		
small (opening < 5000	,					
	mm )		0	0		
Number of passive vents			4			
Number of fans			2			
Number of ext. doors without draug	It 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 infiltra				359.86		
Water heating				[kWh/y]		
Energy content of heated water				1391		
	nly?	ı	No	232		
Is hot water heated at point of use of	2					
				Yes		
Is hot water storage present?						
Is hot water storage present? If yes:	o [litroo]			100		
Is hot water storage present? If yes: Hot water storage volum	e [litres]			120		
Is hot water storage present? If yes: Hot water storage volum Insulation type		I	_agging jac	cket		
Is hot water storage present? If yes: Hot water storage volum Insulation type Insulation thickness [mm	]		_agging jac	cket 25		
Is hot water storage present? If yes: Hot water storage volum Insulation type Insulation thickness [mm Does HW system have s	i] separate tii		_agging jac	cket 25 Yes		
Is hot water storage present? If yes: Hot water storage volum Insulation type Insulation thickness [mm	i] separate tii		_agging jac	cket 25		

#### Solar and other energy gains

(a) Solar gains					
Orientation Window Glazing ty	oe Overshadin	a Flux	Shading	Solar gains	
area [m <sup>2</sup> ]	oc oversnaam	[W/m <sup>2</sup> ]	factor [-]	[W]	
North 5.00 Single glaz	zed Average		0 1.0	50.0	
	zed(low-e) Average		9 1.0	0.0	
	zed(low-e) Average		4 1.0	0.0	
	ized(low-e) Average		2 1.0		
South 4.60 Single glaz			4 1.0	156.4	
	zed(low-e) Average		2 1.0	0.0	
West 1.40 Single glaz	· · · ·	2			
	zed(low-e) Average		9 1.0		
	zed(low-e) Average	2		0.0	
Totals 11.00				234.4	
(b) Other energy gains		[W]			
Water heating gains		248.9			
Lights, appliances, cooking, occu	pants	431.9			
Is the following heating / ventilation	n equipment present?				
Central heating pump	No				
Warm air heating system	em fan No				
Mechanical ventilation	system No				
Gains from heating / ventilation ed	quipment	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					
•		•	e. Fan-assiste	ed electric storage heate	rs
0,	rol, e.g. single room ther				
Mean internal temperature [C]		19.35			
Base temperature [C]		16.81			
Degree days [C d]		2169			
Energy to meet space heat demai	nd [kWh/y]	18732			
				NI-	
Is space heating distribution piper				No	
Is space heating distribution piper		a in ground noor?		No	
Total area of ground (or lower) flo	or [m²]			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		22418			
Heat Energy Rating [kWh/m <sup>2</sup> y]	19 [[( 10 11 / 3]				
0, 0, ,,		278.73			
At/V		0.98			
MPHER [kWh/m <sup>2</sup> y]		96.46			
		Does not comply			
HER as percentage of MPHER		289%			

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

,	Overall dwelling dimensior	าร									
	Floor		A١	/erage store	эу		Volume				
	[m	n <sup>2</sup> ]		height [m]			[m <sup>3</sup> ]				
	Ground floor 4	41.42		2.48			102.51				
		39.01		2.40			93.62				
	Second floor	0.00		0.00			0.00				
	Additional parts	0.00					0.00				
		30.43									
	Volume [m3] 19	96.13									
	Rate of heat loss through t	Ar	ea	U-value	A		Maximum Element			ues (HER) mment (op	
		[m	1 <sup>2</sup> ]	[W/m <sup>2</sup> K]	[W	//K]	type				
	Roof (type 1)	3	39.01	0.42		16.38		No	-		
	Roof (type 2)		0.00	0.00		0.00		Yes	-		
	Wall (type 1)	ç	96.00	0.22		21.12		Yes	-		
	Wall (type 2) Ground floor (type 1)	4	0.00 41.42	0.00 0.86		0.00 35.62		Yes 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	a (1)	0.00	0.00		0.00	Opening	Yes	-		
	Element adj to unheated area	a (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 0.00	3.00 0.00		11.59 0.00			-		
	Door (type 2) Other		0.00	0.00			Opening	Yes	-		
	Other		0.00	0.00			Opening	Yes	_		
	Other		0.00	0.00			Opening	Yes	-		
	Other		0.00	0.00			Opening	Yes	-		
	Compliance with maximum e	elemental U-	-value	s (HER)				No			
	Area of external elements (A					91.29					
	Rate of heat loss through ele					37.49					
	Rate of heat loss due to then			]		20.62					
	Rate of heat loss through the		Ŋ		D	58.12					
	Rate of heat loss due to ve	ntilation									
	Basic air change rate						[ac/h]				
	Type of construction			Standard (r	nasor		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 <sup>3</sup> /h]				
	Number of large flues/chimne					1	40				
	Number of small flues					1	20				
	Number of permanent vents					0	0				
	large (opening >	5000 mm <sup>2</sup>	)			0	0				
	small (opening <	5000 mm <sup>2</sup>	<sup>2</sup> )			0	0				
	Number of passive vents					4	40				
	Number of fans					2	20				
	Number of ext. doors without	0	oby			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 vent	tilation [W/K	]				61.27				
	Specific heat loss - fabric and						219.38				
	M-4										
	Water heating	4					[kWh/y]				
	Energy content of heated wa Is hot water heated at point of				No		1391 232				
	is not water neated at point of	n use only?			INU		232				
	Is hot water storage present?	?					Yes				
	If yes:	•									
	Hot water storage	e volume [lit	res]				120				
	Insulation type	-			Lagg	ing jac					
	Insulation thickne						25				
	Does HW system			me control?	,		Yes				
	Tank loss factor [ Storage losses [kWh/y]	kvvn/litre y]					12.60 1512				
	otoraye losses [Kvvii/y]						1312				

#### Solar and other energy gains

Solar and other energy gains							
(a) Solar gains					<u>.</u>		
Orientation Window Glazing typ	De	Overshading		Flux	-	Solar gains	
area [m²]				[W/m <sup>2</sup> ]	factor [-]	[W]	
North 5.00 Single glaz	ed .	Average		10	1.0	50.0	
Northeast 0.00 Double gla	zed(low-e)	Average		9	1.0	0.0	
East 0.00 Double gla	zed(low-e)	Average		14	1.0	0.0	
Southeast 0.00 Double gla	zed(low-e)	Average		22	1.0	0.0	
South 4.60 Single glaz	ed .	Average		34	1.0	156.4	
Southwest 0.00 Double gla	zed(low-e)	Average		22	1.0	0.0	
West 1.40 Single glaz	. ,	Average		20	1.0	28.0	
Northwest 0.00 Double gla		0		9	1.0	0.0	
Rooflights 0.00 Double gla	. ,	•		25	1.0		
Totals 11.00		J				234.4	
(b) Other energy gains			[W]				
Water heating gains			248.9				
Lights, appliances, cooking, occup	ante		431.9				
Lights, appliances, cooking, occup	Jants		431.5				
le the following besting (ventilation	n aquinmant	nrocont?					
Is the following heating / ventilation		No					
Central heating pump							
Warm air heating syste		No					
Mechanical ventilation		No					
Gains from heating / ventilation eq	quipment		0.0				
Total other gains [W]			680.8				
Total gains [W]			915.2				
Gain/loss ratio [K]		4.17					
Utilisation factor [-]		0.99					
Utilisation factor [-] Useful gains [W]		0.99 902.9					
Useful gains [W]		902.9					
Useful gains [W]		902.9					
Useful gains [W] Temperature rise from gains [K] Space heating	based systen	902.9 4.12	vithin hea	ted space.	Fan-assiste	ed electric s	torage heaters
Useful gains [W] Temperature rise from gains [K] Space heating Responsiveness Solid-fuel b		902.9 4.12		•	Fan-assiste	ed electric s	torage heaters
Useful gains [W] Temperature rise from gains [K] Space heating Responsiveness Solid-fuel b		902.9 4.12 ns with boiler v		•	Fan-assiste	ed electric s	torage heaters
Useful gains [W] Temperature rise from gains [K] Space heating Responsiveness Solid-fuel b Control category Basic control		902.9 4.12 ns with boiler v	ostat plus	•	Fan-assiste	ed electric s	torage heaters
Useful gains [W] Temperature rise from gains [K] Space heating Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C]		902.9 4.12 ns with boiler v	ostat plus 19.35	•	Fan-assiste	ed electric s	torage heaters
Useful gains [W] Temperature rise from gains [K] Space heating Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C]	rol, e.g. singl	902.9 4.12 ns with boiler v	ostat plus 19.35 15.23	•	Fan-assiste	ed electric s	torage heaters
Useful gains [W] Temperature rise from gains [K] Space heating Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d]	rol, e.g. singl	902.9 4.12 ns with boiler v	ostat plus 19.35 15.23 1839	•	Fan-assiste	ed electric s	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar	rol, e.g. singl nd [kWh/y]	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682	•	Fan-assist	ed electric s No	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew	rol, e.g. singl nd [kWh/y] vork/ductwor	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic?	timer	Fan-assiste	No	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic?	timer	Fan-assist	No No	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic?	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic?	timer	Fan-assist	No No	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y]	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic? n ground 1	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] Space heating Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) flor Distribution loss [kWh/y] Equipment energy use [kWh/y]	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic? n ground f	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y]	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic? n ground 1	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y] Equipment energy use [kWh/y]	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic? n ground f	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y] Equipment energy use [kWh/y] Energy for space heating [kWh/y] <b>Heat Energy Rating</b>	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor or [m <sup>2</sup> ]	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic? or attic? or attic? 0 9682	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y] Equipment energy use [kWh/y] Energy for space heating [kWh/y] <b>Heat Energy Rating</b> Energy for space and water heating	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor or [m <sup>2</sup> ]	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic? o ground f 9682 0 9682 13368	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y] Equipment energy use [kWh/y] Energy for space heating [kWh/y] <b>Heat Energy Rating</b> Energy for space and water heatin <b>Heat Energy Rating [kWh/m<sup>2</sup> y]</b>	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor or [m <sup>2</sup> ]	902.9 4.12 ns with boiler v le room thermo	bstat plus 19.35 15.23 1839 9682 or attic? n ground f 0 9682 13368 166.21	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y] Equipment energy use [kWh/y] Energy for space heating [kWh/y] <b>Heat Energy Rating</b> Energy for space and water heatin <b>Heat Energy Rating</b> [kWh/m <sup>2</sup> y] At/V	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor or [m <sup>2</sup> ]	902.9 4.12 ns with boiler v le room thermo	ostat plus 19.35 15.23 1839 9682 or attic? o ground f 9682 0 9682 13368	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y] Equipment energy use [kWh/y] Energy for space heating [kWh/y] <b>Heat Energy Rating</b> Energy for space and water heatin <b>Heat Energy Rating [kWh/m<sup>2</sup> y]</b>	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor or [m <sup>2</sup> ]	902.9 4.12 ns with boiler v le room thermo	bstat plus 19.35 15.23 1839 9682 or attic? n ground f 0 9682 13368 166.21	timer	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) floo Distribution loss [kWh/y] Equipment energy use [kWh/y] Energy for space heating [kWh/y] <b>Heat Energy Rating</b> Energy for space and water heatin <b>Heat Energy Rating</b> [kWh/m <sup>2</sup> y] At/V	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor or [m <sup>2</sup> ]	902.9 4.12 Ins with boiler v le room thermo k in floor void k embedded ir	bstat plus 19.35 15.23 1839 9682 or attic? n ground f 9682 13368 166.21 0.98	floor?	Fan-assist	No No O	torage heaters
Useful gains [W] Temperature rise from gains [K] <b>Space heating</b> Responsiveness Solid-fuel b Control category Basic contr Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demar Is space heating distribution pipew Is space heating distribution pipew Is space heating distribution pipew Total area of ground (or lower) flor Distribution loss [kWh/y] Equipment energy use [kWh/y] Energy for space heating [kWh/y] <b>Heat Energy Rating</b> Energy for space and water heatin <b>Heat Energy Rating</b> [kWh/m <sup>2</sup> y] At/V MPHER [kWh/m <sup>2</sup> y]	rol, e.g. singl nd [kWh/y] vork/ductwor vork/ductwor or [m <sup>2</sup> ]	902.9 4.12 Ins with boiler v le room thermo k in floor void k embedded ir	bstat plus 19.35 15.23 1839 9682 or attic? n ground f 0 9682 13368 <b>166.21</b> 0.98 96.46	floor?	Fan-assist	No No O	torage heaters

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

Overall dwelling dime	nsions						
	Floor area	A	verage store	ey	Volume		
	[m <sup>2</sup> ]		height [m]		[m <sup>3</sup> ]		
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 throu	ugh the build	ling fabr	ic		Maximum	elemental L	J-values (HER)
	-	Area	U-value	A*U	Element	Compliance	Comment (optional)
		[m <sup>2</sup> ]	[W/m <sup>2</sup> K]	[W/K]	type		
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 Element adj to unheated	d area (1)	0.00 0.00	0.00 0.00	0.00	Opening	Yes	-
Element adj to unheated		0.00	3.00		Opening	Yes	-
Rooflights		0.00	0.00	0.00	opening	100	-
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		Opening	Yes	-
Other		0.00	0.00	0.00	Opening	Yes	-
Compliance with maxim		I U-value	s (HER)			No	
Area of external element				191.29			
Rate of heat loss throug				269.01			
Rate of heat loss due to			J	40.35			
Rate of heat loss throug		////		309.36			
Rate of heat loss due	to ventilation	i i			[//-]		
Basic air change rate			Standard (r	naconn/)	[ac/h] 0.40		
Type of construction Number of storeys			Standard (r	11a50111y) 2	0.40		
Suspended timber floor	2			No	0.10		
Total basic air change r					0.50		
· · · · · · · · · · · · · · · · · · ·							
Infiltration due to flues,	vents, fans, et	tc.			[m <sup>3</sup> /h]		
Number of large flues/cl	himneys			1	40		
Number of small flues				0	0		
Number of permanent v				0	0		
large (openir	ng > 5000 m	ım²)		0	0		
small (openii	ng < 5000 m	າm²)		0	0		
Number of passive vent	s			4	40		
Number of fans				2	20		
Number of ext. doors wi	-	lobby		0	0		
Total due to flues, vents	s, etc. [ac/h]				0.51		
Gross air change rate					1.01		
Number of sides shelter	red			2	0.86		
Effective air change rate				-	0.87		
Rate of heat loss due to		V/K]			56.21		
Specific heat loss - fabr					365.57		
Water heating					[kWh/y]		
Energy content of heate	ed water				1391		
Is hot water heated at p		ly?		No	232		
ls hot water storage pre	cont?				Yes		
Is hot water storage pre If yes:	SCILL				165		
	orage volume	[litres]			120		
Insulation ty	0			Factory-ap			
Insulation th	ickness [mm]				100		
	/stem have se		me control?		Yes		
	ctor [kWh/litre	e y]			0.97		
Storage losses [kWh/y]					116		

# Solar and other energy gains (a) Solar gains

(a) Solar gains					
Orientation Window Glazing type	Overshading	Flux	Shading	Solar gains	
area [m <sup>2</sup> ]		[W/m <sup>2</sup> ]	factor [-]	[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)		9	1.0		
Rooflights 0.00 Double glazed(low-e)	Average	25	1.0		
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					
Central heating pump	No				
Warm air heating system fan	No				
Mechanical ventilation system	No 0.0				
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					
	red radiator or warm-air	systems: a	as oil or dir	ect electric r	oom heater systems
	gle room thermostat plus		13, 011 01 011		oon neater systems
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/ductwo		<b>n n</b>		No	
Is space heating distribution pipework/ductwo	ork embedded in ground	floor?		No	
Total area of ground (or lower) floor [m <sup>2</sup> ]				0	
Distribution loss [kWh/y]				0	
Equipment energy use [kWh/y]	0				
Energy for space heating [kWh/y]	18186				
	10100				
Heat Energy Rating					
Energy for space and water heating [kWh/y]	20251				
Heat Energy Rating [kWh/m <sup>2</sup> y]	251.79				
At/V	0.98				
MPHER [kWh/m <sup>2</sup> y]	96.46				
Compliance	Does not co	omply			
HER as percentage of MPHER	261%				

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

Overall dwelling dim	ensions							
	Floor area	A	verage stor	еу	Volume			
One word floor	[m <sup>2</sup> ]		height [m]		[m <sup>3</sup> ]			
Ground floor First floor	41.42 39.01		2.48 2.40		102.51 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 three	-	i <b>ng fabr</b> Area	ic U-value	A*U	Maximum Element		al U-values (l nce Commer	
		[m <sup>2</sup> ]	[W/m <sup>2</sup> K]	[W/K]	type	Compilai	ice comme	it (optional)
Roof (type 1)		39.01	0.18			Yes	-	
Roof (type 2)		0.00	0.00	0.00		Yes	-	
Wall (type 1)		96.00	0.22			Yes	-	
Wall (type 2)		0.00	0.00			Yes	-	
Ground floor (type 1) Ground floor (type 2)		41.42 0.00	0.86 0.00			No Yes	-	
Other exposed floor		0.00	0.00			163	-	
Element adj to unheat	ed area (1)	0.00	0.00		Opening	Yes	-	
Element adj to unheat	ed area (2)	0.00	0.00	0.00	Opening	Yes	-	
Rooflights		0.00	0.00				-	
Window (type 1)		11.00	4.80				-	
Window (type 2) Door (type 1)		0.00 3.86	0.00 3.00				-	
Door (type 2)		0.00	0.00				-	
Other		0.00	0.00		Opening	Yes	-	
Other		0.00	0.00		Opening	Yes	-	
Other		0.00	0.00		Opening	Yes	-	
Other		0.00	0.00	0.00	Opening	Yes	-	
Compliance with maxi Area of external eleme		U-value	S (HER)	101 00		No		
Rate of heat loss throu		//к1		191.29 128.13				
Rate of heat loss due			a	19.22				
Rate of heat loss throu	•	•••		147.35				
Rate of heat loss due Basic air change rate	e to ventilation				[ac/h]	1		
Type of construction			Standard (	masonry)	0.40			
Number of storeys				2				
Suspended timber floo	or?			No	0.00	1		
Total basic air change	rate				0.50	1		
Infiltration due to flues	, vents, fans, et	с.			[m <sup>3</sup> /h]			
Number of large flues/	chimneys/			1				
Number of small flues				0				
Number of permanent		2		0				
• • •	ning > 5000 mi			0				
( I	ning < 5000 m	m⁻)		0				
Number of passive ve Number of fans	IIIS			4				
Number of ext. doors	without draught	lobby		0				
Total due to flues, ven	its, etc. [ac/h]				0.51			
Gross air change rate					1.01			
Number of sides shelt	ered			2				
Effective air change ra	ate				0.87			
Rate of heat loss due		-			56.21			
Specific heat loss - fat	oric and infiltration	on [W/K]			203.56	i		
Water heating					[kWh/y]			
Energy content of hea	ted water				1391			
Is hot water heated at	point of use onl	y?		No	232			
Is hot water storage p	resent?				Yes			
If yes:								
	storage volume	[litres]			120			
Insulation				⊢actory-ap	plied foam 100			
	thickness [mm] system have se	narate ti	me control	,	Yes			
	factor [kWh/litre	•			0.97			
Storage losses [kWh/y					116			

### Solar and other energy gains

(a) Solar gains						
Orientation Window Glazing type	Overshading		Flux	Shading	Solar gains	
area [m <sup>2</sup> ]	5		[W/m <sup>2</sup> ]	factor [-]	[W]	
North 5.00 Single glazed	Average		10	1.0		
Northeast 0.00 Double glazed(low-e)	0		9	1.0		
East 0.00 Double glazed(low-e)			14	1.0		
Southeast 0.00 Double glazed(low-e)	•		22	1.0		
South 4.60 Single glazed	Average		34	1.0		
Southwest 0.00 Double glazed(low-e)	•		22	1.0		
West 1.40 Single glazed	Average		20	1.0		
Northwest 0.00 Double glazed (low-e)	0		20	1.0		
Rooflights 0.00 Double glazed(low-e)			25	1.0		
Totals 11.00	Average		25	1.0	234.4	
10tais 11.00					234.4	
(b) Other energy gains		[W]				
Water heating gains		101.1				
Lights, appliances, cooking, occupants		431.9				
Lights, appliances, cooking, occupants		431.9				
Is the following heating / ventilation equipment	at procent?					
	Yes					
Central heating pump	No					
Warm air heating system fan	No					
Mechanical ventilation system	INU	10.0				
Gains from heating / ventilation equipment		10.0				
Total other gains DA/		E42 0				
Total other gains [W]		543.0				
Total gains [W]	2.02	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				11 11-		
Space heating Responsiveness Standard gas- or oil-fi				is, oil or dir	ect electric r	oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin		stat plus		is, oil or dir	ect electric r	oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin     Mean internal temperature [C]		stat plus 18.45		is, oil or dir	ect electric r	oom heater systems
Space heating Responsiveness Standard gas- or oil-fi Control category Basic control, e.g. sin Mean internal temperature [C] Base temperature [C]		stat plus 18.45 14.67		ıs, oil or dir	ect electric r	oom heater systems
Space heating Responsiveness Standard gas- or oil-fi Control category Basic control, e.g. sin Mean internal temperature [C] Base temperature [C] Degree days [C d]		stat plus 18.45 14.67 1721		ıs, oil or dir	ect electric r	oom heater systems
Space heating Responsiveness Standard gas- or oil-fi Control category Basic control, e.g. sin Mean internal temperature [C] Base temperature [C]		stat plus 18.45 14.67		ıs, oil or dir	ect electric r	oom heater systems
Space heating Responsiveness Standard gas- or oil-fi Control category Basic control, e.g. sin Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demand [kWh/y]	gle room thermo	stat plus 18.45 14.67 1721 8406		is, oil or dir		oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin     Mean internal temperature [C]   Base temperature [C]     Degree days [C d]   Energy to meet space heat demand [kWh/y]     Is space heating distribution pipework/ductwork	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic?	timer	is, oil or dir	No	oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin     Mean internal temperature [C]   Base temperature [C]     Degree days [C d]   Energy to meet space heat demand [kWh/y]     Is space heating distribution pipework/ductwork   Is space heating distribution pipework/ductwork	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic?	timer	is, oil or dir		oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin     Mean internal temperature [C]   Base temperature [C]     Degree days [C d]   Energy to meet space heat demand [kWh/y]     Is space heating distribution pipework/ductwork	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic?	timer	is, oil or dir	No No 0	oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin     Mean internal temperature [C]   Base temperature [C]     Degree days [C d]   Energy to meet space heat demand [kWh/y]     Is space heating distribution pipework/ductwork   Is space heating distribution pipework/ductwork	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic?	timer	is, oil or dir	No No	oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin     Mean internal temperature [C]   Base temperature [C]     Degree days [C d]   Energy to meet space heat demand [kWh/y]     Is space heating distribution pipework/ductwork   Is space heating distribution pipework/ductwork     Total area of ground (or lower) floor [m <sup>2</sup> ]   Image: control c	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic?	timer	is, oil or dir	No No 0	oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin     Mean internal temperature [C]   Base temperature [C]     Degree days [C d]   Energy to meet space heat demand [kWh/y]     Is space heating distribution pipework/ductwork   Is space heating distribution pipework/ductwork     Total area of ground (or lower) floor [m <sup>2</sup> ]   Image: control c	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic?	timer	ıs, oil or dir	No No 0	oom heater systems
Space heating Responsiveness Standard gas- or oil-fi Control category Basic control, e.g. sin Mean internal temperature [C] Base temperature [C] Degree days [C d] Energy to meet space heat demand [kWh/y] Is space heating distribution pipework/ductwo Is space heating distribution pipework/ductwo Total area of ground (or lower) floor [m <sup>2</sup> ] Distribution loss [kWh/y]	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic? ground f	timer	is, oil or dir	No No 0	oom heater systems
Space heating   Responsiveness Standard gas- or oil-fi   Control category Basic control, e.g. sin   Mean internal temperature [C]   Base temperature [C]   Degree days [C d]   Energy to meet space heat demand [kWh/y]   Is space heating distribution pipework/ductwork   Is space heating distribution pipework/ductwork   Total area of ground (or lower) floor [m <sup>2</sup> ]   Distribution loss [kWh/y]   Equipment energy use [kWh/y]	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic? ground f	timer	ıs, oil or dir	No No 0	oom heater systems
Space heating   Responsiveness Standard gas- or oil-fi   Control category Basic control, e.g. sin   Mean internal temperature [C]   Base temperature [C]   Degree days [C d]   Energy to meet space heat demand [kWh/y]   Is space heating distribution pipework/ductwork   Is space heating distribution pipework/ductwork   Total area of ground (or lower) floor [m <sup>2</sup> ]   Distribution loss [kWh/y]   Equipment energy use [kWh/y]	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic? ground f	timer	ıs, oil or dir	No No 0	oom heater systems
Space heating     Responsiveness   Standard gas- or oil-fi     Control category   Basic control, e.g. sin     Mean internal temperature [C]   Base temperature [C]     Base temperature [C]   Degree days [C d]     Energy to meet space heat demand [kWh/y]   Is space heating distribution pipework/ductwork     Is space heating distribution pipework/ductwork   Total area of ground (or lower) floor [m <sup>2</sup> ]     Distribution loss [kWh/y]   Equipment energy use [kWh/y]     Energy for space heating [kWh/y]   Energy for space heating [kWh/y]	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic? ground f	timer	ıs, oil or dir	No No 0	oom heater systems
Space heating   Responsiveness Standard gas- or oil-fi   Control category Basic control, e.g. sin   Mean internal temperature [C]   Base temperature [C]   Degree days [C d]   Energy to meet space heat demand [kWh/y]   Is space heating distribution pipework/ductwe   Total area of ground (or lower) floor [m²]   Distribution loss [kWh/y]   Equipment energy use [kWh/y]   Energy for space heating [kWh/y]   Heat Energy Rating	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic? ground f 120 8526	timer	ıs, oil or dir	No No 0	oom heater systems
Space heating   Responsiveness Standard gas- or oil-fi   Control category Basic control, e.g. sin   Mean internal temperature [C]   Base temperature [C]   Degree days [C d]   Energy to meet space heat demand [kWh/y]   Is space heating distribution pipework/ductwe   Total area of ground (or lower) floor [m²]   Distribution loss [kWh/y]   Equipment energy use [kWh/y]   Energy for space heating [kWh/y]   Heat Energy Rating   Energy for space and water heating [kWh/y]	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic? 9 ground f 120 8526 10591	timer	ıs, oil or dir	No No 0	oom heater systems
Space heating   Responsiveness Standard gas- or oil-fi   Control category Basic control, e.g. sin   Mean internal temperature [C]   Base temperature [C]   Degree days [C d]   Energy to meet space heat demand [kWh/y]   Is space heating distribution pipework/ductwork   Total area of ground (or lower) floor [m²]   Distribution loss [kWh/y]   Equipment energy use [kWh/y]   Energy for space heating [kWh/y]   Heat Energy Rating   Energy for space and water heating [kWh/y]   Heat Energy Rating [kWh/m² y]   At/V	gle room thermo ork in floor void o	stat plus 18.45 14.67 1721 8406 or attic? ground f 120 8526 10591 <b>131.68</b> 0.98	timer	ıs, oil or dir	No No 0	oom heater systems
Space heating   Responsiveness Standard gas- or oil-fi   Control category Basic control, e.g. sin   Mean internal temperature [C]   Base temperature [C]   Degree days [C d]   Energy to meet space heat demand [kWh/y]   Is space heating distribution pipework/ductwork   Total area of ground (or lower) floor [m <sup>2</sup> ]   Distribution loss [kWh/y]   Equipment energy use [kWh/y]   Energy for space heating [kWh/y]   Heat Energy Rating   Energy for space and water heating [kWh/y]   Heat Energy Rating [kWh/m <sup>2</sup> y]   At/V   MPHER [kWh/m <sup>2</sup> y]	gle room thermo	stat plus 18.45 14.67 1721 8406 or attic? ground f 120 8526 10591 <b>131.68</b> 0.98 96.46	loor?	ıs, oil or dir	No No 0	oom heater systems
Space heating   Responsiveness Standard gas- or oil-fi   Control category Basic control, e.g. sin   Mean internal temperature [C]   Base temperature [C]   Degree days [C d]   Energy to meet space heat demand [kWh/y]   Is space heating distribution pipework/ductwork   Total area of ground (or lower) floor [m²]   Distribution loss [kWh/y]   Equipment energy use [kWh/y]   Energy for space heating [kWh/y]   Heat Energy Rating   Energy for space and water heating [kWh/y]   Heat Energy Rating [kWh/m² y]   At/V	gle room thermo	stat plus 18.45 14.67 1721 8406 or attic? ground f 120 8526 10591 <b>131.68</b> 0.98	loor?	ıs, oil or dir	No No 0	oom heater systems

# 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.

				Desi	red Heatii	ng Prograi	mme		
	Room	Usage p	period 1	Usage	period 2	Usage	period 3	Usage	period 4
		Start	Finish	Start	Finish	Start	Finish	Start	Finish
	Kitchen / Dining			12:20	13:30	17:00	18:40		
e,	Utility			12:20	13:30	17:00	18:40		
uo,	Sitting Room					18:00	23:00		
	Hall	7:40	8:40	12:20	13:30	17:00	17:40		
	Master Bedroom	7:40	8:40			22:00	23:00		
2	Bedroom 2	7:40	8:40			20:00	21:00	3:00	4:00
au	Bedroom 3	7:40	8:40			20:00	22:00		
Z0	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

				ng Program	g Programme				
	Room	Usage period 1		Usage period 2		Usage period 3		Usage period 4	
		Start	Finish	Start	Finish	Start	Finish	Start	Finish
1	Kitchen / Dining	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
a)	Utility	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
0	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
	Master Bedroom	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
2	Bedroom 2	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
ne	Bedroom 3	7:40	8:40	12:20	13:30	17:00	23:00	3:00	4:00
20	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.

	Desired Heating Programme									
	Room	Usage period 1		Usage period 2		Usage period 3		Usage	period 4	
		Start	Finish	Start	Finish	Start	Finish	Start	Finish	
	Kitchen / Dining					17:00	18:40			
à	Utility					17:00	18:40			
0 u	Sitting Room					18:00	22:00			
· `	Hall	7:40	8:40			17:00	17:40			
	Master Bedroom	7:40	8:40			22:00	23:00			
~	Bedroom 2									
e u	Bedroom 3									
$\sim$	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) <u>Occupancy scenario (a), original house, no upgrade.</u>

Net Delivered Heat	Heat required (HER data) <i>[kWh/y]</i>	Saving [kWh/y]	Saving %	Heat Energy Rating [ <i>kWh/m2y</i> ]
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) <u>Occupancy scenario (b), original house, no upgrade.</u>

Net Delivered Heat	Heat required (HER data) <i>[kWh/y]</i>	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) <u>Occupancy scenario (c), original house, no upgrade.</u>

Net Delivered Heat	Heat required (HER data) <i>[kWh/y]</i>	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) <u>Occupancy scenario (a), original house, upgrade.</u>

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) <u>Occupancy scenario (b), original house, upgrade.</u>

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) <u>Occupancy scenario (c), original house, upgrade.</u>

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.

	Heat required	CO2	Cost
Net Delivered Heat	[kWh/y]	kg	€
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 <i>[kWh/y]</i>	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 <i>[kWh/y]</i>	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