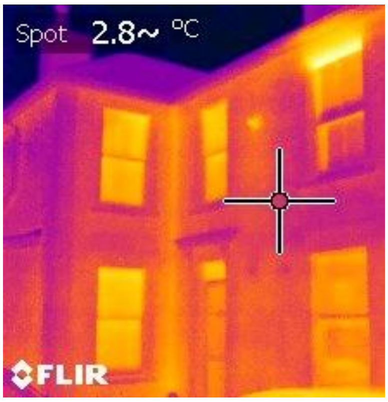
Refit West:
Update from the front line

appendix 1
technical case studies

August 2011

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Forum for the Future is a non-profit organisation working globally with business and government to create a sustainable future. We aim to transform the critical systems that we all depend on, such as food, energy and finance, to make them fit for the challenges of the 21st century. We have 15 years experience inspiring new thinking, building creative partnerships and developing practical innovations to change our world.

If you would like to work with FFTF to develop, deliver or assess a large-scale domestic retrofit project please contact b.ross@forumforthefuture.org

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The Energy Saving Trust is the UK's leading impartial organisation helping people to save energy and reduce carbon emissions. We work with hundreds of organisations and groups in the public and private sectors, providing insight and support that enables them to deliver energy-saving initiatives for consumers across the UK. Our research provides a knowledge bank that many other organisations have drawn on in developing energy-saving policies.

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Executive Summary

In order for the UK to implement a large-scale home energy retrofit scheme and to reduce the 27% of UK carbon emissions that come from our 27 million existing homes we must ensure:

- There is the required **demand** from homeowners
- The **delivery** processes are trusted and capable of high quality cost effective works
- **Financial mechanisms** enable access to capital and recognition of the increased value of homes that are fit for the future

70% of the homes in the UK are owner-occupied, presenting enormous potential for reductions in monthly fuel bills and greater comfort for homeowners. Nationally, success in tackling domestic energy efficiency will reduce greenhouse gas emissions and increase national energy security.

Forum for the Future's Refit West project has been working in the Bristol City region to support homeowners to carry out energy efficiency works to their homes. The Energy Saving Trust provided strategic technical support to assist with the development of a robust delivery model that has the potential for wide replicability for whole house refurbishment in the UK. This report presents detailed technical case studies from three homes retrofit projects shadowed by the Energy Saving Trust.

Property: Redland, North Bristol
Summary of Works: New windows, boiler, solar thermal, MVHR and insulation to internal solid walls, floors, roof, eves.
Investment: £72,500 + VAT

	Energy Performance Certificate Rating (EPC)	Environmental Impact Rating (EI)	Tonnes CO_2 per annum (CO_2)	Modelled energy cost
Before				
SAP2005	41	37	16.7	£3,260
SAP2009	46	39	16.8	£3,160
After				
SAP2005	80	82	5.5	£1,415
SAP2009	78	80	7	£1,640

Property: Southville, South Bristol
Summary of Works: New windows and insulation to floors and roof.
Investment: £10,000 + VAT

	Energy Performance Certificate Rating (EPC)	Environmental Impact Rating (EI)	Tonnes CO_2 per annum (CO_2)	Modelled energy cost
Before				
SAP2005	52	50	8	£1,770
SAP2009	56	54	7.8	£1,530
After				
SAP2005	58	55	7	£1,570
SAP2009	60	55	7.2	£1,455

Property: Thornbury, South Gloucestershire
Summary of Works: New windows, solid fuel stove and external insulation to solid walls.
Investment: £32,000 + VAT

	Energy Performance Certificate Rating (EPC)	Environmental Impact Rating (EI)	Tonnes CO_2 per annum (CO_2)	Modelled energy cost
Before				
SAP2005	64	58	6.3	£1,355
SAP2009	64	58	6.7	£1,345
After				
SAP2005	81	81	4.3	£930
SAP2009	79	81	4.6	£955

1. Introduction

Refit West[1] is a project developed and managed by Forum for the Future[2]. This report outlines the dwellings investigated by the Energy Saving Trust[3], with technical support provided by the Building Research Establishment (BRE)[4]. It provides evidence and case studies supporting the report '*Refit West: Update for the front line – real homeowner journeys and barriers the Green Deal must overcome*', which navigates the customer experience of owner occupied domestic retrofit for energy efficiency.

The initial plan for detailed evaluation of individual homes (from late 2009) was to follow five dwellings from commencement to completion and to offer insight and technical back-up to ensure that no easy measures were overlooked during the refurbishment phase.

However, the project was set back by delays, due mainly to the actual practical nature of refurbishing existing dwellings. As outlined in the main report it is not straight forward to carry out works when real people and real dwellings are involved. National notional savings in CO_2 emissions rely on the ability to upgrade every dwelling to their modelled maximum capability, without any problems occurring that could result in lower reductions in CO_2 emissions, increased costs, or both. Clearly this belief in itself needs to be reconsidered.

The ultimate aim for Refit West is to set up a model of how to ramp up the number of home-owner led whole house refurbishments. Whether this is through one major project or an extended approach to upgrading over time is less important. It is recognised that there are numerous factors driving the nature of works and the scheduling of these.

Although not scaling up in line with initial Refit West project aspirations there is no reason to think that going forward large numbers of existing dwellings will not be refurbished in the years to come. The Refit West model has been designed to be flexible and adaptable enough to fit well into the proposed Green Deal[5]. Ultimately, only three dwellings were shadowed by the Energy Saving Trust, and the enclosed analysis, carried out on their behalf by the BRE, compares each of the dwellings in terms of their starting position, what was originally planned, and what was ultimately done. The CO_2 emission/energy use/running costs are either taken directly from SAP2005/2009[6] data, or in respect to cooking/appliances, taken from the methodology of the Code for Sustainable Homes (May 2009 version)[7] (SAP2005 data) or the SAP2009 specification document.

It should be remembered that SAP uses a standard occupancy methodology to provide an asset rating comparison between different house types, and as such its use here is taking it beyond its intended purpose, as has been mentioned in the main report.

N.B. All EPC band information is presented as 'EPC band X/Y' unless otherwise stated, where the 'X/Y' represents the SAP/Environmental Impact rating achieved by the dwelling respectively.

[1] www.forumforthefuture.org/projects/refit-west
[2] www.forumforthefuture.org
[3] www.energysavingtrust.org.uk/housing
[4] www.bre.co.uk
[5] www.decc.gov.uk/en/content/cms/what_we_do/consumers/green_deal/green_deal.aspx
[6] http://projects.bre.co.uk/sap2005/ and http://www.bre.co.uk/sap2009/page.jsp?id=1642
[7] www.planningportal.gov.uk/buildingregulations/greenerbuildings/sustainablehomes/technicalguide

2. Redland, North Bristol

- Semi-detached house, floor area 244m^2

Of the three Refit West dwellings shadowed by the Energy Saving Trust, 26 Carnarvon Road has to be the most successful by some margin. The design, and more importantly delivery, of the majority of originally planned measures were incorporated into the refurbishment works carried out. This was in no small part enabled by the budget available to the homeowner. That said, it could have been even better as discussed later in this case study (see section 2.2 Survey and Recommendations below) and it narrowly missed out on achieving an EPC band B SAP rating.

Starting from an EPC band E (SAP rating)/band F (environmental impact rating), this very large semi-detached property was responsible for in the order of 16.5~17 tonnes of CO_2 emissions a year, and an annual energy use of between 75,000kWh to 80,000kWh with associated predicted (by SAP) running cost in the region of £3,200 per annum.

At the start of this project the dwelling had significant heat losses through its solid stone walls and the mainly single glazed windows, despite having a recent loft conversion and utility room extension. Fabric heat losses accounted for some 70% of total heat losses, and the existing dwelling had a Fabric Energy Efficiency Standard in excess of 170kWh/m^2/yr. Ventilation heat losses (more than 20%) would also have been an issue because of the open fires in the living room and two bedrooms, the majority of the windows being poorly sealed single glazing, the lack of effective draught-proofing of service entry points and uninsulated suspended timber ground floor.

Actual billing information was provided by previous homeowners who had a similar demographic to the current owners who participated in the Refit West project. This showed that energy use was in the region of about half of the modelled figure, suggesting that the former occupants were already energy use conscious. This raises the question about the assumptions used for the SAP standard occupancy rates and set points, and that these are not an accurate reflection of the energy consumption on this property. One significant implication is that modelled energy performance improvements to the property would be likely to overestimate potential energy, financial and carbon savings achieved in practice.

2.1 Pre-Work Building Specification

Main dwelling	Fabric U-value
Insulated roof, 200mm mineral wool	0.22 W/m^{2}K
Solid walls, 500mm thick stone	2.44 W/m^{2}K
Uninsulated suspended timber floor	0.52 W/m^{2}K
Windows;	
Single glazed timber frames (85%)	4.80 W/m^{2}K
Double glazed u-PVC frames (15%)	2.80 W/m^{2}K
Doors, unglazed solid timber	3.00 W/m^{2}K

<u>Loft conversion (carried out to Part L 2002)</u>

Insulated roof, flat ceiling	0.16 W/m^2K
Insulated roof, sloping ceiling	0.30 W/m^2K
Insulated stud walls	0.35 W/m^2K
Roof lights, double glazed	3.50 W/m^2K

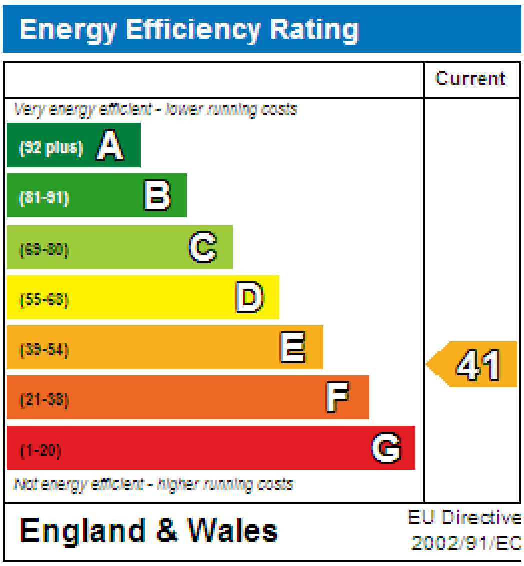
<u>Utility room extension</u>

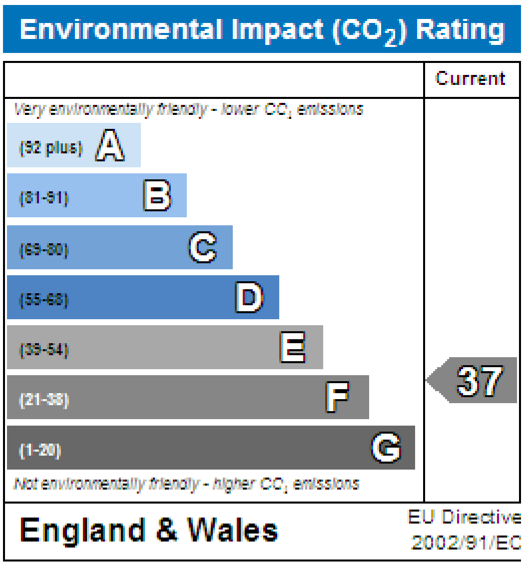
Uninsulated roof	2.20 W/m^2K
Solid walls, 102mm thick brick	2.60 W/m^2K
Uninsulated solid floor	0.76 W/m^2K
Doors, double glazed u-PVC frames	2.80 W/m^2K
Window, single glazed solid timber	4.80 W/m^2K

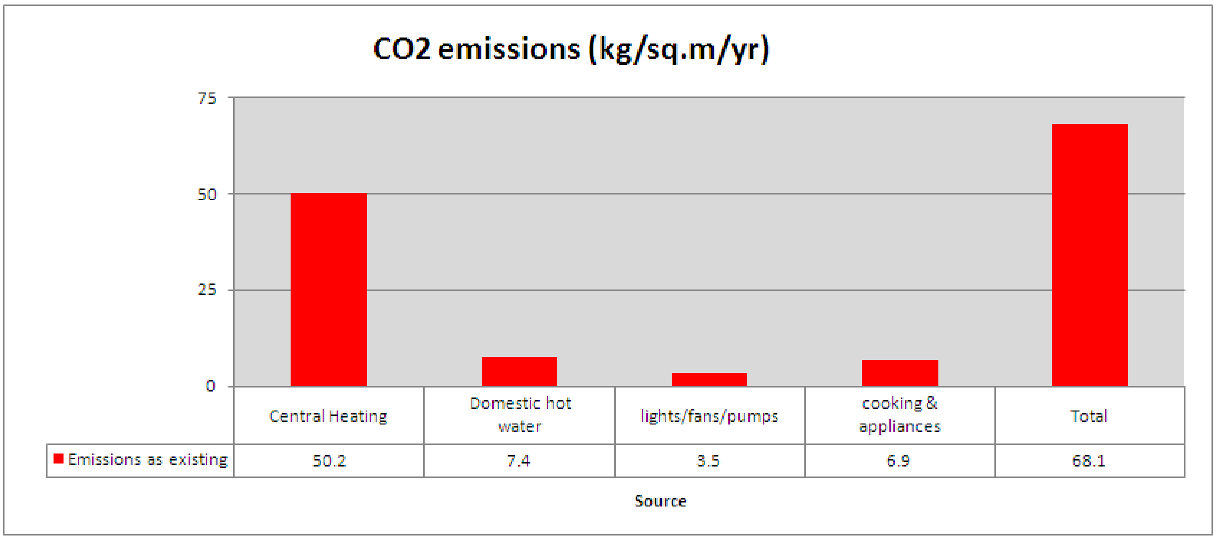
<u>Other features</u>

- Natural ventilation
- RdSAP default procedure for assessing envelope air leakage rate for age and type of property ~ 15 $m^3/hr/m^2$ @ 50Pa
- Regular boiler 68% efficiency, programmer and TRVs, open fire secondary room heating
- Water storage cylinder 165 litre capacity, 25mm insulated jacket, no pipe insulation
- 33% low energy efficient light fittings

2.1.1 SAP2005 analysis







Total CO_2 emissions for the dwelling were about 68 kg/m^2/yr which equates to approximately 16.7 tonnes of CO_2 per year (EPC band E/F). As the dwelling was not well insulated, about three-quarters of the CO_2 emissions came from the energy needed to heat the dwelling.

The dwelling's total emissions were about two and a half times that of the national average for all UK housing which is about 6.5 tonnes of CO_2 per year.

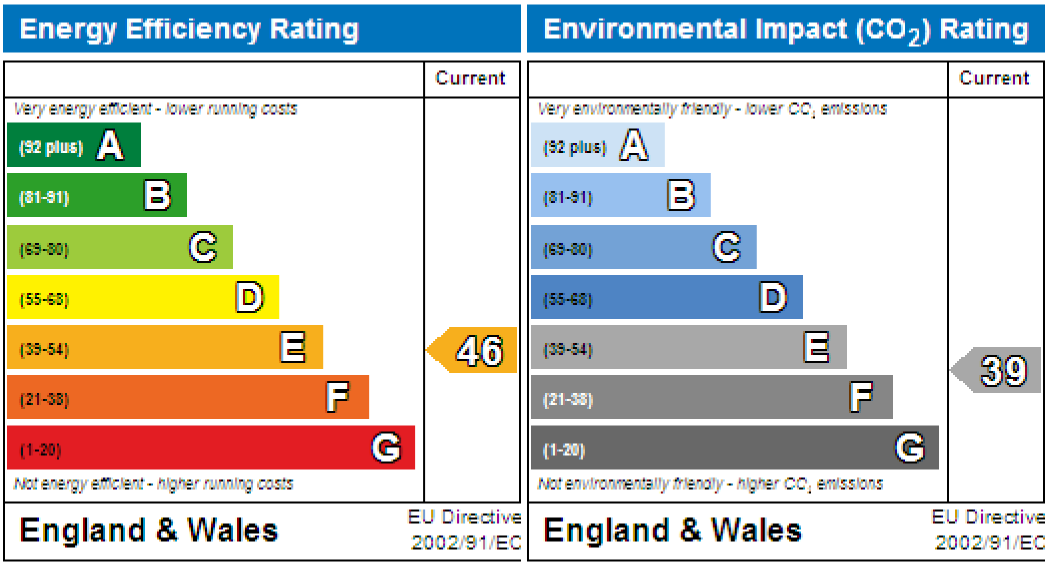
The average CO_2 emissions from solid walled dwellings (taken as pre-1919 dwellings) are about 8.3 tonnes per annum. For its property type this home produced about twice the CO_2 emissions per year more than the average. It should be noted that the property is also about twice as large as the average solid walled semi-detached dwelling.

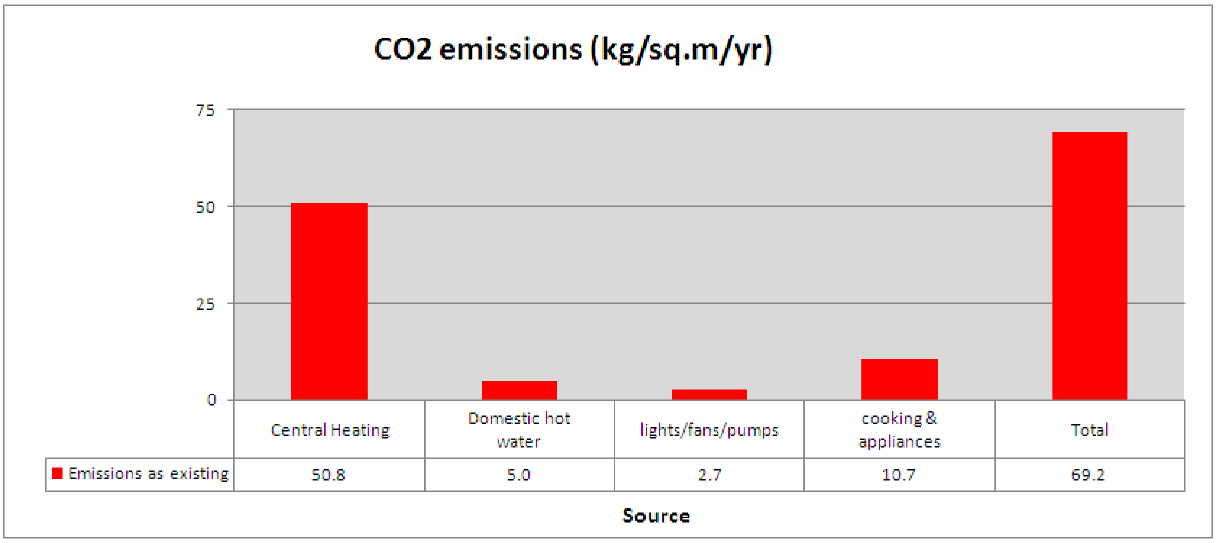
The table below shows how much energy each of these categories used on an annual basis and the associated running costs. These modelled figures have been compared to actual consumption data where possible.

			SAP2005 Outputs		
Energy source and consumption category		Measured energy data (kWh/yr)	Total energy demand (kWh/yr)	Energy demand per square metre (kWh/yr/m^2)	Annual running costs (£/yr)
Gas	Main heating, and hot water	32,310	62,390	260	2,210
	Cooking		1,300		
Solid fuel	Secondary heating	NA	10,820	44	390
Electric	Lights, fans and pumps	7,770	2,040	22	660
	Appliances		3,420		
Total		40,080	79,970	326	3,260

As mentioned earlier, SAP uses a standard pattern of occupancy and use to be able to compare the energy efficiency of different dwelling types. With such a large difference between the actual and predicted heating energy demand, it might therefore be the case that the dwelling was previously heated less than the standard SAP modelling.

2.1.2 SAP2009 analysis





Total CO_2 emissions for this house were about 69 kg/m^2/yr which equates to approximately 16.8 tonnes of CO_2 per year (EPC Band E/E). As the dwelling was not well insulated, about three-quarters of the CO_2 emissions came from the energy needed to heat the dwelling.

The dwelling's total emissions were about two and a half times that of the national average for all UK housing which is about 6.5 tonnes of CO_2 per year.

The average CO_2 emissions from solid walled dwellings (taken as pre-1919 dwellings) are about 8.3 tonnes per annum. For its property type this home produced about twice the CO_2 emissions per year more than the average. It should be noted that the property is also about twice as large as the average solid walled semi-detached property.

The table below shows how much energy each of these categories used on an annual basis and the associated running costs. These modelled figures have been compared to actual consumption data where possible.

Energy source and consumption category		Measured energy data (kWh/yr)	SAP2009 Outputs		
			Total energy demand (kWh/yr)	Energy demand per square metre (kWh/yr/m^2)	Annual running costs (£/yr)
Gas	Main heating, and hot water	32,310	57,840	240	2,050
	Cooking		970		
Solid fuel	Secondary heating	NA	10,710	44	385
Electric	Lights, fans and pumps	7,770	1,300	25	725
	Appliances		4,690		
Total		40,080	75,510	309	3,160

The slight difference in energy demand for heating and hot water (and hence costs) between SAP2005 and SAP2009 is mainly down to the change from an annual assessment (under SAP2005) to a monthly assessment in SAP2009, together with improved hot water use information obtained from field trials undertaken by the Energy Saving Trust. However, although this produces slightly less energy use from SAP2009, the overall CO_2 emissions still increase due mainly to the fact that the CO_2 emission factor for electricity use has increased by more than 20%.

The increase reported for energy use from appliances between the methodologies is in recognition that we use ever more appliances, (flat screen TVs, computer console games etc.). Even though the energy used by increasingly efficient ‘white goods’ has decreased recently, these are not replacing older models sufficiently quickly to offset this additional energy use from other appliances. The overall effect is more pronounced in larger dwellings.

2.2 Survey and Recommendations

The initial survey of this property was carried out by Bristol DEA[8]. This included options analysis for potential thermal efficiency and energy generation upgrades using SAP2005 and presented a Predicted Energy Assessment (PEA) for the property based on a combination of works. The proposed works for this dwelling predicted that the EPC rating would be raised to 77/81, or EPC bands B/C with the following measures being proposed:

i. Insulate the external walls to the 2006 building regulations requirement of U = 0.35 W/m^{2}K
ii. Insulate the timber suspended ground floors to U = 0.22 W/m^{2}K
iii. Top up the roof insulation to U = 0.11 W/m^{2}K where possible
iv. High performance double glazing as a replacement of the existing single glazing
v. SEDBUK(2005) band A condensing boiler, with log burning secondary heating
vi. Solar thermal system with high performance twin coiled cylinder
vii. MVHR ventilation system with air-tightness strategy
viii. Low energy lighting throughout the dwelling
ix. 2kWp installation of solar PV

Insulating the dwelling’s fabric should always be the first design option considered. It makes little sense to use renewable or low carbon energy and then to waste it by not reducing energy demand first. With this mind, the originally proposed method of tackling the refurbishment by applying laminate plasterboard to the inside of the external walls (~60mm PU/PIR type insulation), insulating the ground floor/roof and fitting high performance replacement double glazing would have the benefit of raising the EPC rating to achieve high C/low D.

8 www.bristoldea.co.uk

The next logical step after insulating the dwelling to a high degree of energy efficiency is then to look at improving the heating system. This is not just a matter of considering its efficiency, but also ensuring that it is sized according to the demand placed upon it, as this will in turn optimise the system. Following the replacement of the boiler, the provision of a well-insulated hot water cylinder and sufficient controls on the heating and hot water system will allow the whole system to operate as efficiently as possible. Water heating demand can then be reduced further by incorporating a solar thermal hot water system sized/optimised according to demand.

A further way of reducing the heating demand is to include a ventilation system with heat recovery. With a dwelling with such a large heated volume (~680m^3) this is not only an appropriate consideration in energy efficiency terms, but also as a means to ensure indoor air quality for the dwelling's occupants. The down side of this is that although a high proportion of what would be lost heat is recaptured, the ventilation system uses electricity and needs to run 24/7. Whilst there is reference to a 'holiday switch' on the system installed there was no guidance provided on how to use this to avoid using excess electricity to run the fan or unwanted heat recovery during the summertime. However, running the ventilation system during the summer, without heat recovery, will assist in preventing the dwelling from overheating. It is also necessary to ensure that unwanted air leakage is reduced to a minimum as this will allow for maximising the efficiency of the whole system.

Installing 100% low energy lighting also makes sense, and as tungsten filament bulbs will not be available soon under EU law, this will shortly become the norm. It should be noted that SAP does not currently differentiate between different types of low energy lights, such as CFL or LED, although the latter is significantly more efficient than the former.

Following the insulating of the dwelling, and improving the domestic services, the final part is to look at other renewable options. It was initially proposed to include a ~2kWp solar PV system. The overall effect of all of these proposals would have been sufficient to achieve a SAP rating of 81, which is the bottom of the EPC SAP band B. Without the solar PV, the dwelling would have still fared well, achieving an EPC band C/C and a SAP rating of 75 bringing it close to what a newly built dwelling would achieve.

After further investigation not all of this was installed in the dwelling. The completed works are identified in section 2.3 below. The solar PV system was not installed as the roof aspect and shading did not allow for an optimum use of space. A solar thermal system was installed and cabling introduced to allow for simple future retrofit of a PV system. The final spec also included a much higher level of insulation to the fabric of the dwelling, reducing further the demand for energy. This was considered to be a small marginal cost for the added benefit and avoidance of further thermal works in the future.

Upon completion of the refurbishment works, an air-tightness test was carried out on the dwelling. The result of which at 5.05 m^3/m^{2}hr @ 50Pa is very good for a refurbishment of an existing dwelling and is close to what current new build dwellings are regularly achieving. The air-tightness test provided an opportunity to undertake an air leakage audit with the use of a smoke pen. This informed the contractor how and where to reduce unwanted air leakage further.

2.3 Project Works and Post-Work Building Specification

Works carried out are identified in italics.

Main dwelling	**Fabric U-value**
Insulated roof, 200mm mineral wool	
- *Upgraded with 70mm Quinn-therm*	*0.13 W/m^{2}K*
Solid walls, 500mm thick stone	

- *Upgraded with 70mm Quinn-therm*	*0.25 W/m²K*
Suspended timber floor	
- *Upgraded with 200mm Knauf Roll44*	*0.17 W/m²K*
Windows;	
Double glazed timber frames (85%)	*1.70 W/m²K*
Double glazed u-PVC frames (15%)	2.80 W/m²K
Doors, unglazed solid timber	3.00 W/m²K

Loft conversion (carried out to Part L 2002)

Insulated roof, flat ceiling	0.16 W/m²K
Insulated roof, sloping ceiling	0.30 W/m²K
Insulated stud walls	
- *Upgraded with 80mm Quinn-therm*	*0.26 W/m²K*
Roof lights, double glazed	3.50 W/m²K

Utility room extension

Uninsulated roof	2.20 W/m²K
Solid walls, 102mm thick brick	
- *Upgraded with 70mm Quinn-therm*	*0.25 W/m²K*
Insulated solid floor	
- *Upgraded with 100mm Quinn-therm*	*0.17 W/m²K*
Window, double glazed timber frame	*1.70 W/m²K*
Doors, double glazed u-PVC frames	2.80 W/m²K

Other features

- MVHR ventilation system, Villavent VR 700 DC; SFP 1.85 W/ls and HR efficiency 82%
- Airtightness testing post work ~ 5.05 m³/hr/m² @ 50Pa
- Vaillant Ecotech Plus 624 regular boiler (SEDBUK2005) 91.2% efficiency, time and temperature zone control and weather compensation, closed log burning secondary room heating
- Water storage 300 litre capacity combined solar cylinder, declared loss 2.40 kWh/day, full pipe insulation
- Solar thermal system, 4.6m² flat plate with solar powered pump
- 100% low energy efficient light fittings

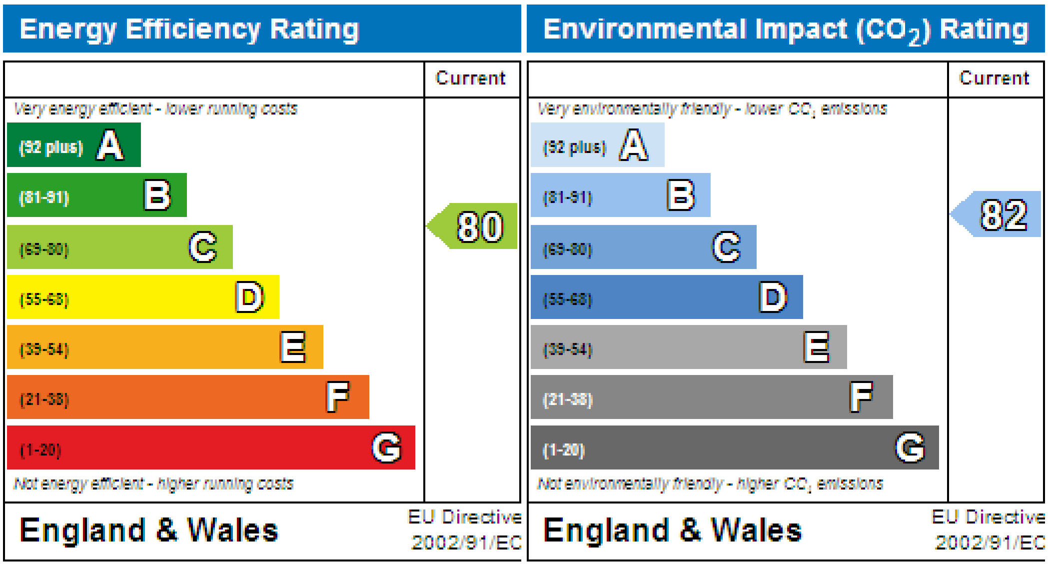
As can be seen above, the actual levels of insulation installed in most cases went beyond the levels originally proposed. The external walls, with a U-value of 0.25 W/m²K, actually exceed of what is currently required by building regulations (U = 0.30 W/m²K) when a solid external wall is insulated.

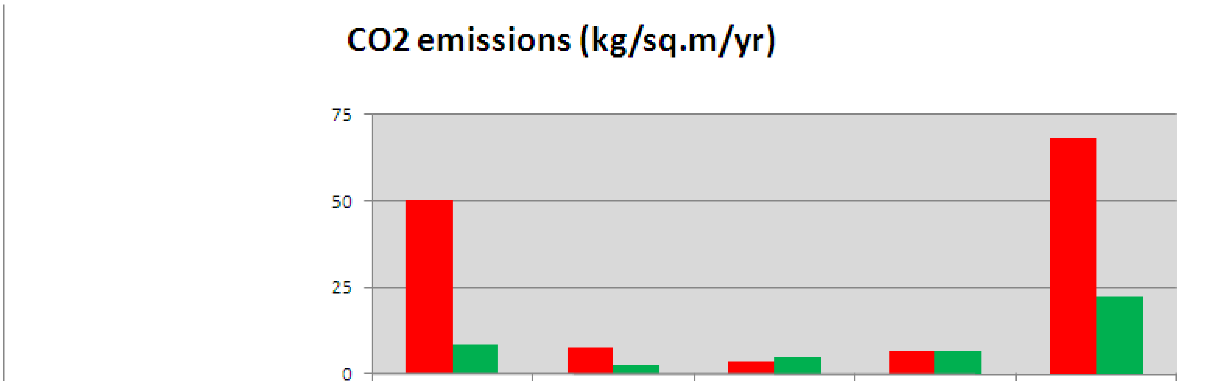
Additionally the services have been optimised to some degree, with the MVHR unit being an exception. With a specific fan power of 1.85 W/ls, this is well above the Energy Saving Trust recommended specific fan power (2009) of 0.80 W/ls, adding about two thirds of a tonne of CO_2 emissions. However, having a ventilation system that is produced by the same manufacturer as the heating/hot water/solar thermal systems will bring other benefits for servicing etc., potentially meaning that the MVHR system will remain close to optimised efficiency.

The overall effect is that the dwelling actually achieves a higher EPC rating than originally designed when the solar PV is excluded, and it only just falls short of achieving an EPC band B rating.

The total budget spent on these works was £72,500 + VAT. This included all thermal upgrade works, air tightness, energy efficiency & generation, making good and incidental costs, e.g. building control.

2.3.1 SAP2005 analysis





	Central Heating	Domestic hot water	lights/fans/ pumps	cooking & appliances	Total
Emissions prior to upgrading	50.2	7.4	3.5	6.9	68.1
Emissions following upgrading	8.4	2.6	4.8	6.9	22.6

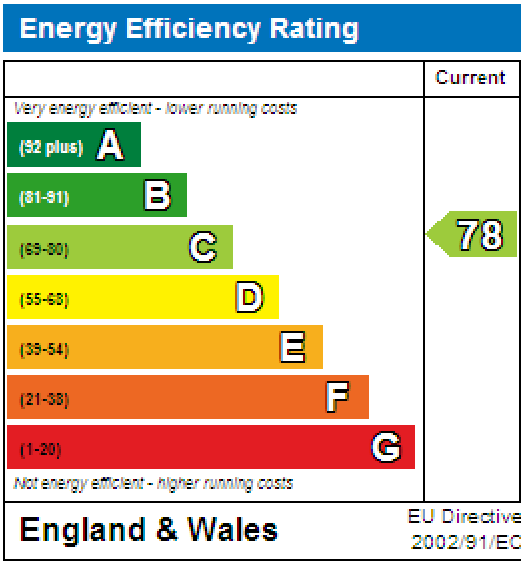
Source

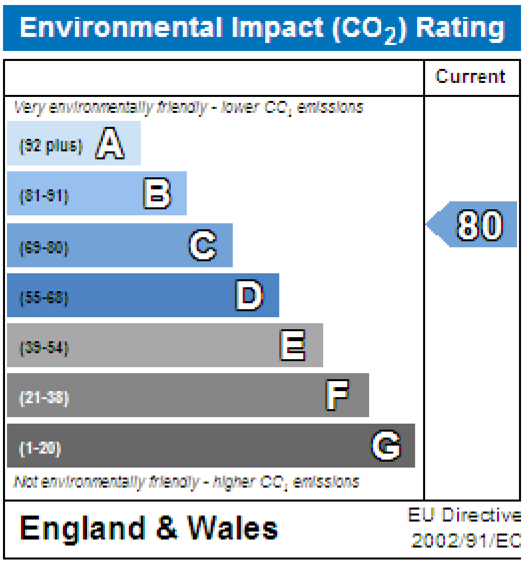
Total CO_2 emissions for this house are 22.6 kg/m^2/year which equates to approximately 5.5 tonnes of CO_2 per year (top of EPC band C/bottom of band B). This represents a 67% reduction. The dwelling's total emissions are now below that of the national average for all UK housing (approx 6.5 tonnes of CO_2 per year), and about two-thirds of the CO_2 emissions of the average solid walled dwelling (approx 8.3 tonnes of CO_2 per year).

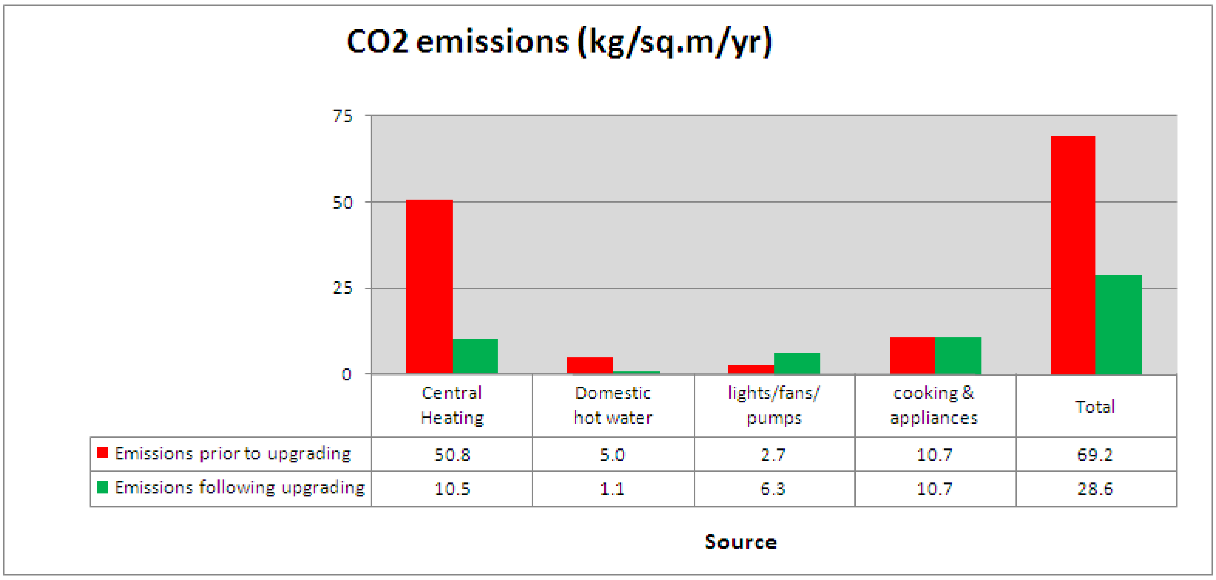
The table below shows how much energy each of these categories uses on an annual basis and the associated running costs;

		SAP2005 Outputs		
Energy source and consumption category		Total energy demand (kWh/yr)	Energy demand per square metre (kWh/yr/m^2)	Annual running costs (£/yr)
Gas	Main heating, and hot water	13,590	61	600
	Cooking	1,300		
Solid fuel	Secondary heating	1,650	7	65
Electric	Lights, fans and pumps	2,780	25	750
	Appliances	3,420		
Total		22,740	93	1,415

2.3.2 SAP2009 analysis







Total CO_2 emissions for this house are 28.6 kg/m^2/year which equates to approximately 7 tonnes of CO_2 per year (EPC Band C/C), which represents a 59% reduction. According to SAP2009 the dwelling's total emissions are now about that of the national average for all UK housing (approx 6.5

tonnes of CO_2 per year), and about two-thirds of the CO_2 emissions of the average solid walled dwelling (approx 8.3 tonnes of CO_2 per year).

The table below shows how much energy each of these categories uses on an annual basis and the associated running costs;

		SAP2009 Outputs		
Energy source and consumption category		Total energy demand (kWh/yr)	Energy demand per square metre (kWh/yr/m^2)	Annual running costs (£/yr)
Gas	Main heating, and hot water	14,270	62	630
	Cooking	970		
Solid fuel	Secondary heating	2,050	8	80
Electric	Lights, fans and pumps	2,970	31	930
	Appliances	4,690		
Total		24,950	101	1,640

The difference in energy demand for heating and hot water (and hence costs) between SAP2005 and SAP2009 is mainly down to the change from an annual assessment (under SAP2005) to a monthly assessment in SAP2009, together with improved hot water use information obtained from field trials undertaken by the Energy Saving Trust. However, although this produces slightly less energy use from SAP2009, the overall CO_2 emissions still increase due mainly to the fact that the CO_2 emission factor for electricity use has increased by more than 20%.

As reported in section 2.1 above the increase reported for energy use from appliances is in recognition that we use ever more appliances in our homes.

3. Southville, South Bristol

- Corner end terrace house, floor area 128m²

The starting point for this dwelling was also an EPC band E (SAP rating). This large corner end terrace property was responsible for circa 8 tonnes of CO_2 emissions a year, and an annual energy use of between 36,000kWh to 37,000kWh with associated predicted running cost in the region of £1,700 per annum.

Looking at the actual specification that existed before the refurbishment, and the SAP2005/2009 analysis, the dwelling had significant heat losses through its solid walls and only being half double glazed. Fabric heat losses account for nearly 75% of total heat losses, and the existing dwelling had a Fabric Energy Efficiency Standard in excess of 170kWh/m²yr. Ventilation heat losses (less than 20%) would also have been an issue because of the leaky single glazing, the lack of effective draught-proofing of service entry points and uninsulated suspended timber ground floor.

3.1 Pre-Work Building Specification

Main dwelling	**Fabric U-value**
Insulated roof, 200mm mineral wool	0.24 W/m²K
Solid walls, 215mm thick brick	2.10 W/m²K
Uninsulated suspended timber floor	0.45 W/m²K
Windows;	
Single glazed timber frames (66%)	4.80 W/m²K
Double glazed u-PVC frames (34%)	2.80 W/m²K
Doors, unglazed solid timber	3.00 W/m²K
Kitchen/Utility room extension	
Insulated roof	0.35 W/m²K
Uninsulated cavity walls	1.00 W/m²K
Uninsulated solid floor	0.77 W/m²K
Doors, half double glazed timber frames	2.90 W/m²K
Windows, double glazed timber	2.80 W/m²K
Roof-lights, double glazed	4.10 W/m²K

Other features

- Natural ventilation
- RdSAP default procedure for assessing envelope air leakage rate for age and type of property ~ 15 m³/hr/m² @ 50Pa

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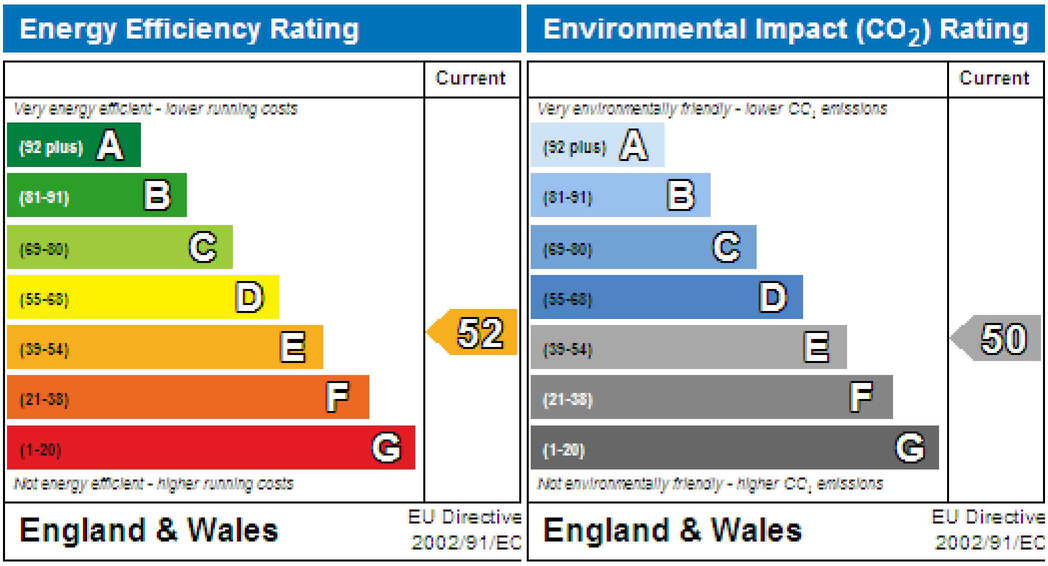
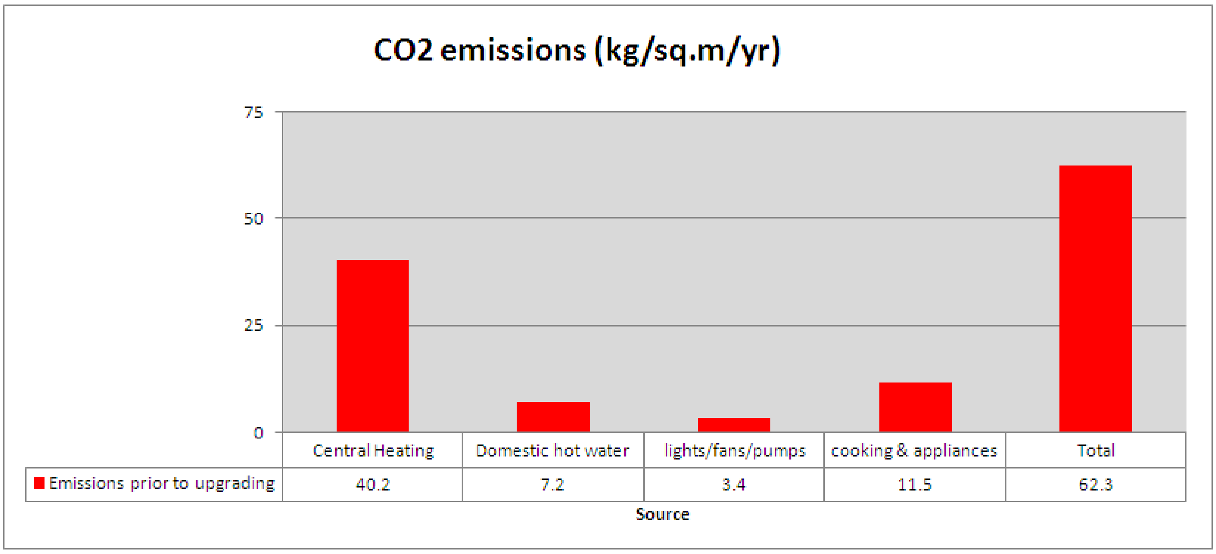
- Worcester combi boiler 78% efficiency, programmer, room thermostat and TRVs, closed log burning secondary room heating
- 50% low energy efficient light fittings

3.1.1 SAP2005 analysis





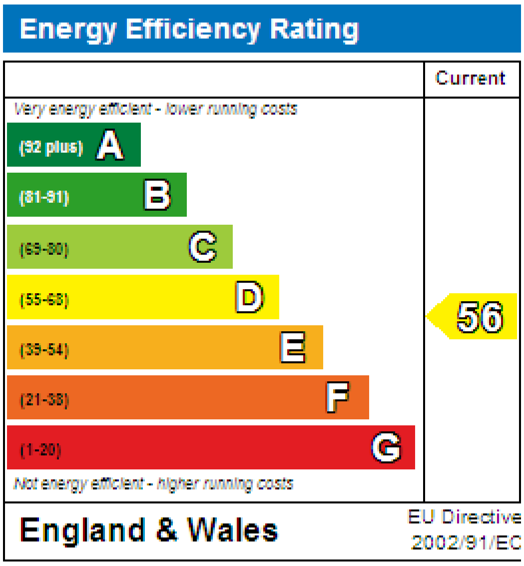
Total CO_2 emissions for this house were 62.3 kg/m^2/year which equates to approximately 8 tonnes of CO_2 per year (EPC band E/E). As the dwelling was not well insulated, about two-thirds of the CO_2 emissions came from the energy needed to heat the dwelling.

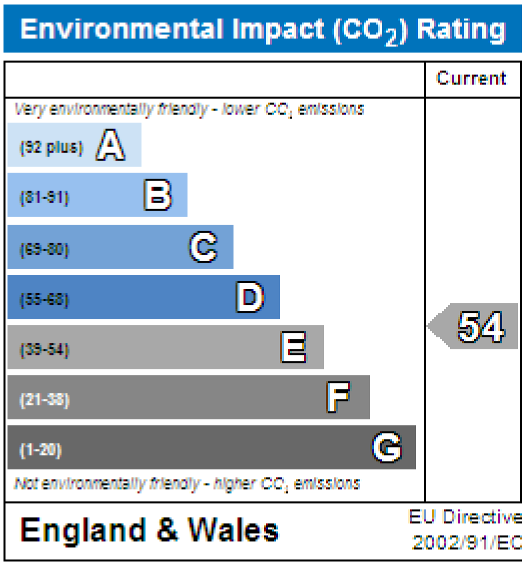
The dwelling's total emissions were nearly a third higher than that of the national average for all UK housing (of approx 6.5 tonnes CO_2 per annum), but about on par with the average solid walled dwelling (of approx 8.3 tonnes CO_2 per annum).

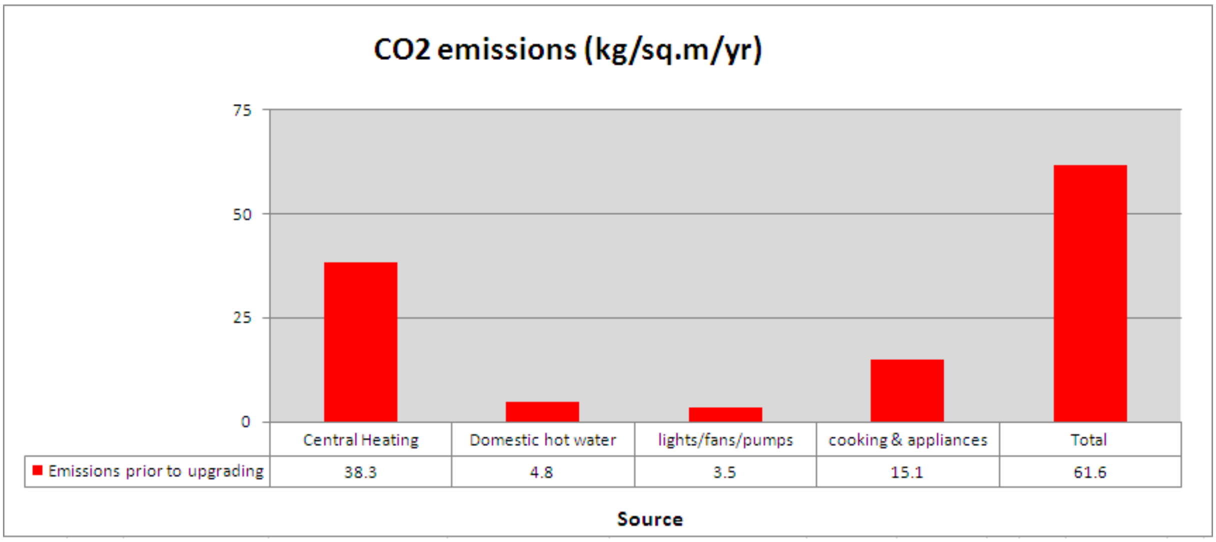
The following table shows how much energy each of these categories used on an annual basis and the associated running costs;

Energy source and consumption category		Measured energy data (kWh/yr)	SAP2005 Outputs: Total energy demand (kWh/yr)	SAP2005 Outputs: Energy demand per square metre (kWh/yr/m^2)	SAP2005 Outputs: Annual running costs (£/yr)
Gas	Main heating, and hot water	NA	30,840	251	1,170
	Cooking		1,300		
Solid fuel	Secondary heating	NA	3,260	26	125
Electric	Lights, fans and pumps	NA	1,040	31	475
	Appliances		2,900		
Total		NA	39,340	308	1,770

3.1.2 SAP2009 analysis







Total CO_2 emissions for this house were 61.6 kg/m^2/year which equates to approximately 7.8 tonnes of CO_2 per year (EPC band D/E). As the dwelling was not well insulated, about two-thirds of the CO_2 emissions come from the energy needed to heat the dwelling.

The dwelling's total emissions were nearly a third higher than that of the national average for all UK housing (of approx 6.5 tonnes CO_2 per annum), but about on par with average solid walled dwelling (of approx 8.3 tonnes CO_2 per annum).

The table below shows how much energy each of these categories used on an annual basis and the associated running costs;

			SAP2009 Outputs		
Energy source and consumption category		Measured energy data (kWh/yr)	Total energy demand (kWh/yr)	Energy demand per square metre (kWh/yr/m^2)	Annual running costs (£/yr)
Gas	Main heating, and hot water	NA	27,680	215	910
	Cooking		1,300		
Solid fuel	Secondary heating	NA	3,110	24	120
Electric	Lights, fans and pumps	NA	780	35	500
	Appliances		3,370		
Total		NA	36,240	274	1,530

The difference in energy demand for heating and hot water (and hence costs) between SAP2005 and SAP2009 is mainly down to the change from an annual assessment (under SAP2005) to a monthly assessment in SAP2009, together with improved hot water use information obtained from field trials undertaken by the Energy Saving Trust. However, although this produces slightly less energy use from SAP2009, the overall CO_2 emissions still increase due mainly to the fact that the CO_2 emission factor for electricity use has increased by more than 20%.

As reported in section 2.1 above the increase reported for energy use from appliances is in recognition that we use ever more appliances in our homes.

3.2 Survey and Recommendations

The initial survey of this property was carried out by Bristol DEA. This included options analysis for potential thermal efficiency and energy generation upgrades using SAP2005 and presented a Predicted Energy Assessment (PEA) for the property based on a combination of works. The proposed works for this dwelling predicted that the EPC rating would be raised to 80/77, or EPC bands B/B with the following measures being proposed:

i. Insulate the external walls to the 2006 building regulations requirement of U = 0.35 W/m^2K
ii. Insulate the timber suspended ground floors to U = 0.22 W/m^2K
iii. Top up the roof insulation to U = 0.11 W/m^2K where possible
iv. High performance double glazing as a replacement of the existing single glazing
v. Air-tightness strategy
vi. Low energy lighting throughout the dwelling

Insulating the dwelling's fabric was the most important design option considered for this dwelling. With this mind, the originally proposed method of tackling the refurbishment by applying laminate plasterboard to the inside of the external walls (~60mm PU/PIR type insulation), insulating the ground floor/roof and fitting high performance replacement double glazing would have the benefit of raising the EPC rating to C/C alone.

It is also necessary to ensure that unwanted air leakage is reduced to a minimum. However in doing so, adequate controllable ventilation is required to ensure indoor air quality. Therefore extract fans have been fitted to the wet rooms, i.e. the kitchen and bathroom.

Installing 100% low energy lighting also makes sense, as tungsten filament bulbs will not be available soon due to EU law, this will soon become the norm.

Not all of this was actually installed in the dwelling, and below is a review of the actual refurbishment. Because of cost/timing issues, the solid wall insulation was not installed at this time. Installing internal solid wall insulation has to be installed while the dwelling is unoccupied due to it being a very disruptive procedure. However, as both the roofs and the main floor have been insulated, the solid wall insulation is something that might be considered again in future. So this should not be considered as a lost opportunity, but as a potential future improvement that will bring benefits in terms of further reducing CO_2 emissions and running costs.

3.3 Project Works and Post-Work Building Specification

Works carried out are identified in italics.

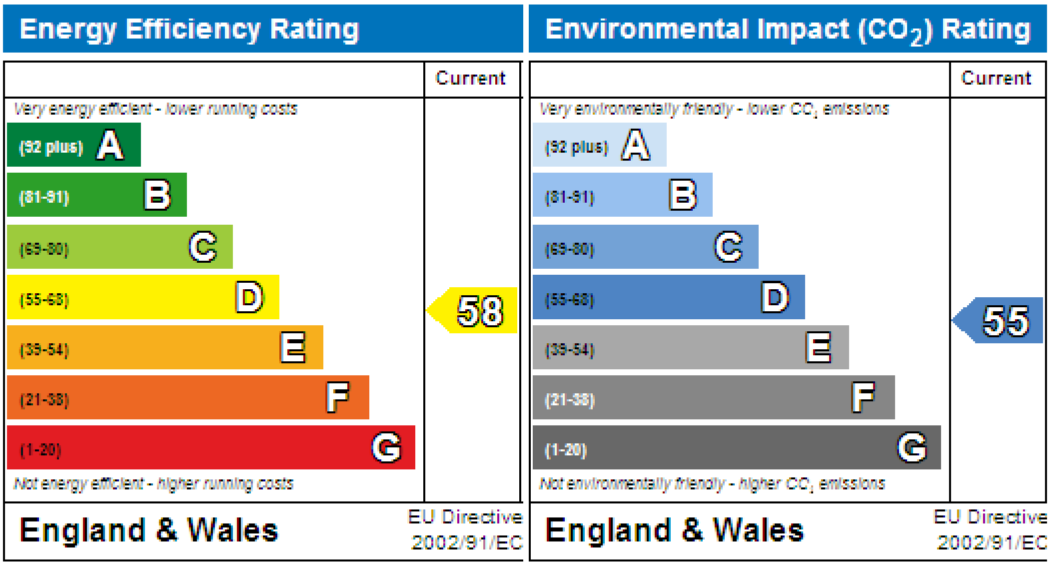
Main dwelling	**Fabric U-value**
Insulated roof, 400mm mineral wool	*0.12 W/m²K*
Solid walls, 215mm thick brick	2.10 W/m²K
Insulated suspended timber floor 150mm mineral wool	*0.20 W/m²K*
Windows;	
New double glazed timber frames (66%)	*1.70 W/m²K*
Double glazed u-PVC frames (34%)	2.80 W/m²K
Doors, unglazed solid timber	3.00 W/m²K
Kitchen/Utility room extension	
Insulated roof further improved with 60mm Kingspan K17	*0.20 W/m²K*
Uninsulated cavity walls	1.00 W/m²K
Uninsulated solid floor	0.77 W/m²K
Doors, half double glazed timber frames	2.90 W/m²K
Windows, double glazed timber	2.80 W/m²K
Roof-lights, double glazed	4.10 W/m²K

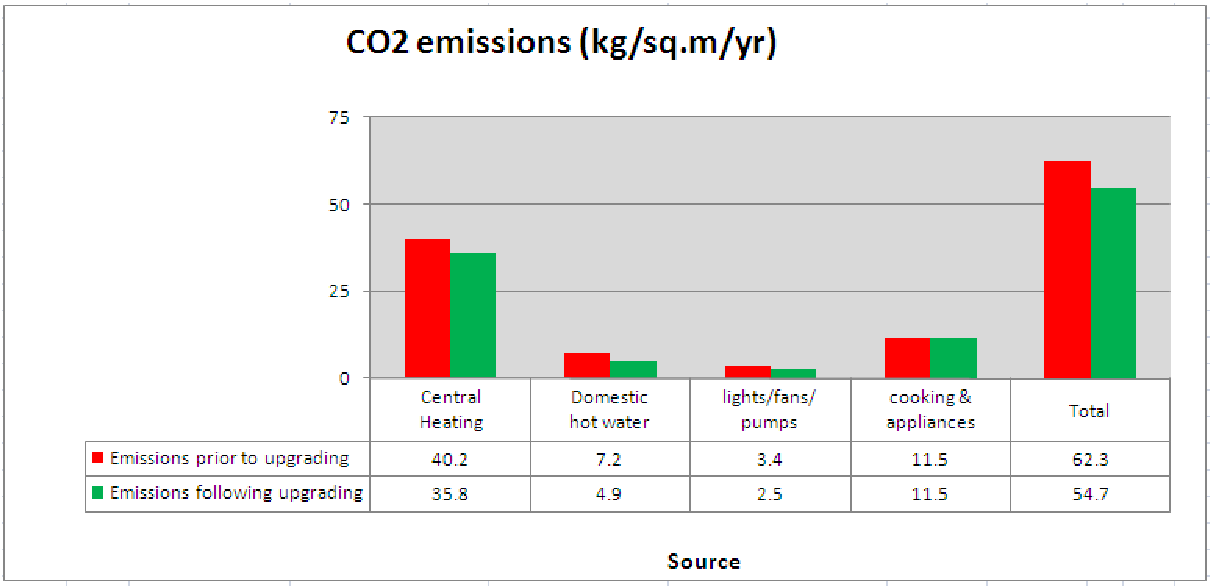
Other features

- *Natural ventilation with extract fans*
- *RdSAP default procedure for assessing envelope air leakage rate for age and type of property ~ 12 m³/hr/m² @ 50Pa*
- Worcester combi boiler 78% efficiency, programmer, room thermostat and TRVs, closed log burning secondary room heating
- *100% low energy efficient light fittings*

The total cost of these works was approximately £9,500 + VAT for all thermal upgrade, glazing and making good. An additional £400 + VAT was spent on the installation of 2 extractor fans plus works required by electrical installation regulations. Whilst not specifically energy/carbon reduction works these were installed to reduce the build-up of moisture within the property, particularly after the increase in air tightness due to new windows.

3.3.1 SAP2005 analysis





	Central Heating	Domestic hot water	lights/fans/ pumps	cooking & appliances	Total
Emissions prior to upgrading	40.2	7.2	3.4	11.5	62.3
Emissions following upgrading	35.8	4.9	2.5	11.5	54.7

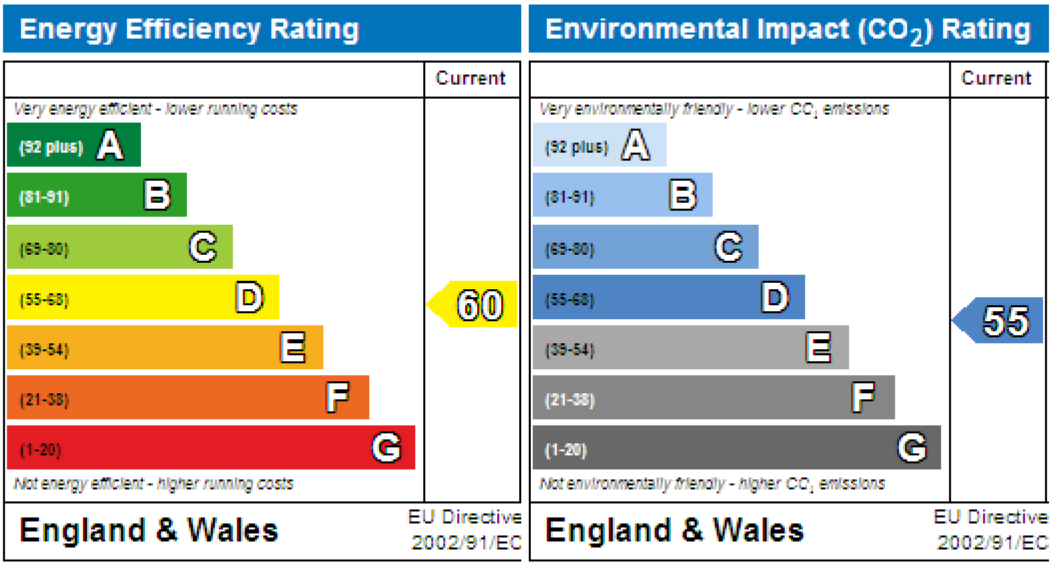
Total CO_2 emissions for this house are 54.7 kg/m^2/year which equates to approximately 7 tonnes of CO_2 per year (EPC Band D/D). This represents a modest 12% reduction.

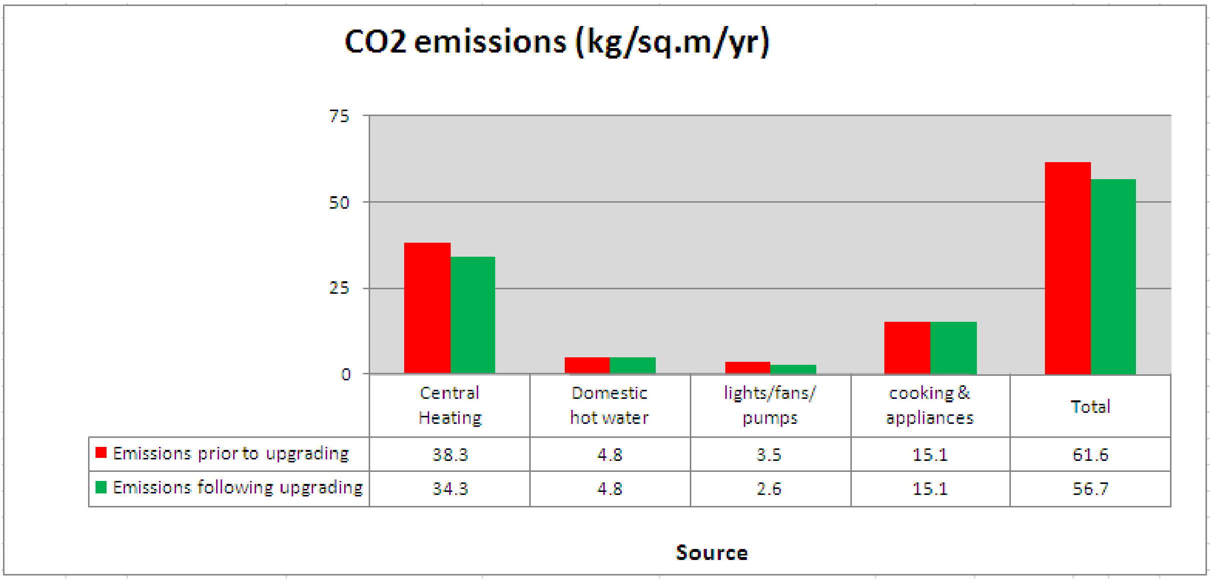
The dwelling's total emissions are now just above the national average for all UK housing (of approx 6.5 tonnes CO_2 per annum), and are below the average of solid walled dwellings (of approx 8.3 tonnes CO_2 per annum).

The table below shows how much energy each of these categories uses on an annual basis and the associated running costs;

Energy source and consumption category		SAP2005 Outputs: Total energy demand (kWh/yr)	SAP2005 Outputs: Energy demand per square metre (kWh/yr/m^2)	SAP2005 Outputs: Annual running costs (£/yr)
Gas	Main heating, and hot water	27,980	219	1,035
	Cooking	1,300		
Solid fuel	Secondary heating	2,900	23	110
Electric	Lights, fans and pumps	760	29	425
	Appliances	2,900		
Total		35,840	271	1,570

3.3.2 SAP2009 analysis





Total CO_2 emissions for this house are 56.7 kg/m^2/yr which equates to approximately 7.2 tonnes of CO_2 per year (EPC Band D/D), which represents a modest 8% reduction.

The dwelling's total emissions are just above the national average for all UK housing (of approx 6.5 tonnes CO_2 per annum), and are below the average of solid walled dwellings (of approx 8.3 tonnes CO_2 per annum).

The table below shows how much energy each of these categories uses on an annual basis and the associated running costs;

Energy source and consumption category		SAP2009 Outputs: Total energy demand (kWh/yr)	SAP2009 Outputs: Energy demand per square metre (kWh/yr/m^2)	SAP2009 Outputs: Annual running costs (£/yr)
Gas	Main heating, and hot water	25120	204	860
	Cooking	950		
Solid fuel	Secondary heating	2,785	22	110
Electric	Lights, fans and pumps	650	31	485
	Appliances	3,370		
Total		32,875	257	1,455

The slight difference in energy demand for heating and hot water (and hence costs) between SAP2005 and SAP2009 is mainly down to the change from an annual assessment (under SAP2005) to a monthly assessment in SAP2009, together with improved hot water use information obtained from field trials undertaken by the Energy Saving Trust. However, although this produces slightly less energy use from SAP2009, the overall CO_2 emissions still increase due mainly to the fact that the CO_2 emission factor for electricity use has increased by more than 20%.

As reported in section 2.1 above the increase reported for energy use from appliances is in recognition that we use ever more appliances in our homes.

4. Thornbury, South Gloucestershire (without workshop)

- Detached house (without workshop), floor area 113m^2

The last dwelling shadowed by the Energy Saving Trust was also a solid walled dwelling, but whereas internal insulation solutions were used elsewhere, here the opportunity arose to use an external insulation solution. The starting point for this dwelling was also an EPC band D (SAP rating). This detached property was responsible for circa 6.5 tonnes of CO_2 emissions a year, and an annual energy use of between 29,500kWh to 31,500kWh with associated predicted running cost in the region of £1,400 per annum.

Looking at the specification that existed before the refurbishment, and the SAP2005/2009 analysis, the dwelling had significant heat losses through its solid stone walls and not being fully double glazed. Fabric heat losses accounted for more than 65% of total heat losses, and the existing dwelling had a Fabric Energy Efficiency Standard in excess of 150kWh/m^{2}yr. An air-tightness test and air leakage audit were carried out at the early stages of the refurbishment. This produced a result of 5.16 m^3/hour/m^2@50Pa showing that ventilation heat losses were less significant than in most existing dwellings. This also allowed the contractors to check for effective draught-proofing of service entry points and the effective installation of the external wall insulation.

The workshop, although attached to the dwelling, was excluded by convention from this analysis as it could not be directly entered from the dwelling.

Actual billing information was provided by the homeowners for gas consumption over a two year period perior to these works being carried out. As with the Carnarvon Road property this showed that energy use was just over half of the modelled figure. A major concern here is that using the standard occupancy rates and set points in SAP, both 2005 and 2009, is not an accurate reflection of the energy consumption on this property. One significant implication is that modelled energy performance improvements to the property would be likely to overestimate potential energy, financial and carbon savings achieved in practice.

4.1 Pre-Work Building Specification

Main dwelling	**Fabric U-value**
Insulated roof, 150mm mineral wool	0.35 W/m^{2}K
Solid walls, 450mm rendered stone	2.30 W/m^{2}K
Insulated solid floor	0.23 W/m^{2}K
Windows;	
Single glazed timber frames (27%)	4.80 W/m^{2}K
Double glazed u-PVC frames (73%)	2.80 W/m^{2}K

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Doors, unglazed solid timber	3.00 W/m²K

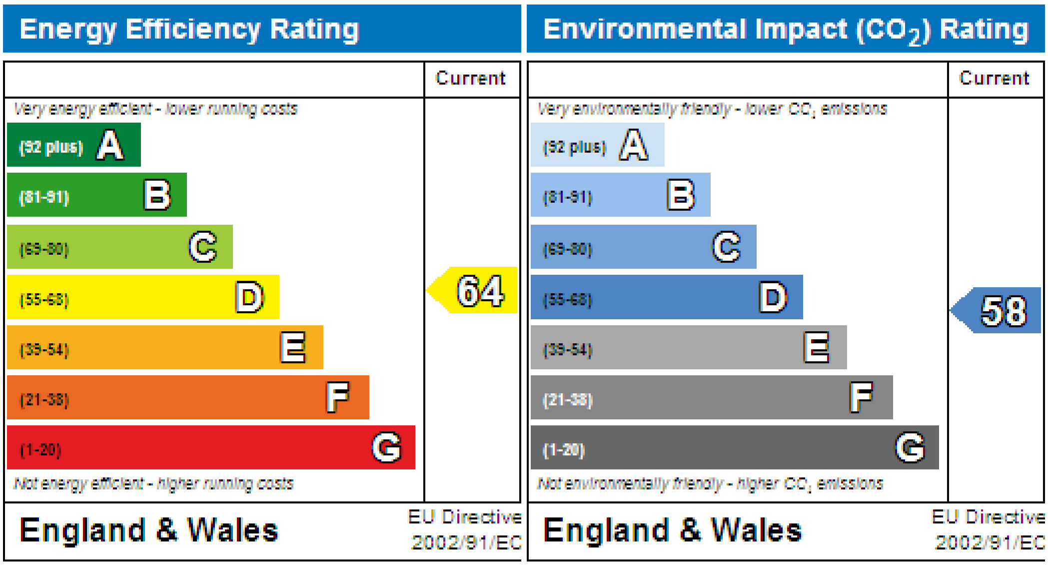
Kitchen/Bedroom extension (completed to Part L 1995)

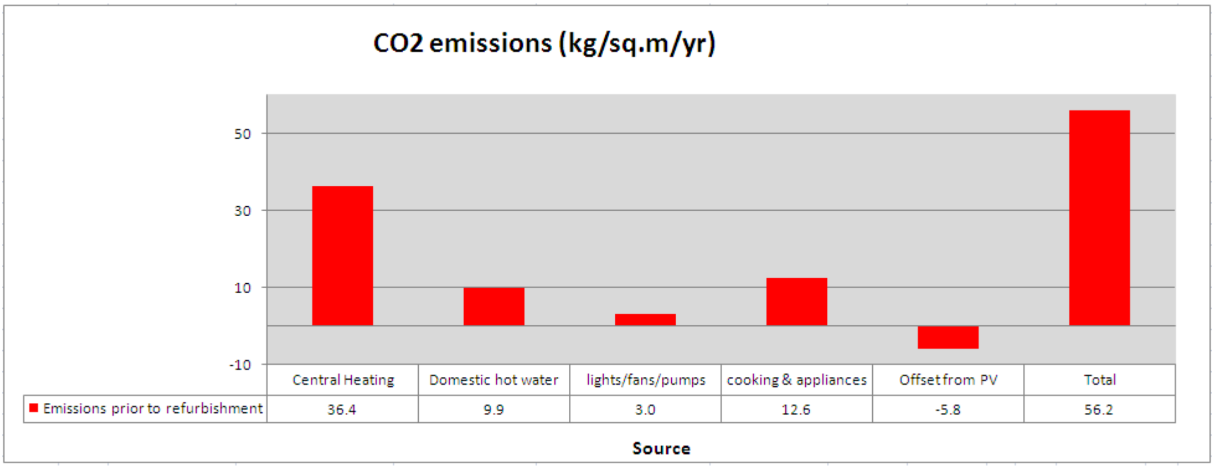
Insulated roof	0.35 W/m²K
Insulated cavity walls	0.32 W/m²K
Insulated solid floor	0.31 W/m²K
Doors, half double glazed timber frames	2.90 W/m²K
Windows, double glazed timber	2.80 W/m²K

Other features

- Natural ventilation with extract fans
- Airtightness testing ~ 5.16 m³/hr/m² @ 50Pa
- Ideal regular condensing boiler 86% efficiency, programmer, room thermostat and TRVs, log burning secondary room heating
- Water storage cylinder 160 litre capacity, 50mm insulated jacket, pipe insulation
- 83% low energy efficient light fittings
- 1.8 kWp solar PV
- 2m² solar thermal – evacuated tube

4.1.1 SAP2005 analysis





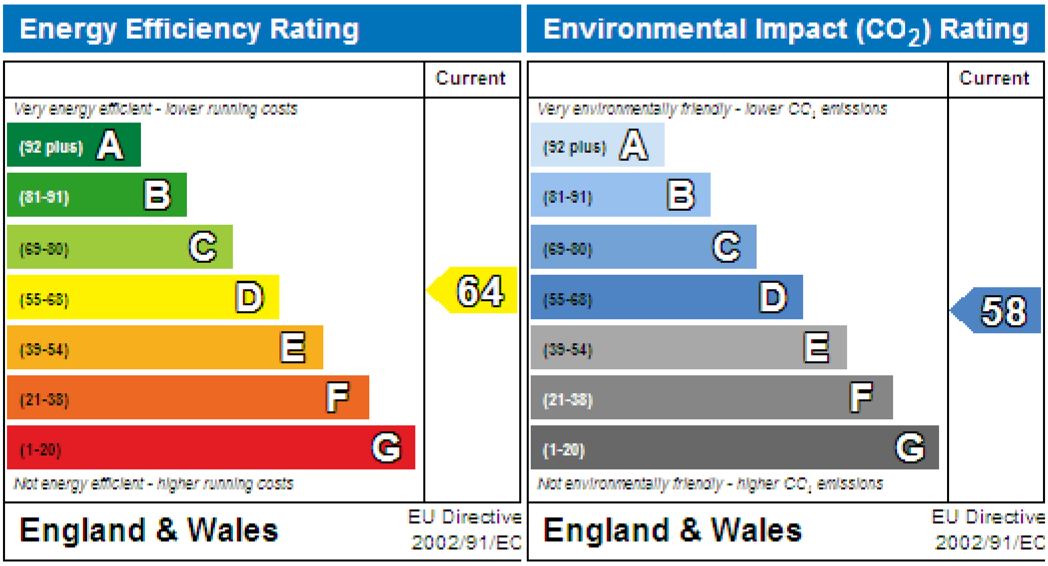
Total CO_2 emissions for this house were about 56 kg/m²/yr which equates to approximately 6.3 tonnes of CO_2 per year (EPC Band D/D) including an offset of about 0.7 tonnes of CO_2 per year from the solar PV system. As the main dwelling walls were not insulated, about two-thirds of the CO_2 emissions came from the energy needed to heat the dwelling.

The overall emissions from the dwelling were about that of the national average for all UK housing (approx 6.5 tonnes CO_2 per annum), and about a quarter lower than the average solid walled dwelling (approx 8.3 tonnes CO_2 per annum).

The table below shows how much energy each category used on an annual basis and the associated running costs;

Energy source and consumption category		Measured energy data (kWh/yr)	SAP2005 Outputs: Total energy demand (kWh/yr)	SAP2005 Outputs: Energy demand per square metre (kWh/yr/m^2)	SAP2005 Outputs: Annual running costs (£/yr)
Gas	Main heating, and hot water	12,000	22,935	214	910
	Cooking		1,290		
Solid fuel	Secondary heating	NA	4,185	37	150
Electric	Lights, fans and pumps	NA	815	32	435
	Appliances		2,780		
	solar PV	NA	-1,150	-10	-140
Total		NA	30,855	273	1,355

4.1.2 SAP2009 analysis



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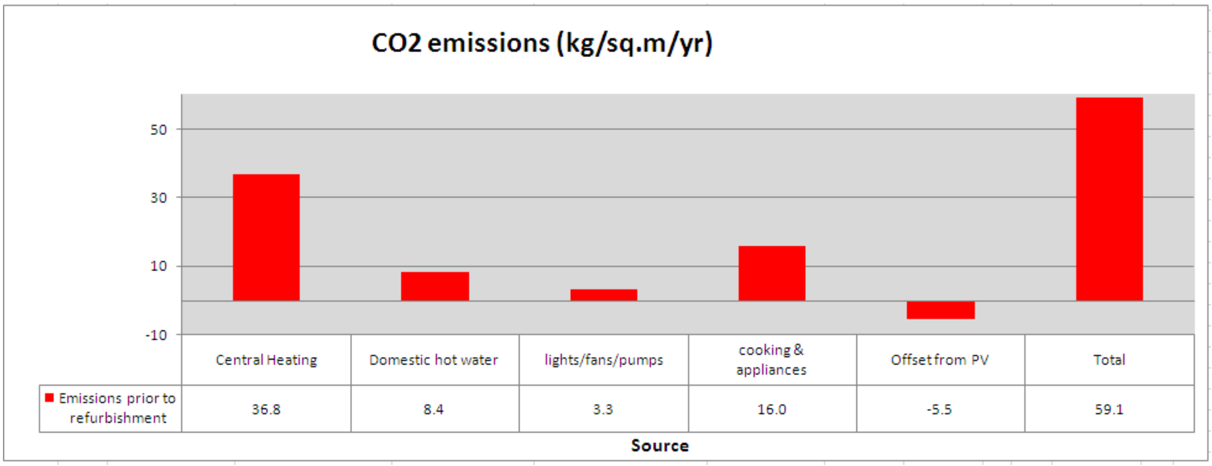


Total CO_2 emissions for this house were about 59 kg/m^2/yr which equates to approximately 6.7 tonnes of CO_2 per year (EPC Band D) including an offset of about 0.7 tonnes of CO_2 per year from the solar PV system. As the main dwelling walls were not insulated, about two-thirds of the CO_2 emissions came from the energy needed to heat the dwelling.

The overall emissions from the dwelling were about that of the national average for all UK housing (approx 6.5 tonnes CO_2 per annum) and about a quarter lower than the average solid walled dwelling (of approx 8.3 tonnes CO_2 per annum).

The table below shows how much energy each category used on an annual basis and the associated running costs;

			SAP2009 Outputs		
Energy source and consumption category		Measured energy data (kWh/yr)	Total energy demand (kWh/yr)	Energy demand per square metre (kWh/yr/m^2)	Annual running costs (£/yr)
Gas	Main heating, and hot water	12,000	21,570	199	855
	Cooking		945		
Solid fuel	Secondary heating	NA	4,100	36	160
Electric	Lights, fans and pumps	NA	730	34	470
	Appliances		3,150		
	Solar PV	NA	-1,180	-10	-140
Total		NA	29,315	259	1,345

The difference in energy demand for heating and hot water (and hence costs) between SAP2005 and SAP2009 is mainly down to the change from an annual assessment (under SAP2005) to a monthly assessment in SAP2009, together with improved hot water use information obtained from field trials undertaken by the Energy Saving Trust. However, although this produces slightly less energy use from SAP2009, the overall CO_2 emissions still increase due mainly to the fact that the CO_2 emission factor for electricity use has increased by more than 20%.

As reported in section 2.1 above the increase reported for energy use from appliances is in recognition that we use ever more appliances in our homes.

4.2 Survey and Recommendations

The initial survey of this property was carried out by Bristol DEA. This included options analysis for potential thermal efficiency and energy generation upgrades using SAP2005 and presented a Predicted Energy Assessment (PEA) for the property based on a combination of works. The proposed works for this dwelling predicted that the EPC rating would be raised to 86/85, or EPC bands B/B with the following measures being proposed:

i. Insulate the external walls to the 2006 building regulations requirement of U = 0.35 W/m^{2}K
ii. Provide log burning secondary heating
iii. High performance double glazing as a replacement to the existing single glazing
iv. Low energy lighting throughout the dwelling

As the existing dwelling already had both solar thermal and solar PV, insulating the dwelling's fabric was the most important design option considered. With this mind, the originally proposed method of tackling the refurbishment by applying laminate plasterboard to the inside of the external walls (~60mm PU/PIR type insulation), insulating the ground floor/roof and fitting high performance replacement double glazing would have had the benefit of raising the EPC rating to C/C.

However, the opportunity presented itself to insulate the dwelling externally as it is a detached dwelling with rendered walls. The additional factors of small room sizes and the disruption caused by installing internal insulation led to the decision to fit external insulation.

Installing 100% low energy lighting also made sense, and as tungsten filament bulbs will not be available soon, this will shortly become the norm.

The original proposal was then actually installed in the dwelling. In addition to the above, the workshop has been brought within the thermal envelope. This has been analysed separately to the upgrade of the main dwelling as by increasing the heated volume, it would not give a true reflection of the actual benefit of completing the works on the original dwelling.

However, in the process of installing the external insulation, an issue arose at the eaves level. As it was not possible to extend the eaves/guttering, the insulation was stopped short below the guttering. It has been noted that this thermal bridge could cause surface condensation to form internally at the junction of the external wall and the roof due to the lack of insulation continuity in this location. If this were to occur at any time, a possible solution would be to insulate the top of the external wall internally for about 450mm below the ceiling with laminate plasterboard with at least 50mm PU/PIR type insulation (or the equivalent in terms of thermal resistance of another insulation type).

4.3 Project Works and Post-Work Building Specification

Works carried out are identified in italics.

Main dwelling	**Fabric U-value**
Insulated roof, 150mm mineral wool	0.35 W/m^{2}K
Solid walls, 450mm rendered stone	
External 100mm EPS / render	*0.32 W/m^{2}K*
Insulated solid floor	0.23 W/m^{2}K
Windows;	
New double glazed timber frames (27%)	*1.70 W/m^{2}K*
Double glazed u-PVC frames (73%)	2.80 W/m^{2}K
Doors, unglazed solid timber	3.00 W/m^{2}K

Kitchen/Bedroom extension (carried out to Part L 1995)

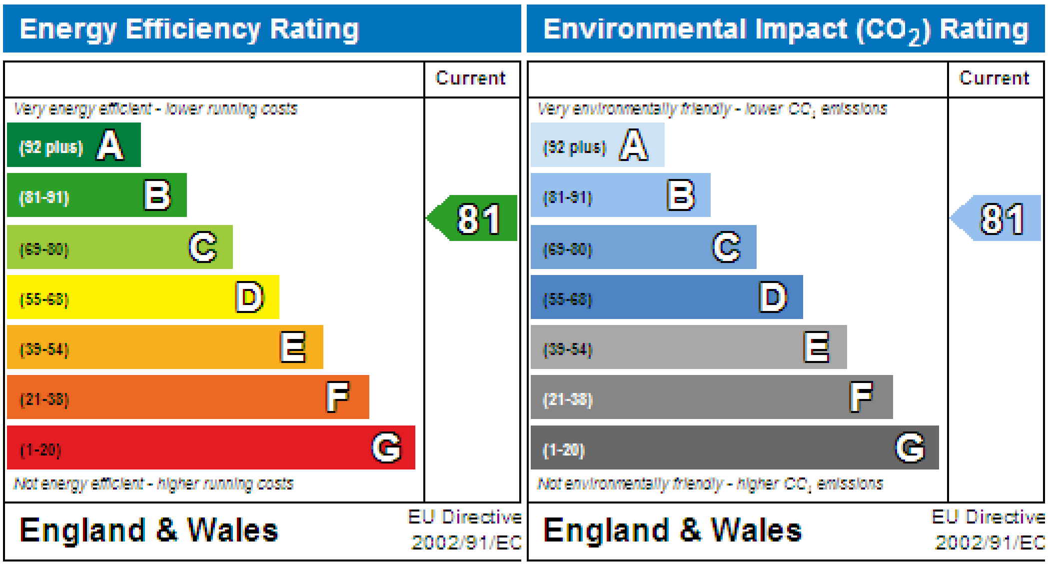
Insulated roof	0.35 W/m²K
Insulated cavity walls	0.32 W/m²K
Insulated solid floor	0.31 W/m²K
Doors, half double glazed timber frames	2.90 W/m²K
Windows, double glazed timber	2.80 W/m²K

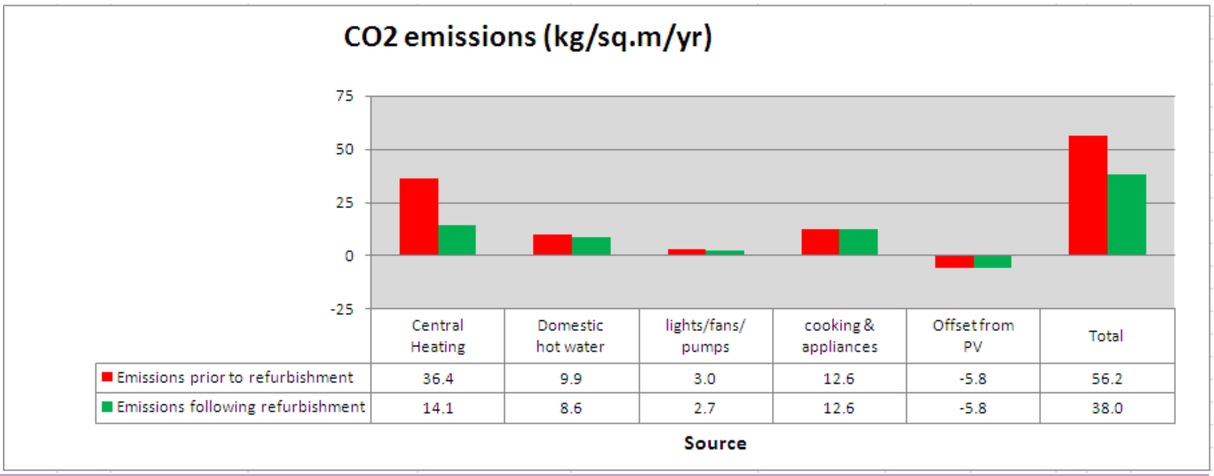
Other features

- *Log burning secondary room heating*
- *100% low energy efficient light fittings*
- Natural ventilation with extract fans
- Airtightness testing ~ 5.16 m³/hr/m² @ 50Pa
- Ideal regular condensing boiler 86% efficiency, programmer, room thermostat and TRVs, log burning secondary room heating
- Water storage cylinder 160 litre capacity, 50mm insulated jacket, pipe insulation
- 1.8 kWp solar PV
- 2m² solar thermal – evacuated tube

The project costs were in the region of £32,000 + VAT for all thermal upgrade, glazing, making good and incidental costs, e.g. the discovery and works to additional chimney.

4.3.1 SAP2005 analysis





	Central Heating	Domestic hot water	lights/fans/ pumps	cooking & appliances	Offset from PV	Total
Emissions prior to refurbishment	36.4	9.9	3.0	12.6	-5.8	56.2
Emissions following refurbishment	14.1	8.6	2.7	12.6	-5.8	38.0

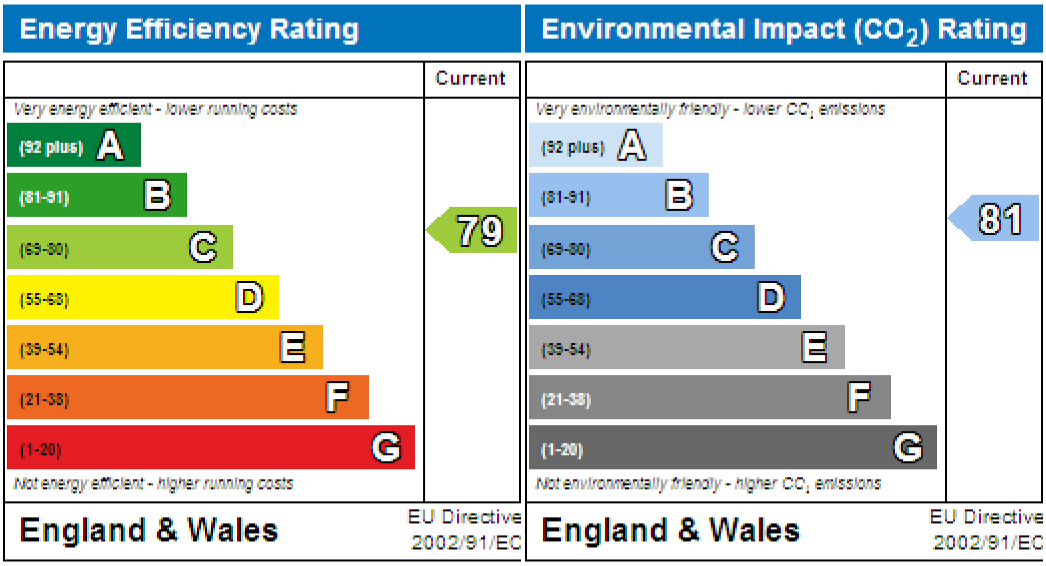
Total CO_2 emissions for this house are about 38 kg/m^2/yr which equates to approximately 4.3 tonnes of CO_2 per year (EPC Band B/B) including an offset of about 0.7 tonnes of CO_2 per year from the solar PV system. There has been a 32% reduction in CO_2 emissions.

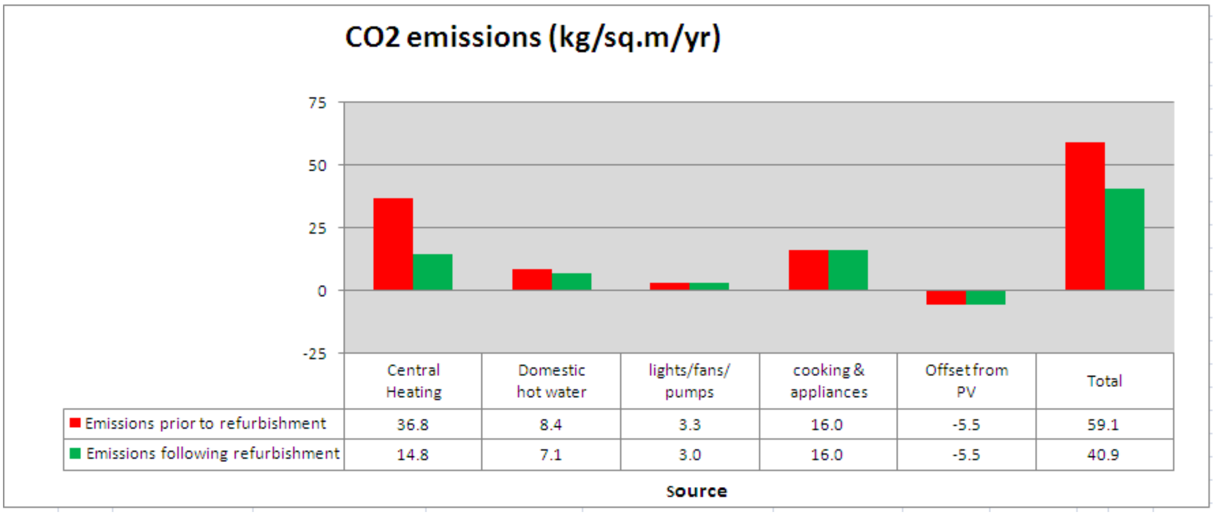
Emissions from this property are now much less than the national average for all UK housing (approx 6.5 tonnes CO_2 per annum), and about half of the average emissions from solid walled dwellings (approx 8.3 tonnes CO_2 per annum).

The table below shows energy use by category on an annual basis and the associated running costs;

Energy source and consumption category		SAP2005 Outputs: Total energy demand (kWh/yr)	SAP2005 Outputs: Energy demand per square metre (kWh/yr/m^2)	SAP2005 Outputs: Annual running costs (£/yr)
Gas	Main heating, and hot water	12,945	123	570
	Cooking	995		
Solid fuel	Secondary heating	1,935	17	75
Electric	Lights, fans and pumps	725	31	425
	Appliances	2,780		
	Solar PV	-1150	-10	-140
Total		18,230	161	930

4.3.2 SAP2009 analysis





Total CO_2 emissions for this house are about 41 kg/m^2/yr which equates to approximately 4.6 tonnes of CO_2 per year (EPC Band C/B) including an offset of about 0.6 tonnes of CO_2 per year from the solar PV system. There has been a 31% reduction in CO_2 emissions.

Emissions from this property are now much less than the national average for all UK housing (approx 6.5 tonnes CO_2 per annum), and about half of the average emissions from solid walled dwellings (approx 8.3 tonnes CO_2 per annum).

The table below shows energy use by category on an annual basis and the associated running costs;

		SAP2009 Outputs		
Energy source and consumption category		Total energy demand (kWh/yr)	Energy demand per square metre (kWh/yr/m^2)	Annual running costs (£/yr)
Gas	Main heating, and hot water	12,435	118	555
	Cooking	945		
Solid fuel	Secondary heating	2,050	18	80
Electric	Lights, fans and pumps	650	34	460
	Appliances	3,150		
	Solar PV	-1180	-10	-140
Total		18,050	160	955

The difference in energy demand for heating and hot water (and hence costs) between SAP2005 and SAP2009 is mainly down to the change from an annual assessment (under SAP2005) to a monthly assessment in SAP2009, together with improved hot water use information obtained from field trials undertaken by the Energy Saving Trust. However, although this produces slightly less energy use from SAP2009, the overall CO_2 emissions still increase due mainly to the fact that the CO_2 emission factor for electricity use has increased by more than 20%.

As reported in section 2.1 above the increase reported for energy use from appliances is in recognition that we use ever more appliances in our homes.

5. Thornbury, South Gloucestershire (with workshop)

- Detached house (with workshop), floor area 129m^2

Following the initial design stages, the proposed works were expanded to include insulating the existing workshop. This additional volume would mean a direct comparison with the original dwelling would not be representative simply as this would cause the CO_2 emissions to increase.

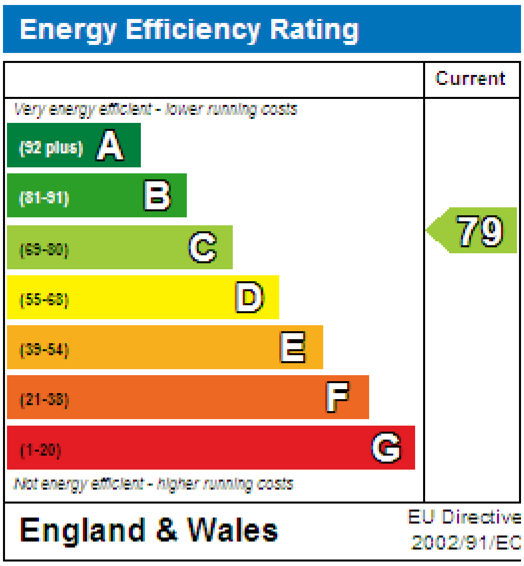
5.1 Project Works and Post-Work Building Spec

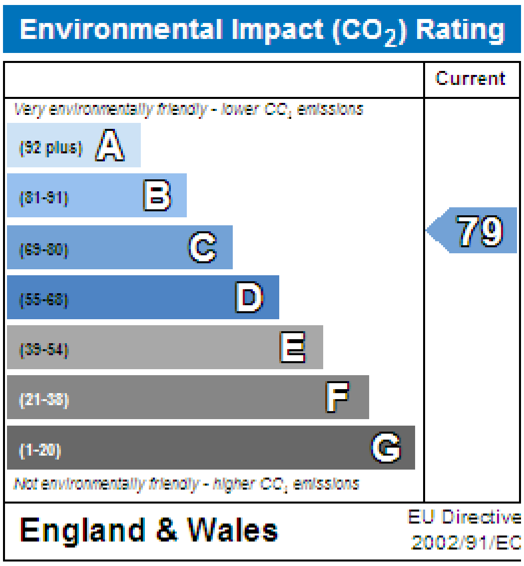
The workshop was upgraded as follows;

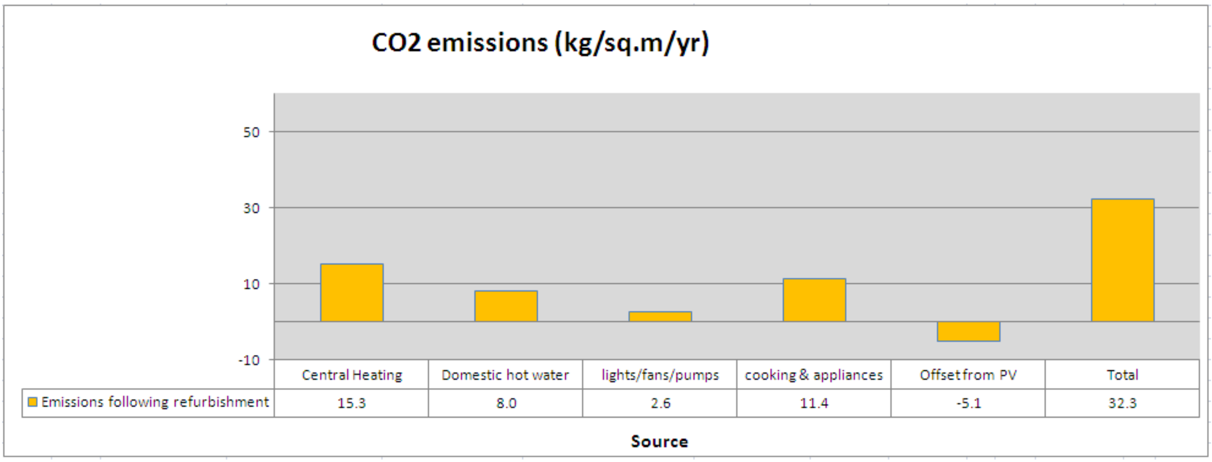
i. Insulate the external walls with the external insulation as the main house U = 0.32 W/m^{2}K
ii. Insulate the floor with 100mm Celotex U = 0.17 W/m^{2}K
iii. Insulate roof with 100mm Celotex between rafters and 50mm Celotex below
iv. High performance double glazing as a replacement to the existing single glazing
v. 2No. Velux double glazed roof lights

Works to exceed building regulations for the workshop cost in the region of were of £5,000 + VAT. This marginal cost of exceeding building regulations was not identified and this element of the project is considered an enhancement to the dwelling.

5.1.1 SAP2005 analysis





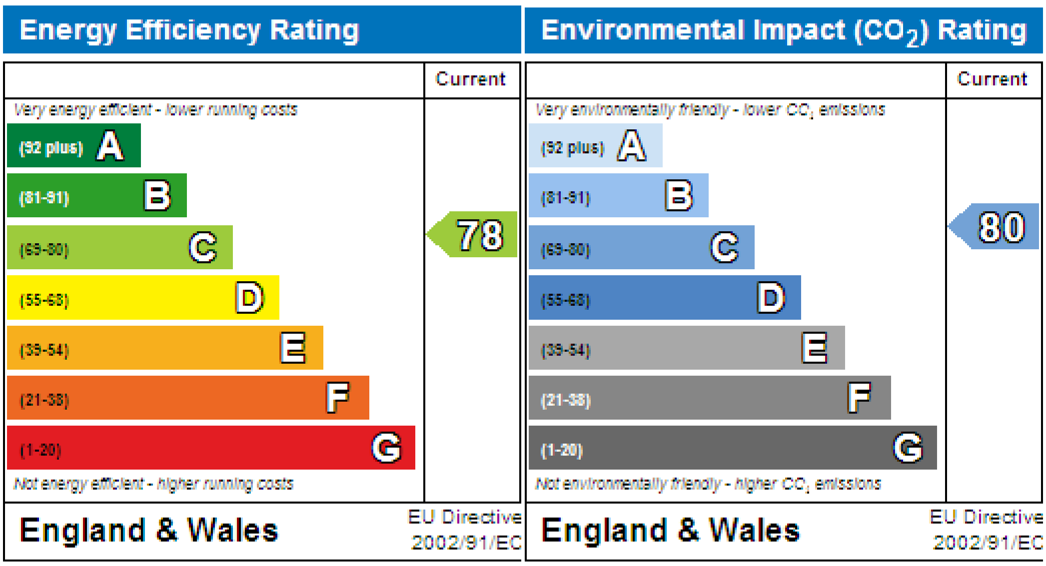


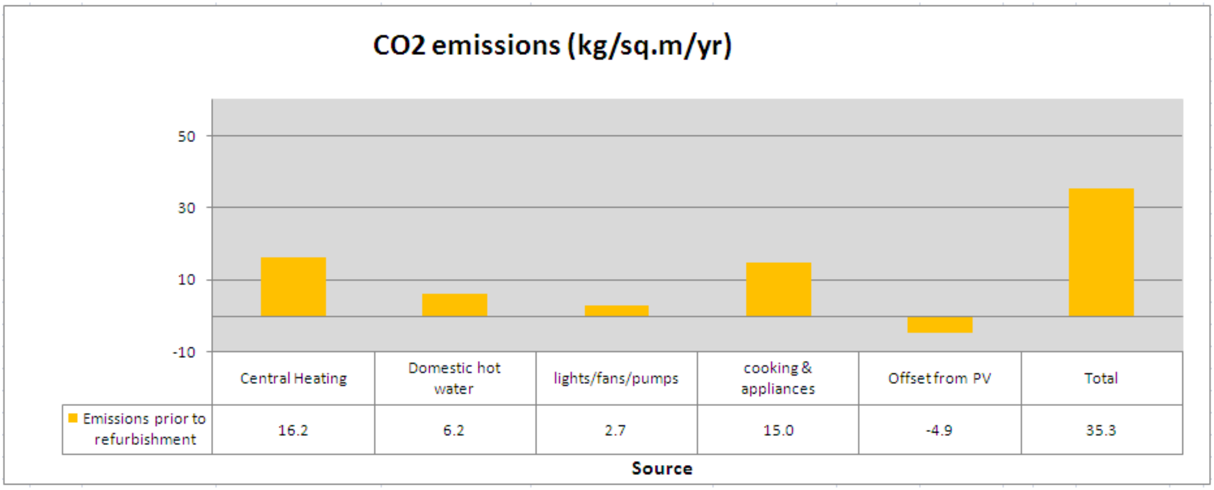
Total CO_2 emissions for the house including workshop are about 32 kg/m^2/yr which equates to approximately 4.2 tonnes of CO_2 per year (EPC Band C/C) including an offset of about 0.7 tonnes of CO_2 per year from the solar PV system.

The table below shows energy use by category on an annual basis and the associated running costs;

Energy source and consumption category		SAP2005 Outputs: Total energy demand (kWh/yr)	SAP2005 Outputs: Energy demand per square metre (kWh/yr/m^2)	SAP2005 Outputs: Annual running costs (£/yr)
Gas	Main heating, and hot water	15,155	125	530
	Cooking	995		
Solid fuel	Secondary heating	2,400	18	90
Electric	Lights, fans and pumps	800	29	450
	Appliances	2900		
	Solar PV	-1150	-9	-140
Total		21,100	163	930

5.1.2 SAP2009 analysis





Total CO_2 emissions for the house including workshop are 35.3 kg/m^2/yr which equates to approximately 4.5 tonnes of CO_2 per year (EPC Band C/C) including an offset of about 0.6 tonnes of CO_2 per year from the solar PV system.

The table below shows energy use by category on an annual basis and the associated running costs;

		SAP2009 Outputs		
Energy source and consumption category		Total energy demand (kWh/yr)	Energy demand per square metre (kWh/yr/m^2)	Annual running costs (£/yr)
Gas	Main heating, and hot water	14,520	120	510
	Cooking	945		
Solid fuel	Secondary heating	2,560	20	100
Electric	Lights, fans and pumps	680	31	490
	Appliances	3,370		
	Solar PV	-1180	-10	-140
Total		20,895	161	960

Project Partners

Homeowners
We would like to thank the homeowners for working with us to learn from their experience and share this with others: Ozzie & Mary, Chris & Isla, Martin, Anthony and Liz, Margaret & Alan, Gavin & Carrie, Jon, Paul, Tim, Sue & Brian and Ben

For further information and personal blogs from the Refit West homeowners see www.refitwest.com

Members of Refit West Consortium
Archipeleco Architects
Bristol City Council
Centre for Sustainable Energy
Ecomotive
Energy Saving Trust
South Gloucestershire Council
Wessex Reinvestment Trust
Bath and North East Somerset Council
Bristol DEA
Chris Howell
Ecos Renew
Footprint Building
Vertigo Sustainable Development Consultants

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UK Green Building Council
WWF

Refit West Contractors
Bristol DEA
Parity Projects

- Refit West homeowner, Chris Preist (right), with Al Doggart of Footprint Building. Over the winter Chris tested the insulation and MVHR system in his finished Refit West home:

"According to our external thermometer, today is the coldest day of the year so far. At about 8am, it was reading -2, and there was a beautiful frost layer on our velux windows, with the winter sun shining through it. So I thought I'd try an experiment and switch the heating off: The inside temperature was reading 18.5c. How would it change through the day? Over the next couple of hours, it sank to 17.5, but then actually went up again to 18 thanks to the winter sun heating the front of the house and that warmth being spread elsewhere. It's now gone back down to 17.5c as the sun has gone in. So 5 hours after turning the heat off, the house has lost about 1 degree."