Hastings Retrofit Project: Retrofit Training Manual

parity projects

in partnership with the Hastings Trust

This manual has visual representation at the links below

http://www.youtube.com/watch?v=drC5n3TIYSE
http://www.youtube.com/watch?v=krVw7-8wgpQ
http://www.youtube.com/watch?v=BSbNEAqdR3Y
On Hastings Trust Website: www.hastingstrust.com

Future Cities
urban networks to face climate change

HASTINGS TRUST

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
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ABOUT PARITY

Parity is an award-winning provider of environmental and energy solutions to the residential building sector. We help our customers identify the most effective ways to reduce the running costs and environmental impact of their properties.

The backbone of our work is the Parity Home Energy Master Plan which identifies the most appropriate measure for specific properties based on impartial physics.

Parity also provides a number of other related services such as eco-renovation project management, training installers and consulting services to local government, housing associations and other organisations.

Parity Projects Ltd.
Westmead House
123 Westmead Road
Sutton
Surrey
SM1 4JH

Tel: +44 (0) 208 643 6630
Email: info@parityprojects.com
Website: www.parityprojects.com

Company Registered in England & Wales No. 5557883

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Table of Contents

1 Introduction

This document has been produced to set down the key issues that incentivise, specify and deliver low energy refurbishment such that training can be undertaken to support future projects. This document provides key information that could be used for delivery training at a strategic and on-site level.

The text herein would need to be expanded-upon to suit the style of the trainer and the audience, but key diagrams, graphs and figures may be copied directly from this document. The technical issues addressed relate to those tackled at the 12 Cambridge Gardens project.

2 Background

2.1 CLIMATE CHANGE

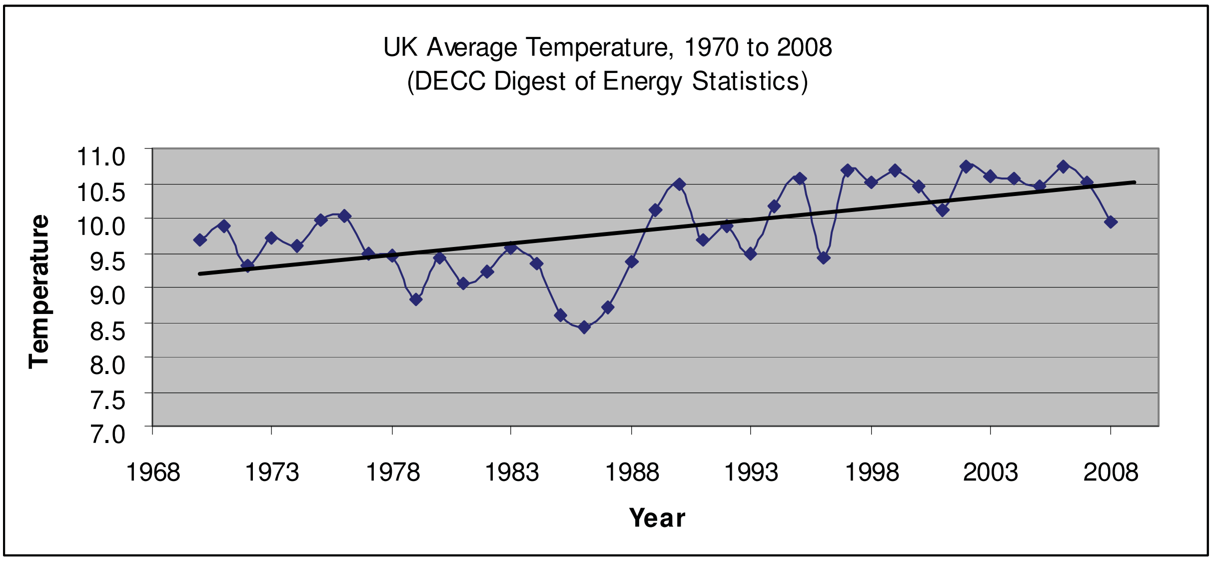


Figure 1 - UK Average Temperatures, 1970 to 2008

'The scientific evidence is now overwhelming: climate change presents very serious global risks, and it demands an urgent global response' - Sir Nicholas Stern, 'The Stern Review' on economics of climate change, October 2006

Predicted effects include:

- More and higher intensity of extreme weather events such as storms, floods and heat waves
- Raised sea levels threatening many low-lying countries and cities
- Increased drought, desertification and loss of rainforest
- Large scale population displacement leading to conflict

Timescale

Predicting changes to a system and vast and complicated as the Earth's climate and weather patterns is extremely difficult. Current modelling suggests significant changes to the climate by the middle of the century though much depends on the rate at which emissions are reduced and the avoidance of certain temperature 'tipping points' which may result in feedback mechanisms.

2.2 PEAK OIL

What is it?

Peak oil is the point in time when the maximum rate of global petroleum extraction is reached, after which the rate of production enters terminal decline. It is widely held that we are currently approaching, or perhaps have recently passed, this point.

The world's economy is heavily dependent on oil with global consumption rising steadily over the past decades. The world currently uses 85 million barrels of oil a day and this is set to increase due to the fast growing economies of China, India and Brazil.

Likely Effects

When demand for oil begins to outstrip supply the result will be a series of price shocks that are likely to cause major knock on effects right across the global economy. The peak in oil prices in 2007 demonstrated that energy bills and food prices are particularly sensitive to changes in the price of oil.

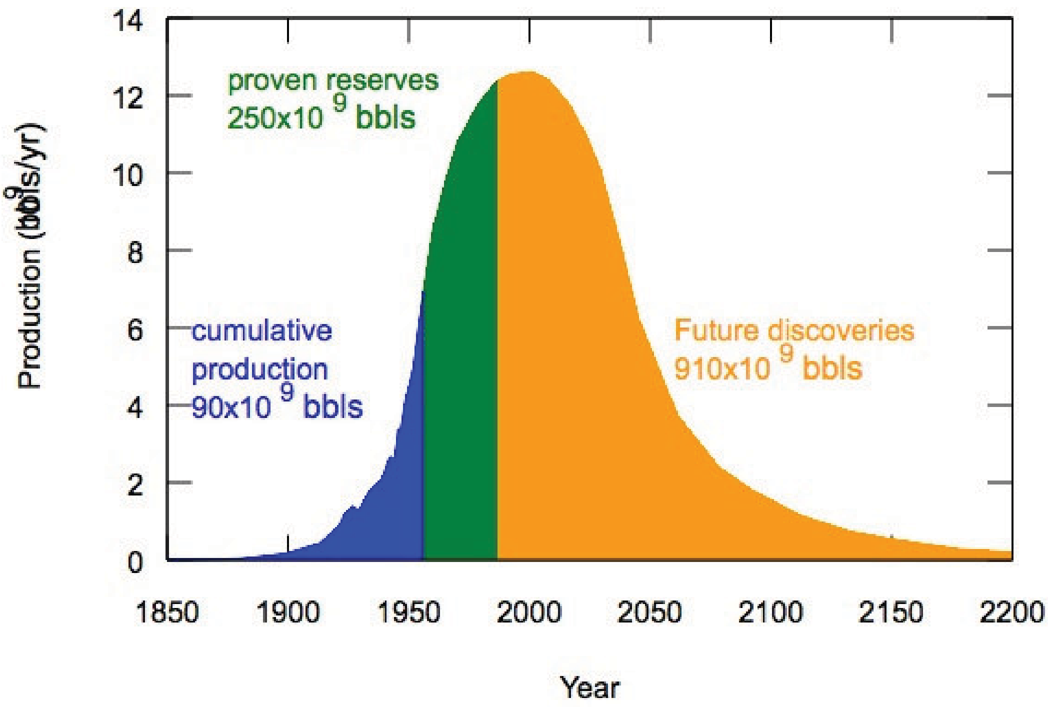


Fig 2 Hubbert Curve Showing Predicted Peak Oil Timescale

2.3 ENERGY SECURITY

What is it?

With the depletion of the North Sea oil and gas reserves, the UK recently became a net energy importer, i.e. we now use more energy than we can produce. This means that we are dependent on imports of oil and gas from other countries.

Our economy's heavy dependency on relatively low cost energy makes it vulnerable to price spikes and supply disruptions. This was born out over the winter of 2009-10 during which gas reserves in the country reached critically low levels and some major users of gas were required to reduce operations.

Likely Effects

The main effects are likely to be volatile energy prices and possible shortages of oil and gas. While restricted availability of oil will effect the economy, gas shortages could potentially effect peoples ability to heat their homes.

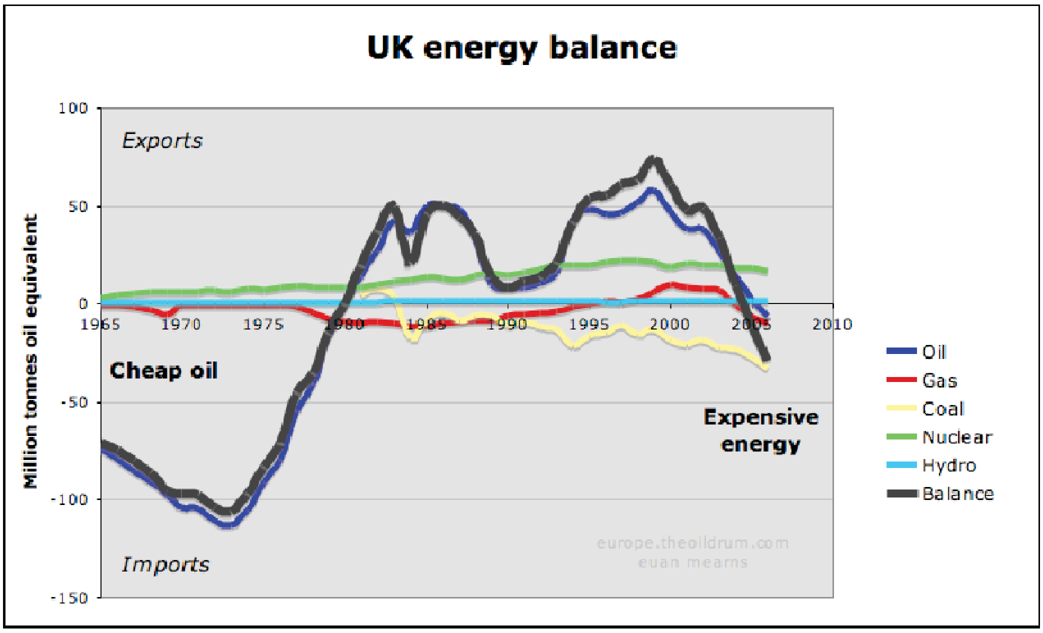


Fig. 3 Historic UK Energy Imports and Exports

2.4 SOLUTIONS

There are two common solutions to all three of these problems:

Use less energy by:

- Reducing amount of energy wasted
- Generating and distributing energy more efficiently
- Using energy more efficiently

Generate more energy from renewable sources such as:

- Wind
- Wave
- Tidal
- Solar

3 Drivers

3.1 POLICY

The Climate Change Act of 2008 commits the government to a reduction in the UK's CO_2 emissions of 80% by 2050. Britain is also signed up to emissions targets at international and EU level.

Policy	Date	Targets
Kyoto Protocol	1997	EU 8% (UK 12%) reduction in CO_2 by 2012 over 1990 levels
European Climate Change Programme	2005	15% - 30% reduction in CO_2 by 2020 over 1990 levels
UK Climate Change Act	2008	80% reduction in CO_2 by 2050 over 1990 levels
Low Carbon Transition Plan	2009	40% electricity from low carbon sources 40% electricity from renewables

Fig 4 - Climate Change Policy and Targets Progression

Energy use in the domestic sector is being tackled through a combination of standards for new buildings, such as the Code for Sustainable Homes (CsFH) and BREEAM, alongside the traditional mechanism for reduction of energy use in buildings, Part L of Building regulations.

Building Regulations

The CfSH and BREEAM can only be applied to new buildings. Part L also applies to new builds but is increasingly being used to drive energy efficiency work during the renovation of existing stock.

3.2 ECONOMIC

The economic logic for improving energy efficiency in the home is two fold:

- Immediate reduction in energy bills
- Reduced exposure to future price and supply volatility

Energy Bills

Domestic energy bills have increased dramatically over the last decade with electricity prices increasing by 108% and gas bills increasing by 250%. Given the increasing demands on fossil fuels from the growing world economy, these trends are likely to continue over the coming decades.

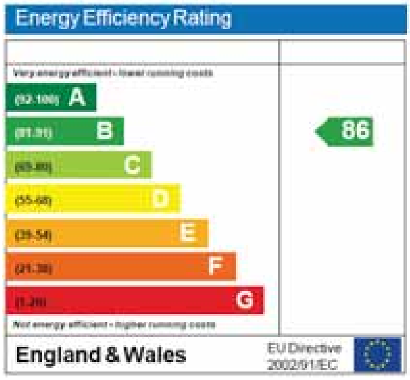
Money invested in energy efficiency measures in the home will be paid back over time through reductions in energy bills. If, as is predicted, energy prices increase in the short to medium term, this effect will be magnified.

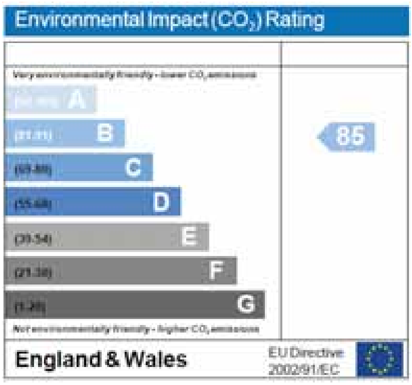
Reducing the amount of energy used means that increases in energy prices will have less of effect on people's ability to pay. It is the same as buying a more efficient car to reduce the effect of petrol price increases.

3.3 BUILDING REGULATIONS PART LB (CONSERVATION OF FUEL AND POWER)

Anyone carrying out building work on a property controlled by building regulations is required by law to assess its performance with regards to the conservation of fuel and power. You are advised to check with the local building control team whether or not your proposal requires approval under the building regulations.

When working on, adding to, or replacing any of the above items, you must check what minimum building regulation requirements apply. At the same time, remember that building regulations are the minimum legal standard – so this is an ideal opportunity to consider specifying the best practical level of performance. Once refurbished, a dwelling is unlikely to be significantly altered again within the foreseeable future.





Current Legislation

The EPBD – Energy Performance of Buildings Directive – is a European directive that means we are legally obliged to place a system of A-G rating on all of our homes. This is the Energy Performance Certificate – EPC.

It mirrors the similar approach also applied to individual components such as windows, and to appliances such as washing machine and refrigerators.

The Energy Efficiency Commitment (EEC) has recently been updated to the Carbon Emissions Reduction Target (CERT). This is the mechanism by which energy providers are forced to turn a proportion of their profits into schemes that reduce the need for energy consumption in homes. This is the funding that drives the cost of 'easy-win' measures such as loft insulation and cavity wall insulation down.

Current Regulations

Part L of the current Building Regulations focuses on the energy efficiency of the fabric of the house. It consists of four sections:

New dwellings -	L1A
Work to existing dwellings -	L1B
New non-domestic buildings -	L2A
Work to existing non-domestic buildings -	L2B

Generally where more than 25% of the thermal envelope is being altered then the whole of that element - wall, roof or floor - must have its thermal insulation levels improved. For instance:
Insertion of cavity wall insulation to a U-value of 0.55W/m2K
Insulated dry lining / externally insulated rendering of walls to a U-value of 0.35W/m2K
Up to 250mm of loft insulation in roofs to a U-value of 0.16W/m2K.
At this time there are requirements under part Part F of the Building Regulations for the ventilation of bathrooms and kitchens, but as yet this does not require the use of energy saving ventilation.

Timber Stud Lined Wall Filled with Rockwool

Should you have any questions over these new energy saving regulations you should contact your local building control officer.
Future Local Agreements

Some Local Authorities are starting to put local arrangements in place to force owners to upgrade homes as they carry out major works. Called ‘Consequential Improvements’ these are taking the renowned ‘Merton Rule’ from new-build work to existing buildings. There are likely to be requirements to place insulation in other parts of the building away from the new loft extension (for instance) that under the scrutiny of the local planning authority.

Future Regulations

The current building regulations are under review, with revised requirements being introduced on 1st October 2010. Please be aware that as you start to plan work towards this period, you will be required to include new considerations:
Even lower U-Values in walls
Greater levels of insulation under the ground floor.
Low energy ventilation technology
High performance windows and doors

Main changes to the 2010 edition;
5 The main strategic changes to ADL1B proposed are:
Emphasise the distinction between requirements set out in the Building Regulations 2000 and guidance as set out in the AD;
Remove the exemptions from the energy efficiency requirements (regulations 9(3) to 9(6)), but include specific guidance on what is reasonable provision with respect to the building work currently listed there (e.g. in historic buildings, buildings with low levels of heating);
Remove the exemption for conservatories in Part L;
Revise the definition of renovation;
Define standards for swimming pool basins in existing dwellings;
Raise standards generally.

2006 - Standards for controlled fittings (W/m^2K)			2010
	New Fittings in Extensions	**Replacement fittings in Exisitng Buildings**	**New = Replacement**
Windows, Roof windows and Rooflights	1.8 (whole unit)	2.2 (whole unit)	1.8
Energy Ratings	B and D	B and E	B and C
Pedestrian Doors	2.2	2.2	1.8

2006 - Standards for thermal elements (W/m^2K)				2010	
	New Thermal Elements	**Replacement Thermal Elements**		**New Thermal Elements**	**Replacement Thermal Elements**
Wall	0.30	0.35	Cavity Wall	0.28	0.55
			Solid Wall		0.30
Pitched Roof - insulation at ceiling	0.16	0.16		0.16	
Piched Roof - insulation at rafter	0.20	0.20		0.16	
flat roof	0.20	0.25		0.16	
Floors	0.22	0.25		0.22	0.25

Table below gives the current target U-values for construction elements in building regulations Part L1B. These minimum standards are due to be increased in the 2010 update to Part L.

Existing construction element	Typical U-value W/m².K	Improvement measure	Target U-value W/m²·K
Cavity walls	1.5	Fill cavity with insulation. It is highly recommended to consider adding additional external or internal insulation to achieve improved levels of performance.	0.5 to 0.6
Solid walls	2.1	Insulate internally using insulation backed dry-lining, insulation with studwork, or insulate externally using wet render, dry cladding or bespoke systems. Between 80 to 140mm of insulation will be required in all cases to achieve the target U-value (dependant upon insulant conductivity).	0.30
Floor	0.70	Insulate above or below concrete slab, or between joists of timber ground floor with between 100 to 200mm of insulation (depending upon geometry).	0.20 to 0.25
Pitched roof (uninsulated)	1.9	Install 250 to 300mm mineral wool quilt (first layer between joists, second layer across joists).	0.16
		Insulate between rafters with insulation in addition to 40 to 100mm of insulation either above or below the rafters (dependant upon insulant conductivity).	0.20
Flat roof	1.5	Add 100 to 160mm of insulation above structural deck (dependant upon insulant conductivity). If replacing a pitched roof should be considered.	0.25
Glazing	3.1	Replace with high performance windows that incorporate integral draught-stripping.	BFRC rating in band C or better

RENOVATION OF THERMAL ELEMENTS

54 Where a ***thermal element*** is being renovated reasonable provision in most cases would be to achieve the standard set out in column (b) of Table 4. Where the works apply to less than 25% of the surface area however reasonable provision could be to do nothing to improve energy performance.

55 If such an upgrade is not technically or functionally feasible or would not achieve a ***simple payback*** of 15 years or less, the element should be upgraded to the best standard that is technically and functionally feasible and which can be achieved within a ***simple payback*** of no greater than 15 years. Guidance on this approach is given in Appendix A.

RETAINED THERMAL ELEMENTS

56 Part L applies to retained ***thermal elements*** in the following circumstances:

a. where an existing ***thermal element*** is part of a building subject to a material change of use;

b. where an existing element is to become part of the thermal envelope and is to be upgraded.

57 Reasonable provision would be to upgrade those ***thermal elements*** whose U-value is worse than the threshold value in column (a) of Table 4 to achieve the U-value given in column (b) of Table 4 provided this is technically, functionally and economically feasible. A reasonable test of economic feasibility is to achieve a ***simple payback*** of 15 years or less. Where the standard given in column (b) is not technically, functionally or economically feasible, then the element should be upgraded to the best standard that is technically and functionally feasible and delivers a simple payback period of 15 years or less.

Examples of where lesser provision than column (b) might apply are where the thickness of the additional insulation might reduce usable floor area by more than 5% or create difficulties with adjoining floor levels, or where the weight of the additional insulation might not be supported by the existing structural frame.

Table 4 **Upgrading retained thermal elements**

Element	(a) Threshold value W/m²·K	(b) Improved value W/m²·K
Cavity wall*	0.70	0.55
Other wall type	0.70	0.35
Floor	0.70	0.25
Pitched roof – insulation at ceiling level	0.35	0.16
Pitched roof – insulation between rafters	0.35	0.20
Flat roof or roof with integral insulation	0.35	0.25

* This only applies in the case of a wall suitable for the installation of cavity insulation. Where this is not the case it should be treated as for 'other wall type.'

Fig. 19 Building Regulations 2006, Document L1B, Conservation of Fuel and Power in Existing Buildings

4 The Domestic Housing Sector

4.1 HOUSING STOCK

There are 23 million homes in Britain making up the oldest housing stock in the developed world, with 8.5 million properties over 60 years old. Demolition rates are low, with an average of 17,000 homes being demolished every year. At this rate it would take 1400 years to replace the whole housing stock. Even if the demolition rate was increased to the historic high of 80,000 per year (last recorded in 1975), it would still take 400 years to completely replace the housing stock.

Of this stock over a third is of solid wall construction.

Historic Trends in Energy Consumption

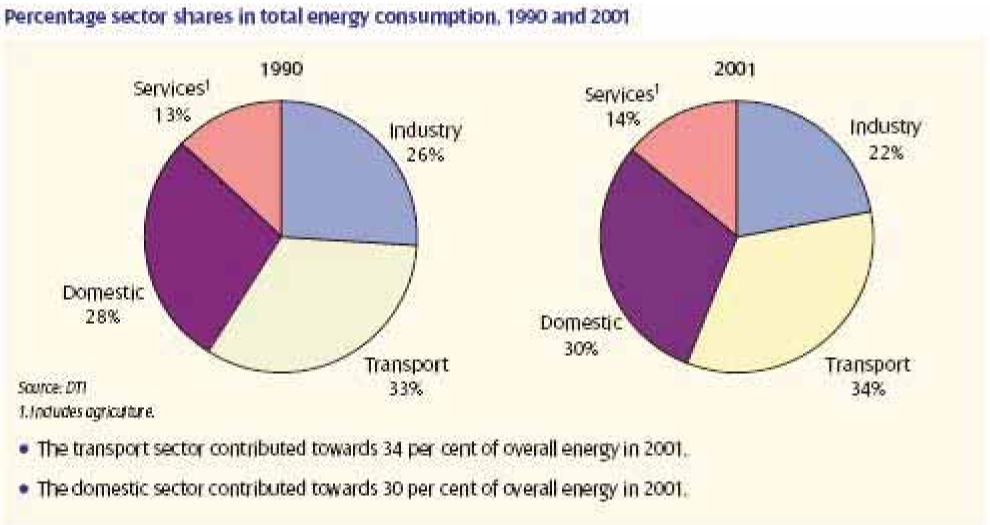


Fig 5 – UK Domestic Energy Use by Sector (source: Energy Use in the UK, Dti)

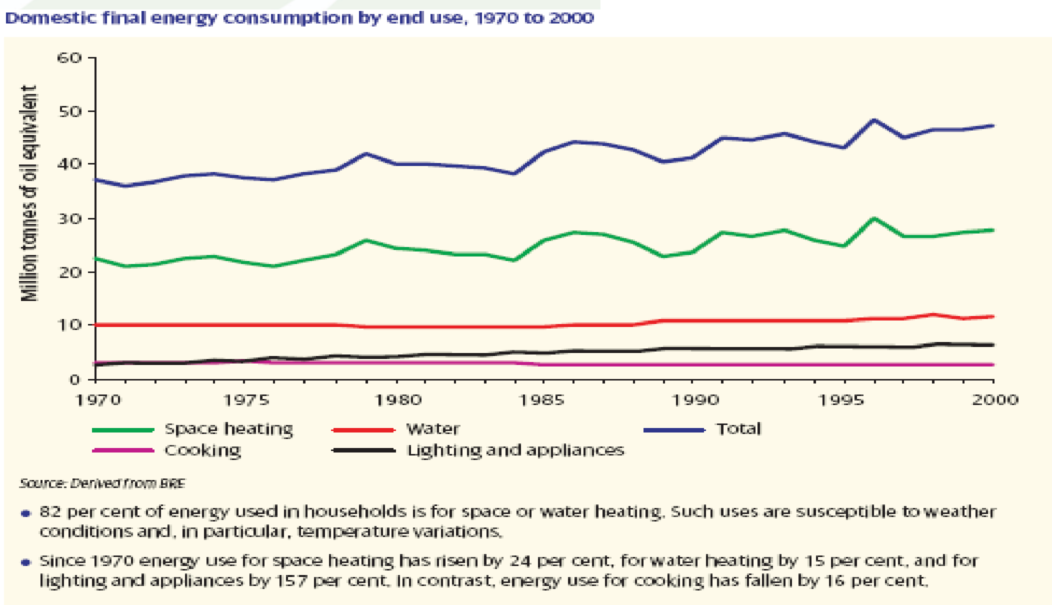


Fig. 6 – Energy Use in the Home (source: Energy Use in the UK, Dti)

4.2 AVERAGE DOMESTIC CONSUMPTION

Figure 6 shows that energy use in the home has been steadily increasing over the last 50 years. A more detailed breakdown of where that energy is used in the average UK home is given in figure 7 where it can be seen that space heating makes up by far the largest element.

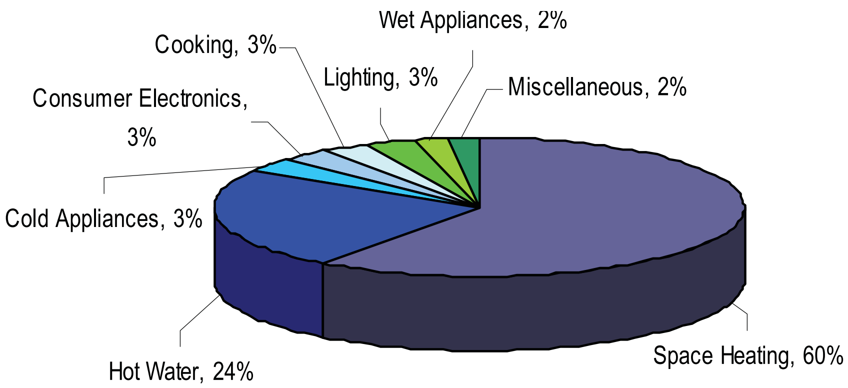


Fig. 7 - UK Domestic Energy by End Use per Average Property

4.3 SAP RATINGS AND CO_2 EMISSIONS

The energy efficiency of a home is rated using a method called the Standard Assessment Procedure or SAP. Homes are given a score between 0 and 100 with a higher score denoting a more energy efficient building. As can be seen from the graph in figure 8, the average SAP rating for a UK home is in the low 50s. New builds should be achieving SAPs in the high 80s.

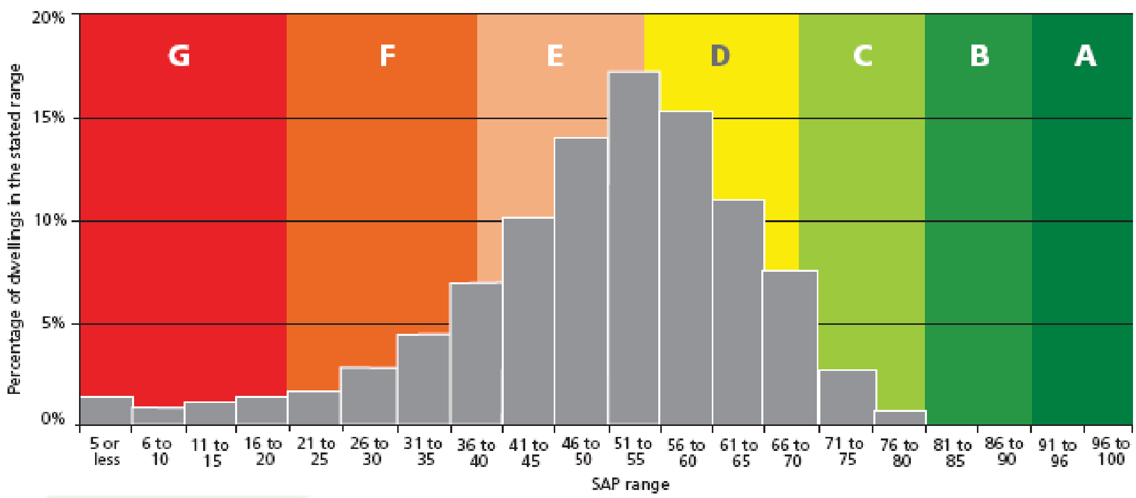


Fig. 8 SAP Ratings of UK Housing Stock (EST, CE309 Sustainable Refurbishment, 2010)

House type	Floor area (m²)	Existing EPC Band	Existing total CO_2 emissions	
			Tonnes/yr	kg/m²/yr
Solid walled detached	104	F	13.7	132
Period end terrace	89	F	6.5	73
Period mid terrace	85	E	6.7	79
1950s semi-detached	90	E	6.5	72
1960s bungalow	64	E	6.2	98
1980s detached	111	E	7.7	69
1980s mid floor flat	61	E	4.2	68
Post 2002 mid terrace	79	C	3.4	43

Fig. 9 - Some Typical Home Energy Ratings and CO2 Emissions (ibid)

5 Whole House Approach to Reducing Energy Use

The next two pages provide two separate analyses of two very different houses types. See how similar measures have a different benefit to the house according to the age of the property i.e. the energy baseline for the new house is a lot lower, so any improvements to the house will have a smaller impact in real terms but a similar implementation cost.

Fig. 13 -Table Of Ranked Measures For Two Different House Types

BUILDING TYPE
Solid Walled, Detached Home
AGE
Built 1880
LOCATION
Chiswick, London
TENURE
Owner occupied

INITIATIVE AREA	DETAILS	ANNUAL FUEL COST SAVING	DIY INSTALL COST	PROF. INSTALL COST	DIY PAYBACK PERIOD (yrs)	PROF. PAYBACK PERIOD (yrs)
HEATING	*Turn down thermostat permanently to 18 degrees from 20 degrees*	*£328*	*£0*	*N/A*	*0.0*	*N/A*
ELECTRICITY	*Systematically replace all non-halogen inefficient lamps with low energy lamps*	*£27*	*£40*	*N/A*	*1.5*	*N/A*
WALL INSULATION	*Internally insulate all solid external walls with 50mm PIR insulation or equivalent*	*£286*	*N/A*	*£3,505*	*N/A*	*12.3*
ELECTRICITY	*Solar PV panels - a six panel array (~8m2) facing south (with 31p FIT)*	*£388*	*N/A*	*£4,800*	*N/A*	*12.4*
APPLIANCES	*Install new top energy rated fridge in kitchen*	*£16*	*£300*	*N/A*	*19.3*	*N/A*
ROOF INSULATION	*Insulate between rafters of sloping ceilings in 2nd floor rooms*	*£49*	*N/A*	*£1,233*	*N/A*	*25.2*
ROOF INSULATION	*Increase insulation in attic space to 300mm*	*£5*	*£186*	*£279*	*35.0*	*52.6*
FLOOR INSULATION	*Insulate suspended ground floor with 150mm mineral wool or equivalent*	*£36*	*N/A*	*£1,484*	*N/A*	*41.4*
ELECTRICITY	*Solar PV panels - a six panel array (~8m2) facing south*	*£96*	*N/A*	*£4,800*	*N/A*	*50.1*
WALL INSULATION	*Externally insulate side solid walls of original house with 50mm PIR insulation or equivalent*	*£191*	*N/A*	*£9,694*	*N/A*	*50.9*
HEATING	*Install a modern highly efficient condensing boiler*	*£47*	*N/A*	*£2,500*	*N/A*	*53.3*
WALL INSULATION	*Externally insulate rear solid walls of original house with 50mm PIR insulation or equivalent*	*£29*	*N/A*	*£1,556*	*N/A*	*53.4*
ELECTRICITY	*Solar PV panels - a three panel array (~4m2) facing south*	*£48*	*N/A*	*£3,150*	*N/A*	*65.7*
HOT WATER	*Install 8m2 flat plate solar panel facing south with solar pump*	*£49*	*N/A*	*£3,700*	*N/A*	*75.6*
WINDOWS	*Upgrade all single glazed windows to Building Regulations for replacement windows*	*£67*	*N/A*	*£11,800*	*N/A*	*177.4*

BUILDING TYPE

Cavity Walled, Semi-Detached Home

AGE

Built 1990

LOCATION

Sutton, London

TENURE

Owner occupied

INITIATIVE AREA	DETAILS	ANNUAL FUEL COST SAVING	DIY INSTALL COST	PROF. INSTALL COST	DIY PAYBACK PERIOD (yrs)	PROF. PAYBACK PERIOD (yrs)
Whole-House Heating	Turn Down Thermostat from 22 to 17 degs C	£50.39	£0.00	£0.00	0.00	0.00
Consumer Electronics	Turn-off Standby Appliances	£54.88	£0.00	£0.00	0.00	0.00
Whole-House Electricity	Install Energy Saving Light Bulbs where not in place	£20.18	£65.00	N/A	3.22	N/A
Whole-House Electricity	Install Energy Efficient Appliances	£23.65	£250.00	N/A	10.57	N/A
Hot Water	Solar Thermal Panels - Cost with scaffolding already in place - Requires switch to gas	£251.48	£3,050.00	£4,500	12.13	17.89
Draughts Heat Loss	General Door/Window/Vent/Loft Hatch Draft-Proofing	£8.95	£150.00	£250	16.75	27.92
Boiler Inefficiency Loss	Lag all heating delivery pipes on external walls/floors	£6.61	£150.00	£250	22.68	37.80
Draughts Heat Loss	Heat Exchange Ventilation - Bathrooms and Kitchen	£8.95	£350.00	£700	39.09	78.17
Whole-House Heating	Underfloor Heating - all floors	£43.90	£2,800.00	£4,000	63.78	91.11
Whole-House Electricity	Photovoltaics	£47.29	£3,010.00	£4,510	63.65	95.37
Roof Heat Loss	Up to Standard Recommended Insulation - 300mm of Rockwool	£3.35	£281.60	£350	83.95	104.34
Roof Heat Loss	Beyond Building Regs Loft - 400mm Rockwool	£3.78	£422.40	£450	111.66	118.96
Door Heat Loss	Replace Front Door with Higher Performance	£2.48	£350.00	£500	141.05	201.49
External Wall Heat Loss	External Insulation - 75mm PIR	£10.94	£2,722.52	£3,322	248.96	303.82
External Wall Heat Loss	Internal Wall Insulation Throughout - 50mm PIR	£8.70	£2,232.00	£3,348	256.50	384.75
Window Heat Loss	Secondary Glazing for those without	£3.49	£1,320.00	£1,620	378.43	464.43
Window Heat Loss	New Triple-Glazed Windows in Main House	£10.13	N/A	£6,050	N/A	597.33

6 Business Considerations

There are a few things to consider when making the business case for low energy refurbishment. The first is to ensure that the cost of the work is as low as possible such that the period of time by which the initial uplifted investment in the energy savings measures is paid back i.e. the payback period. Here follow some key issues to bear in mind to reduce that cost:

6.1 VAT RELIEF ON ENERGY EFFICIENCY WORK IN THE HOME (5%)

Incidental Work

Any work that you undertake as part of the installation process is eligible for the reduced rate.
This includes minor building works, such as planing doors or windows, enlarging loft hatches, and painting or plastering to make good.
But if the installation of energy-saving materials is incidental to another supply you are making - such as the building of an extension or the replacement of a roof - you are making a single supply of construction services (see Notice 708 Buildings and construction).

Insulation
Insulation means materials that are designed and installed because of their insulating qualities.
The reduced rate applies to installations of insulation for: walls; floors; ceilings; roofs or lofts; and water tanks, pipes or other plumbing fittings.
The reduced rate does not apply to essentially decorative products such as curtains and carpets.

What is residential accommodation?
The installation of energy-saving materials is only reduced-rated if they are for use in the following types of residential accommodation: houses, flats or other dwellings; armed forces residential accommodation; children's homes; homes providing care for the elderly, disabled people, or people who suffer or have suffered from drug or alcohol dependency or mental disorder; hospices; institutions that are the sole or main residence of at least 90% of their residents; monasteries, nunneries and similar religious communities; school and university residential accommodation for students and pupils; self catering holiday accommodation; caravans that are sited on permanent residential caravan parks.

They must be either longer than 7 metres or wider than 2.3 metres, excluding towing bars and similar apparatus used solely for the purpose of attaching the caravan to a vehicle; and houseboats that are designed or adapted for permanent habitation and have no means of self propulsion, or other boats which are used as a person's sole or main residence, such as canal boats and Dutch barges, on which the boat owner pays Council Tax or domestic rates.

The reduced rate does not apply to the installation of energy-saving materials in hospitals; prisons or similar institutions; hotels or inns or similar establishments.
Link for full guidelines on VAT reductions on certain energy efficiency measures:

http://www.hmrc.gov.uk/vat/sectors/consumers/energy-saving.htm

6.2 CONCURRENT WORKING

This is the notion that if energy efficiency work can be carried out at the same time as regular building work that both works together will resulting a lower cost to the client. This will reduce the payback period. The following two pages present an example of this. The second page shows how the overall cost of the work cannot be attributed to energy efficiency if the regular building work was going t be done anyway. This presents opportunities for contractors to up-sell their regular work to include energy efficiency work at a moment in time when it is cheapest for the client to buy it.

Example of Cost Advantages of Opportunity Based Approach – Sheep wool Insulation

Room	Dining Room
Scenario	Special Exercise to Insulate, with Radiators
System Description	Sheepwool in Timber Stud Frame - Breathable
Wall Area (m)	10.54

Activity		**Labour**							**Materials**						
		Item	Unit	No.	Rate	SubTotal	VAT	TOTAL	Item	Unit	No.	Rate	SubTotal	VAT	TOTAL
Preparation															
	Strip Wallpaper	Labourer	Day	0.375	£85.00	£31.88	£5.58	£37.45						£0.00	£0.00
Structure			Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
	Timber	Carpenter	Day	0.75	£150.00	£112.50	£19.69	£132.19	2x2				40	£7.00	£47.00
	Rear Membrane	Carpenter	Day	0.25	£150.00	£37.50	£6.56	£44.06	Roof Membrane					£0.00	£0.00
Notional Plumbing First Fix			Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
	Pipework	Plumber	Day	0.375	£110.00	£41.25	£7.22	£48.47	Copper Pipe				15	£2.63	£17.63
Electrical First Fix			Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
	Cables	Electrician	Day	0.5	£120.00	£60.00	£10.50	£70.50	Cables				15	£2.63	£17.63
Place Insulation			Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
	Sheepwool	Carpenter	Day	0.5	£150.00	£75.00	£13.13	£88.13	Sheepwool	m^2	10.54	£16.12	£169.90	£29.73	£199.64
	Window Return Insulation	Carpenter	Day	0.25	£150.00	£37.50	£6.56	£44.06	Celotex	m^2	3	£6.98	£20.94	£3.66	£24.60
Finishes			Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
	Plasterboard	Carpenter	Day	0.125	£150.00	£18.75	£3.28	£22.03	Plasterboard		10.54	£3.00	£31.62	£5.53	£37.15
	Scrim and Skim	Plasterer	Day	0.375	£130.00	£48.75	£8.53	£57.28	Finishing		10.54	£2.00	£21.08	£3.69	£24.77
	Paint	Tradesman	Day	0.1875	£110.00	£20.63	£3.61	£24.23	Paint		10.54	£4.50	£47.43	£8.30	£55.73
Notional Plumbing Second Fix			Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
	Pipework	Plumber	Day	0.0625	£110.00	£6.88	£1.20	£8.08	Items				£25.00	£4.38	£29.38
	Radiator Hang	Plumber	Day	0.125	£110.00	£13.75	£2.41	£16.16						£0.00	£0.00
Electrical First Fix			Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
	Sockets	Electrician	Day	0.125	£120.00	£15.00	£2.63	£17.63	Sockets	No.	3	£7.00	£25.00	£4.38	£29.38
							£90.89	£610.27						£71.92	£482.90
Cost per m2								£57.90							£45.82
															£103.72 per m^2

TOTAL VAT	TOTAL COST
£162.81	£1,093.16

Room	Dining Room	**System Description**	Sheepwool in Timber Stud Frame - Breathable
Scenario	Rewiring Anyway, Decorating Anyway, New Heating Anway	**Wall Area (m)**	10.54

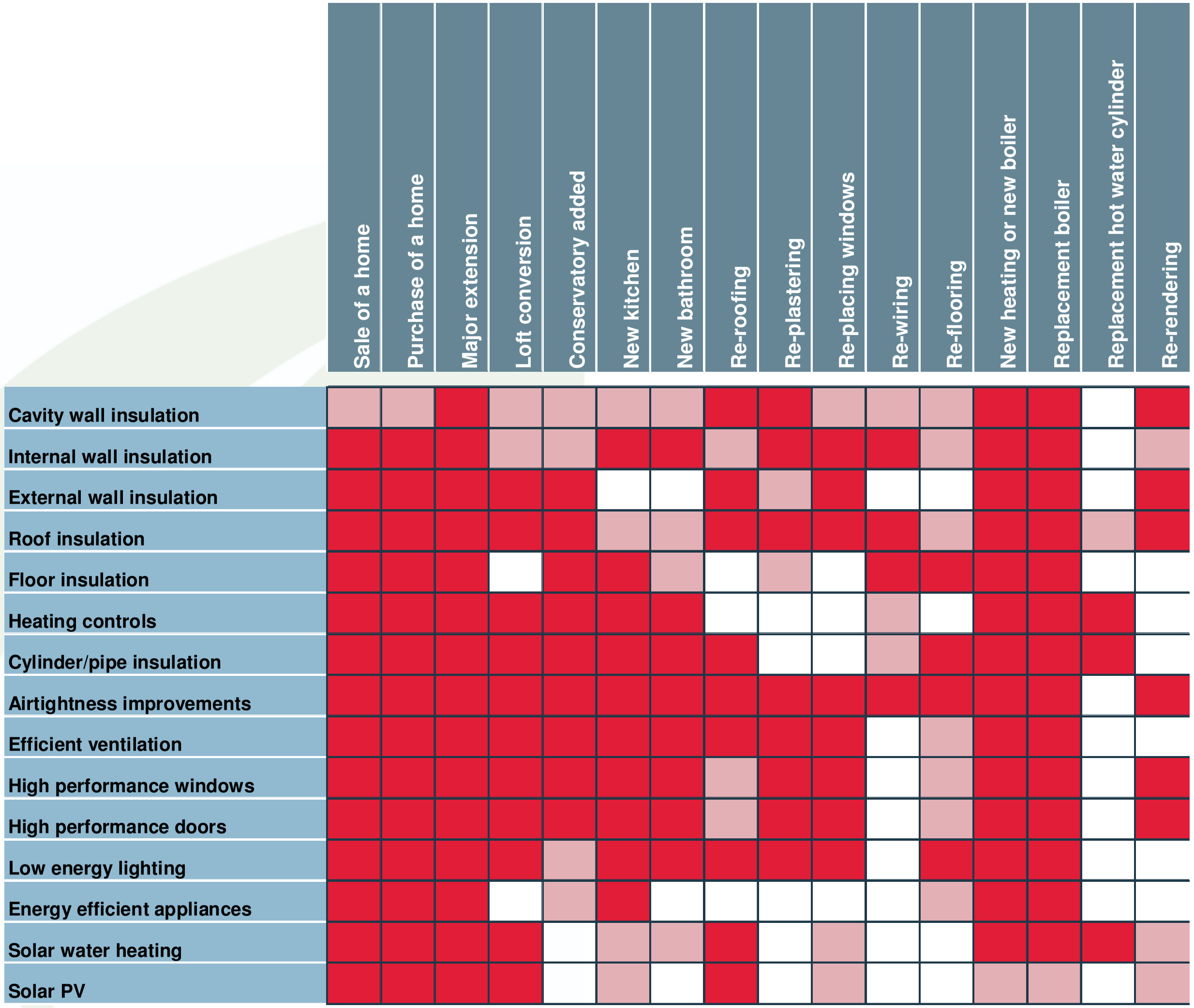
Activity	**Labour**							**Materials**						
	Item	Unit	No.	Rate	SubTotal	VAT	TOTAL	Item	Unit	No.	Rate	SubTotal	VAT	TOTAL
Preparation														
Strip Wallpaper	Labourer	Day	0	£85.00	£0.00	£0.00	£0.00						£0.00	£0.00
Structure		Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
Timber	Carpenter	Day	0.75	£150.00	£112.50	£19.69	£132.19	2x2				40	£7.00	£47.00
Rear Membrane	Carpenter	Day	0.25	£150.00	£37.50	£6.56	£44.06	Roof Membrane					£0.00	£0.00
Notional Plumbing First Fix		Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
Pipework	Plumber	Day	0	£110.00	£0.00	£0.00	£0.00	Copper Pipe				0	£0.00	£0.00
Electrical First Fix		Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
Cables	Electrician	Day	0	£120.00	£0.00	£0.00	£0.00	Cables				15	£2.63	£17.63
Place Insulation		Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
Sheepwool	Carpenter	Day	0.5	£150.00	£75.00	£13.13	£88.13	Sheepwool	m^2	10.54	£16.12	£169.90	£29.73	£199.64
Window Return Insulation	Carpenter	Day	0.25	£150.00	£37.50	£6.56	£44.06	Celotex	m^2	3	£6.98	£20.94	£3.66	£24.60
Finishes		Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
Plasterboard	Carpenter	Day	0.125	£150.00	£18.75	£3.28	£22.03	Plasterboard		10.54	£3.00	£31.62	£5.53	£37.15
Scrim and Skim	Plasterer	Day	0	£130.00	£0.00	£0.00	£0.00	Finishing		10.54	£2.00	£21.08	£3.69	£24.77
Paint	Tradesman	Day	0	£110.00	£0.00	£0.00	£0.00	Paint		10.54	£4.50	£47.43	£8.30	£55.73
Notional Plumbing Second Fix		Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
Pipework	Plumber	Day	0	£110.00	£0.00	£0.00	£0.00	Items				£0.00	£0.00	£0.00
Radiator Hang	Plumber	Day	0	£110.00	£0.00	£0.00	£0.00						£0.00	£0.00
Electrical First Fix		Day		£0.00	£0.00	£0.00	£0.00						£0.00	£0.00
Sockets	Electrician	Day	0	£120.00	£0.00	£0.00	£0.00	Sockets	No.	3	£7.00	£25.00	£4.38	£29.38
						£49.22	£330.47						£64.92	£435.90
Cost per m2							£31.35							£41.36

£72.71 per m^2

TOTAL VAT	TOTAL COST
£114.14	£766.36

Saving from original 30%

6.3 TRIGGER POINTS



This diagram shows the moments of regular building work in the life of a building in which can trigger an opportunity to carry out energy efficiency work.

7 Required Levels of Loft Insulation

The levels of insulation 'required' in a loft are dependent on two factors:

1. An economic level of insulation to stem heat loss.
2. The minimum level of insulation set by UK building regulations.

More often than not, the minimum legal requirement set by Building Regulations is the greater driver. Some clients may wish to go beyond this minimum level to save a greater amount of energy. The benefit of doing this is shown later.

7.1 ROOF CONSTRUCTION

Construction methods have barely changed over the past decades, except for the gradual rise in uvalues required for this element of the house over the years. Crudely, new houses therefore have more insulation in them than older houses and therefore will require less effort to insulate them. We can therefore use a strong rule of thumb that shows that depth of insulation is relative to heat loss in any UK home.

7.2 GENERAL DEPTH OF INSULATION REQUIRED

We have already discussed that installed insulation must perform as required by building regulations or better.

It is easy to understand that as we increase the depth of insulation that the installation will retain more heat. However, insulation materials perform differently from each other and therefore will need to be installed at different depths to achieve the same level of heat retention.

Insulation Material	K-value	Thickness (mm) to reach U = 0.16
Aerogel TM	0.013	90
Phenolic Foam	0.023	160
Polyisocyanurate (PIR)	0.024	160
Extruded Polystyrene (XPS)	0.029	190
Expanded Polystyrene (EPS)	0.030	200
Mineral Wool	0.032	210
Recycled newspaper (Cellulose)	0.036	235
Sheepwool	0.039	250
Hemp-based	0.039	250
Wood Fibre Board	0.040	255
Wool from Recycled Glass	0.044	280

Required Depth of Insulation to Achieve U Value of 0.16. Calculations assume insulation placed in the loft floor – existing roof joists at 600mm centres, 75mm wide.

It is important to recognise that there is a point beyond which it may not be economical to install a further depth of insulation. It will cost the client money to add the insulation, but the fuel saving may not mirror this cost. This is called 'diminishing returns' and is demonstrated on the next page.

Technical Considerations for Insulating Roof Spaces

It is all very well understanding what levels of insulation are required to meet u-value, but it is very clear that the chosen insulation must fit the roof in such a way that it:

- Actually achieves the reduction in heat loss.
- Continues to in the long term with suitable fixing.
- Cause no long term harm to the building.

To achieve this, the following key issues need to be considered when deciding upon the most appropriate approach for the roof space:

- Vapour control and interstitial condensation
- Thermal bridging
- Services
- Interface with other trades

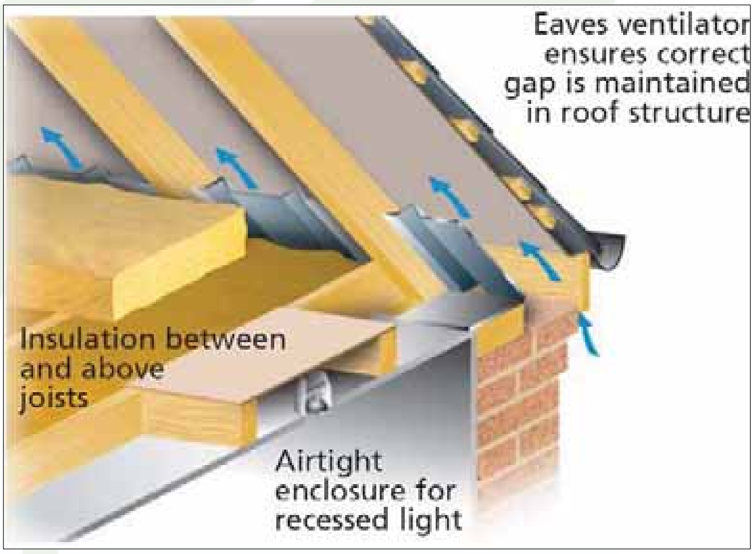
7.3 WATER VAPOUR

70% of the air around us consists of water vapour and condensation forms when this air touches a cold surface. We have all seen his happen on windows in the winter. Basically, risks have to be evaluated for any surface that is in contact with water vapour and whose temperature is low enough for the vapour to condense. If that water can e present long enough to cause any kind of damage, it must be controlled.

This is best avoided by preventing moist air from entering the roof void from within the dwelling. Sealing any service penetrations through the ceiling (such as recessed light fittings – see later) draught-proofing loft hatches and pipes, and sealing and insulating water storage tanks will help avoid condensation.

7.4 INFILTRATION AND VENTILATION

Works undertaken to insulate a dwelling present an excellent opportunity to improve the air tightness of the building, reducing draughts and improving thermal comfort. With roof spaces however, it is essential that some infiltration is required to ensure that the structure of the roof (timber) remains dry for most of the time.



A deliberate path of air must be maintained at the eaves of a house to ensure that timber structure is kept dry. This physical requirement is also policed by Building Regulations. The diagram opposite shows how when insulation is placed in the loft floor, air flow can be maintained through the placement of specialist 'eaves ventilation' units.

As the level of insulation in a building's envelope improves, the flow of air through that building becomes an increasingly dominant factor in the overall heat loss figures. Reducing the airflow through a dwelling is generally a good thing though some airflow is always necessary to maintain indoor air quality. In older properties, a greater level of airflow may be necessary to avoid issues with damp and this is one such occasion.

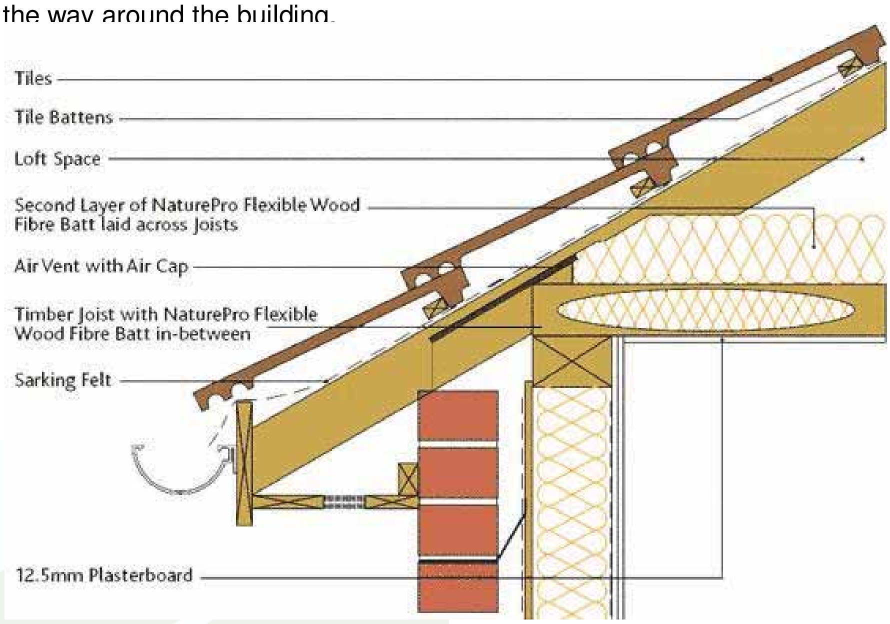
Roof Specific Air Tightness Work

- Seal around all pipe and cable runs through the ceilings and other walls at the edge of the loft space.
- Seal ceiling interfaces with walls by ensuring good plastering or coving adhesive.
- Seal around loft hatch OR replace it with new insulated loft hatch.

7.5 THERMAL BRIDGING

Care must be taken to ensure that whilst the key areas of loft are well insulated, that every potential route for the path of heat loss is minimised throughout. Narrowed insulation or unwieldy fixings are a common cause of this but these occurrences can be designed out if planned in advance.

The following diagram shows how this has been considered in order to maintain an even level of insulation all the way around the building.



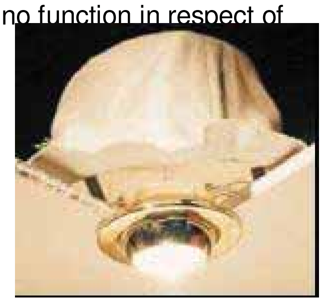
7.6 WIRING

It is most important that insulation is not laid over any existing cables, as this prevents them from dissipating heat when in use. Continued heating will damage the cables, which could in turn lead to a fire risk. If the cables have sufficient slack, they must be raised above the proposed insulation. If not, they may need to be replaced before the roof can be insulated. When replacing the cables within the roof void, a dedicated service void below the existing ceiling should be considered. This could substantially improve the airtightness of the ceiling structure and becomes even more important if new recessed light fittings are to be provided.

The IEE Wiring Regulations 16th Edition BS 7671:2001
Section 527-02-01 says
“Where a wiring system passes through elements of building construction such as floors, walls roofs ceilings, partitions or cavity barriers, the openings remaining after the passage of the wiring system shall be sealed according to the degree of fire resistance of the element(if any)”.

7.7 RECCESSED DOWN-LIGHTING

Care needs to be taken in the selection of a lighting cover to ensure that it is right for the application. Some covers are only tested to BS 476 Part 23. This is a test for light fittings used in association with commercial suspended ceilings designed solely to protect steel beams in lieu of applying protection. It is carried out at zero pressure differential at ceiling level and therefore has no function in respect of floor tests to BS 476 Parts 21 or 22.



A lighting cover with a one hour rating to BS476 Part 23 may only be able to protect a timber decked floor for 15 to 25 minutes because of the positive pressure used in Part 21 test. This is far too short to provide the 90% cover required for a loaded lightweight joisted floor, if it is to achieve the 1 hour separation rating.
It is important to check that the cover selected is correct for the application.

7.8 STORAGE

If a small storage area is required in the roof void, then this should be located as close to the loft hatch as possible. A higher performance material should be used below the proposed storage area because the insulation will be thinner by necessity. The storage decking itself should be either laminated with 100mm of rigid insulation, or supported off 100mm deep cross timbers to spread the load between adjacent ceiling joists, again with insulation placed between. Any boxing over existing recessed lighting should also be insulated with higher performance materials to make up for the reduced thickness of insulation in this spot.

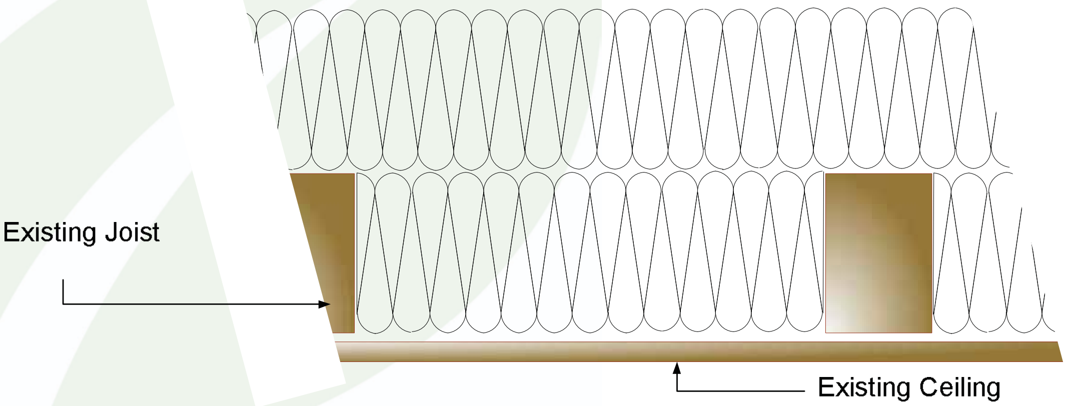
7.9 TWO KEY APPROACHES: INSULATING THE LOFT FLOOR AND INSULATING AT RAFTER LEVEL

All of the above key items need to be considered for each of the two key areas of loft insulation:

- At loft floor
- At the rafter level

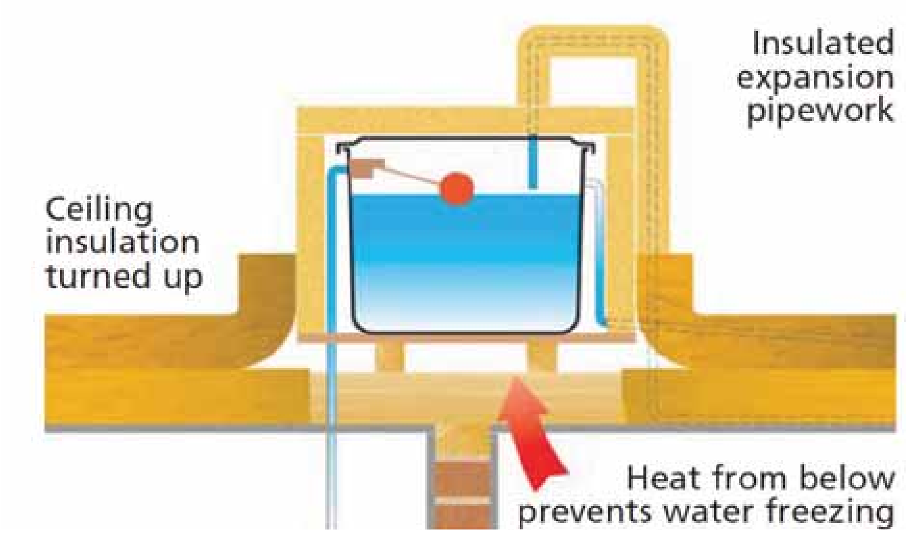
7.10 THE LOFT FLOOR

This schematic shows how the full depth of insulation required will go above the joist height.



Available as a subsidised measure from energy suppliers.

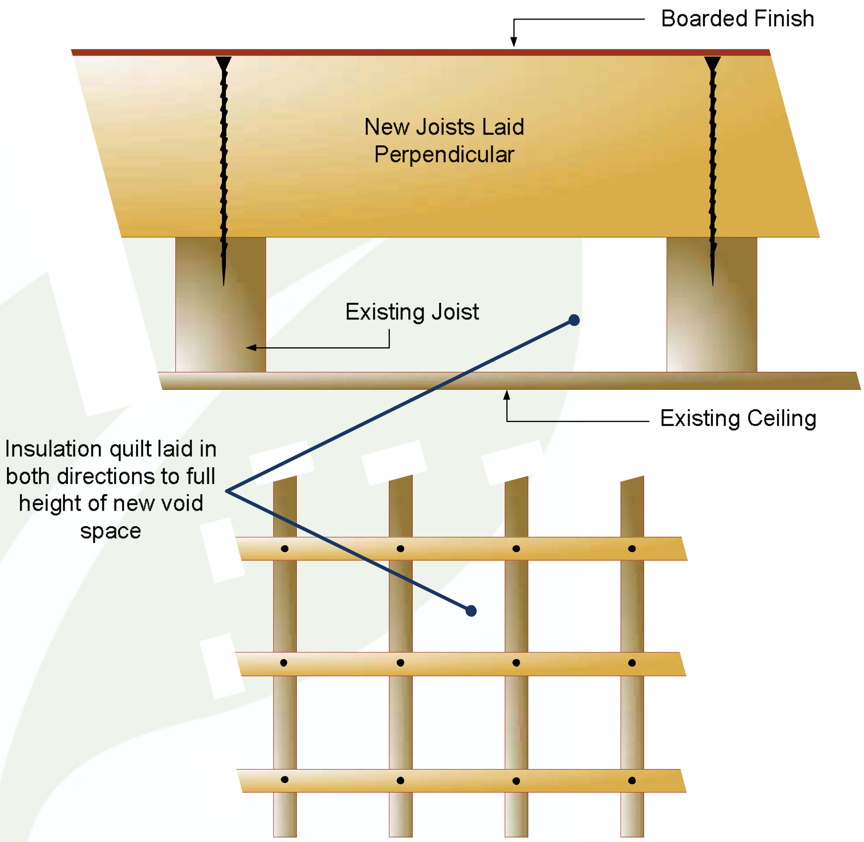
To stop water tanks freezing, no insulation should be placed below them.



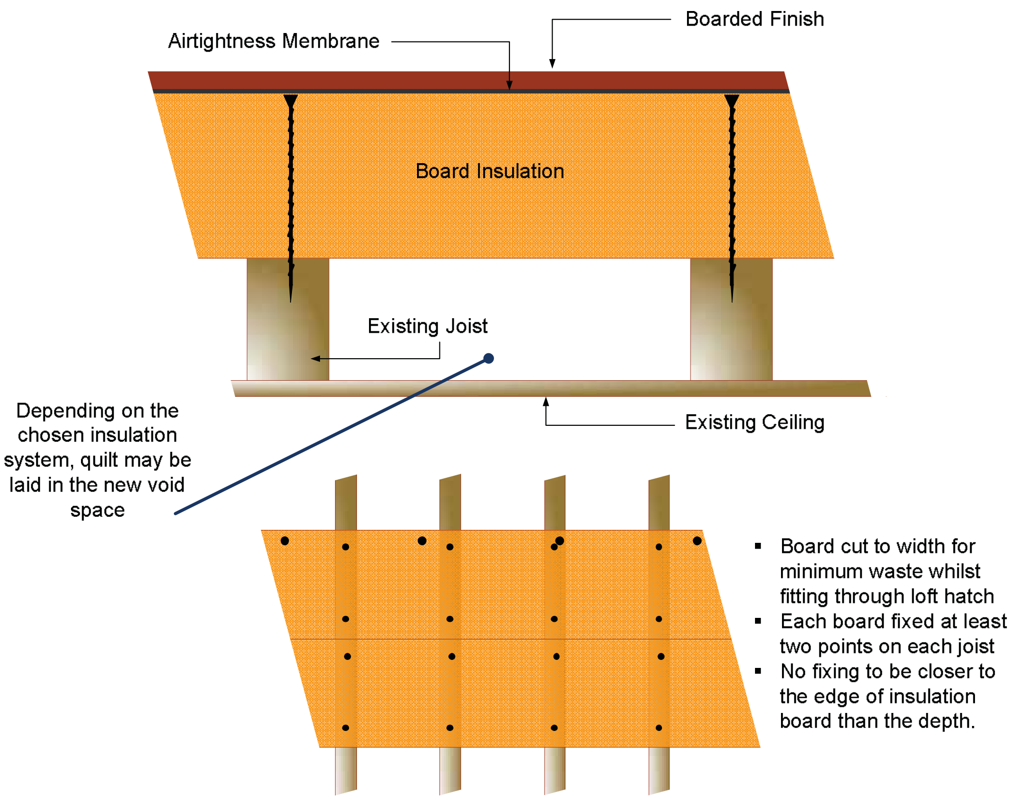
The only problem is that the insulation at recommended depths means that the loft cannot be used for storage. Two other options exist in this situation:

1. Structure Build Up
2. High performance insulation over rafter.

Both of these approaches are shown below.



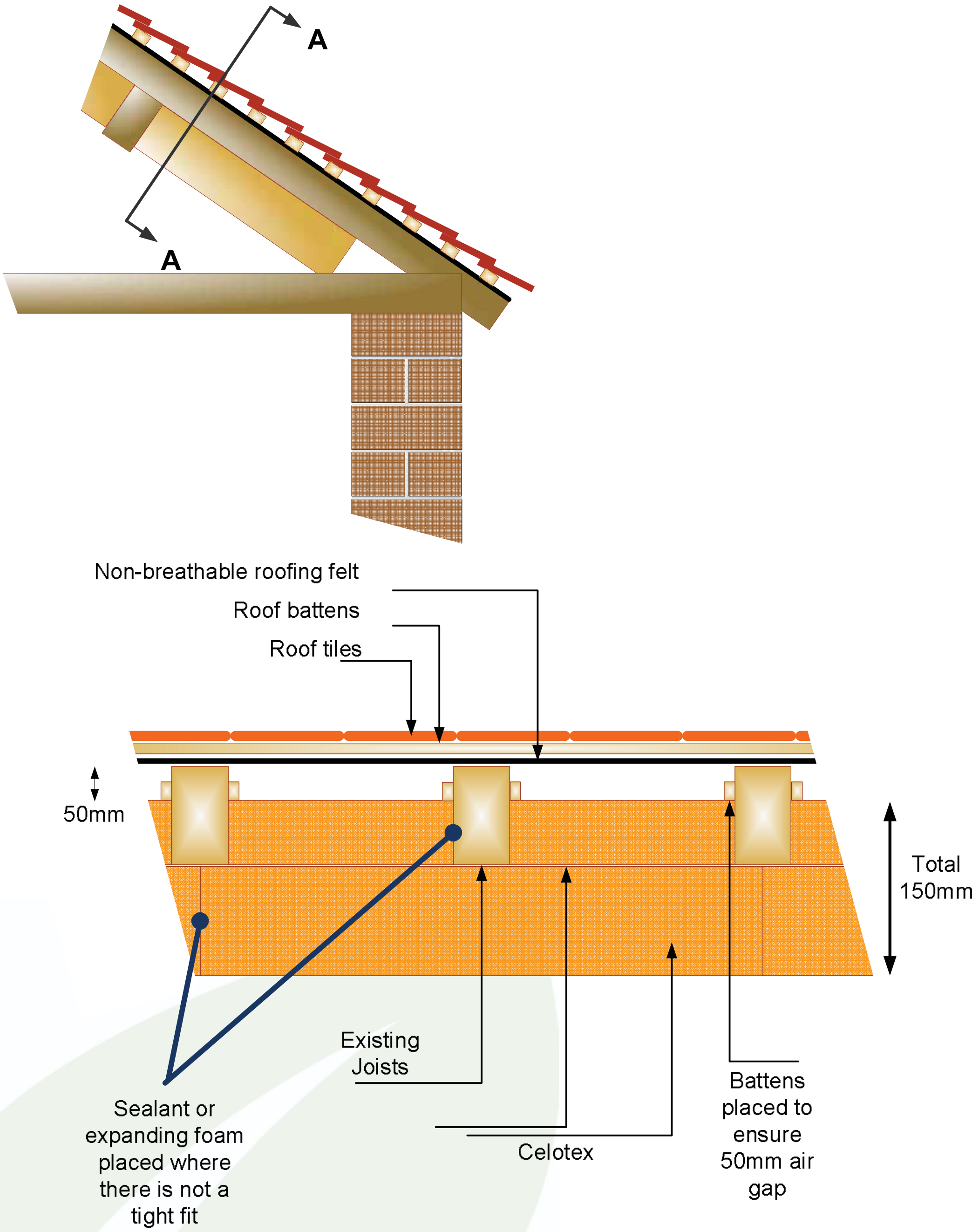
Typical Cost - £15/m^2



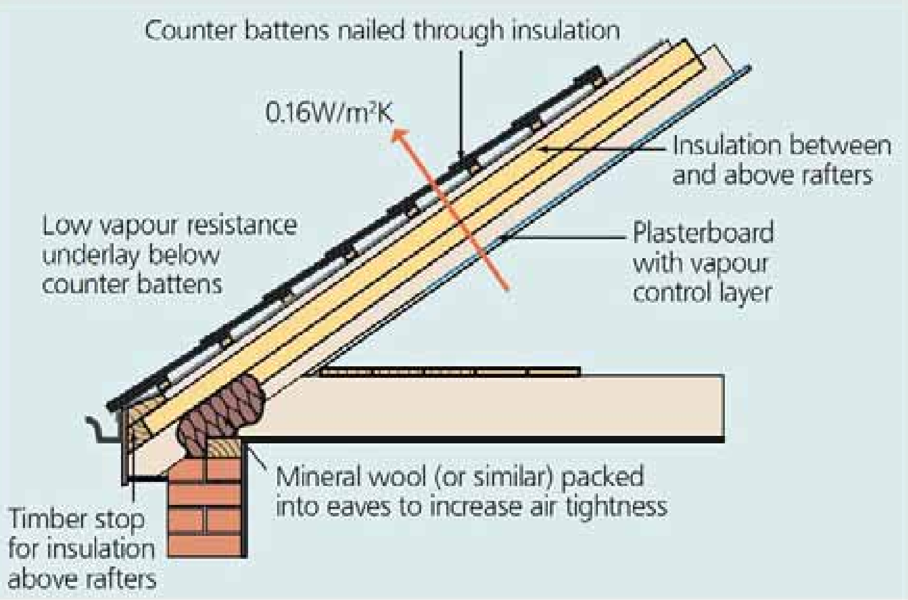
7.11 INSULATION AT RAFTER LEVEL

Although it is possible to insulate at rafter level whether the loft is a habitable space or not, it should only be done where there is an existing room in the roof space, or when converting a loft into habitable space. When the loft is not used as habitable space, it clearly makes sense to insulate at ceiling level in order to minimise the heated volume of the dwelling. If rafter level insulation accompanies re-roofing, consideration should be given to placing the insulation above and between the rafters. This will raise the roof level slightly and may need planning permission but will improve the fixing of the insulation.

When using internal insulation, it is important to maintain any existing cross ventilation. To achieve this, insulation between the rafters must provide a 50mm space between the insulation and the roof structure (see figure 17). Where a breathable sarking membrane exists or is provided, this gap can be reduced. The insulation must however not come into contact with the membrane, as this could impair its ability to breathe. Extra insulation will need to be placed below the rafters to give a reasonable level of thermal resistance. Table 9 shows U-values that can be achieved using insulation placed between the rafters and thermal laminate plasterboard below them (assuming a spacing of 600mm).


A
A
Non-breathable roofing felt
Roof battens
Roof tiles
50mm
Total 150mm
Existing Joists
Sealant or expanding foam placed where there is not a tight fit
Celotex
Battens placed to ensure 50mm air gap

Section A-A



Raised Loft Structure and Recessed Light

Loft Hatch and Increased Depth

Raised Loft Structure prior to full insulation

8 Solid Walls Design and Construction

Learning outcome: The student should have a clear understanding of the nature of the majority of solid walls, their age, original design rational and construction techniques how they deal with moisture and water vapour, the nature of interstitial condensation and how introducing solid wall insulation may cause this.

8.1 WALL CONSTRUCTION

Wall construction methods have changed over the century first with cavity walls becoming the standard method. The urgent need for new homes in the post war reconstruction led to a number of non traditional methods of construction being used, including pre-formed concrete panels and steel frames though cavity wall construction remains the most common form. Since the 80's, cavity insulation for new builds had been a mandatory part of building regulations, though this does not always mean that it was included. In the past decade, so called *modern methods of construction* (including an increased amount of off site production of structural elements) have become more popular.

Table 4 - Evolution of Wall Construction in the UK (EST CE309)

Decade	Development of cavity walls	Cavity width
1920s	Solid walls still dominate, but cavity walls grow in popularity.	Typically between 50mm and 100mm
1930s	Cavity walls become main form of construction, but some solid walls still built.	Typically between 50mm and 100mm
1940s and 1950s	Cavity width becomes standardised.	50mm
1960s	Concrete blocks used to inner leaf.	50mm
1970s	Lightweight blocks are introduced.	50mm
1980s	Partial fill cavity wall insulation introduced, cavity widths increased.	60-70mm
1990s onwards	Full fill cavity wall insulation becomes dominant.	50-100mm

Despite having been phased out over half a century ago, solid wall homes still make up about 28% of the UK housing stock. While an un-insulated cavity wall does reduce heat loss compared to an equivalent solid wall, the chief advantage of cavity walls is the ease with which insulation may be retrofitted to the property. Filling a wall cavity with insulation can be done relatively cheaply and with little or no disruption to the resident while having a dramatic effect on the heat loss from the home.

Heat loss through solid walls in an un-insulated home is around 45%, compared with 33% through cavity walls. Not all cavity walls are suitable for cavity wall insulation and need to be treated as if they are solid walls. There are a number reasons why this might be the case including rubble in the cavity, non-rustproof wall ties and how exposed the site is. In addition, even when filled, walls with a 50mm cavity may only achieve u-values of around 0.55 W/m^{2}K and may need further insulation to be applied if the UK's CO_2 emissions targets are to be achieved.

8.2 MOISTURE IN SOLID WALLS

Insulating an older, solid wall may change the way in which it deals with the passage of moisture and water vapour through its fabric. Installing insulation that results in moisture becoming trapped within the wall structure can result in serious long term damage as well as air quality problems arising form mould growth. There are two possible methods to deal with moisture issue – either using breathable or non breathable materials - but before deciding which system to use, it is important to understand the nature of the wall that is being insulated and the design logic behind its construction.

8.2.1 Traditional Design

Older wall construction techniques, i.e. solid wall, relied on the fabric of the walls being able to absorb and release water vapour on both the internal and external faces. For this to occur, the materials in the wall construction needed to have good hygroscopic qualities, which was generally the case during the period when solid wall construction was the norm. Lime based mortars, renders and paints are all very good at allowing the free passage of water vapour through a wall.

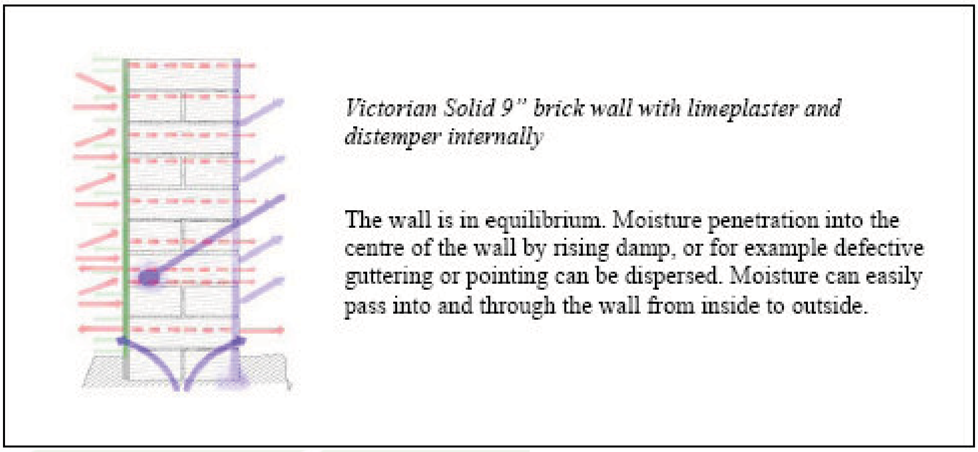


Fig. 15 - Traditional Wall Moisture Control (Source: Breathability, Neil May 16/04/05)

Since the invention of modern latex based paints and the prevalence of cement based renders and gypsum based plasters, many older solid walls have been incorrectly coated, either internally, externally or both, with these less breathable materials, leading to potential problems.

Moisture can enter a wall from the outside, through cracks or other breaks in the render, through porous materials, such as old brickwork, or through holes or bad detailing of the roof, and also from the inside through surface condensation, interstitial condensation and through rising damp.

Insulating the walls can have an effect on all of these issues. External insulation can solve many problems such as porous materials and cracks, as well as condensation, both surface and interstitial. It can, however, trap moisture from roof leaks or rising damp inside the wall. Internal insulation may increase the danger of both forms of condensation as well as trapping moisture, either from rising damp or external penetration, in the wall.

8.3 VAPOUR AND CONDENSATION

Internal air tends to contain high concentrations of water vapour due to all the washing, cooking and bathing that takes place in the home. When this water vapour meets a cold surface, condensation forms, which can lead to dampness problems and mould growth. Surface condensation can be seen on window panes or particularly cold sections of external walls, however due to the way water vapour can penetrate through many materials, condensation may also be forming within the structural elements of a home.

Moisture vapor naturally diffuses into and through wall structures — a phenomenon called "vapor drive." The degree of vapor drive is controlled by the porosity of the wall, together with environmental factors, especially:

Moisture gradients — Moisture vapor will naturally move from a high concentration to a lower concentration, until it is in balance. If the vapor pressure is high outside the wall and low inside the wall, vapor drive will be directed inward (and vice versa). The greater the difference of this vapor pressure or "concentration gradient," the greater the vapor drive.

Temperature gradients — Moisture vapor will naturally move from the warm side of a wall to the cooler side. If the temperature is high inside the building and lower outside the building, vapor drive will be directed outward (and vice versa). The greater the difference of this "temperature gradient," the greater the vapor drive.

In other words, the movement of moisture via diffusion is a result of differences in vapor pressure that are related to the temperature and moisture content of the air. Of these two, temperature is the greatest factor impacting vapor drive. In fact, when the temperature differences between indoors and out is great (say, 20 degrees or more), the vapor drive can be quite strong. Add a significant difference in humidity, and the vapor drive becomes even more vigorous.

8.3.1 Surface Condensation

Fig. 16 – Damage Caused by Surface Condensation

By insulating a home's walls we are, in effect, increasing their internal surface temperature. Wherever cold bridges across the insulation occur, cold spots are likely to form, attracting the moisture in the air and resulting in increased level of condensation at those points. This can lead to localised dampness and mould growth problems.

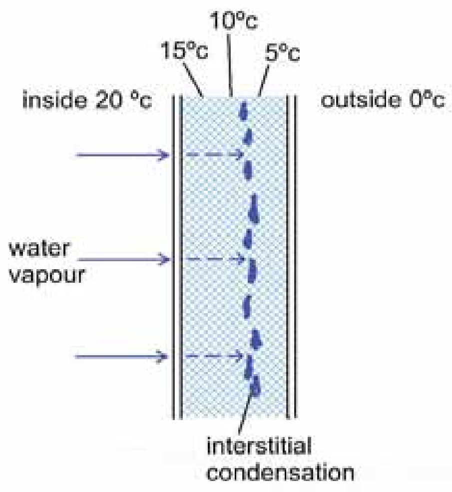


Fig. 17- Interstitial Condensation in Solid Wall

8.3.2 Interstitial Condensation

Interstitial condensation occurs when warm, moist air from inside a building penetrates into the fabric of a structure and meets a cold surface, where it cools, reducing its ability to carry moisture and increasing the risk of condensation forming within the construction.

This moisture may become trapped within the structure and cause serious damage as well as result in mould growth.

Interstitial condensation may be avoided by fitting a vapour barrier on the internal face of the building element. For this technique to work, it is very important that the vapour barrier remain unbroken, cover the whole surface and ideally be returned a short way along adjoining elements.

8.3.3 Vapour Barriers

The role of a vapour barrier is to prevent the relatively warm moist air inside the home from penetrating into the wall and roof structure where it may potentially cause interstitial condensation. A vapour barrier may be constructed of a number of different materials though most commonly it is polyethylene plastic. Multifoil insulation may be used to perform the same function, as can a correctly installed ply or OSB layer.

Fig 18 – Vapour Barrier and Tape

8.3.4 Rising Damp

Rising damp describes the upward movement of moisture through permeable building materials by capillary action. Many solid walls were built without the benefit of modern, flexible damp proof courses; often using slate or having no DPC at all.

Fig 19 – Damage Caused by Rising Damp

Again, the traditional solution to rising damp was to have a large area of breathable wall to help evaporate any moisture that did occur. Covering a wall designed like this with materials that do not allow the free passage of moisture results in moisture being trapped in the wall and possibly causing damage, or being forced into other areas of the building fabric.

Correctly identifying rising damp as the cause of dampness in a wall can be a complicated procedure and misdiagnoses are not uncommon.

It is important to ensure that all other possible sources of damp, such as roof leaks or guttering problems, are fully identified and corrected before making a final decision. There are a number of techniques for tackling rising damp including, chemical and physical damp proof courses as well as specially designed venting bricks.

8.3.5 Rain Penetration

Water ingress through the external face is another common way for moisture to enter into a wall structure. There is a greater likelihood of this happening in wetter parts of the country and in locations that are more exposed to the weather. Bare brick walls can often allow the passage of rain water no matter how well they have been constructed. Cracks in rendered facades can also allow water into the wall and have the secondary effect of not allowing the moisture to be released as easily. Leaking guttering and down pipes may also lead to damp problems in walls.

Fig. 20 – Damage Caused by Rain Penetration

External wall insulation may help to solve rain penetration problems by forming a protective shield between the weather and the existing, porous surface.

9 Solid Wall Insulation

Learning outcomes: The student should have a good understanding of the options for solid wall insulation, the materials and techniques available, the pros and cons of external and internal wall insulation, the difference between system and non-system installation methods and the potential need for interaction with other specialist contractors.

9.1 OPTIONS FOR SOLID WALL INSULATION

Insulation can be installed onto both the inside and outside of solid walls. Both methods have advantages and disadvantages and a number of design considerations should be taken into account before a decision is made in which method to use. In some instances, a combination of the two methods may be the most appropriate solution.

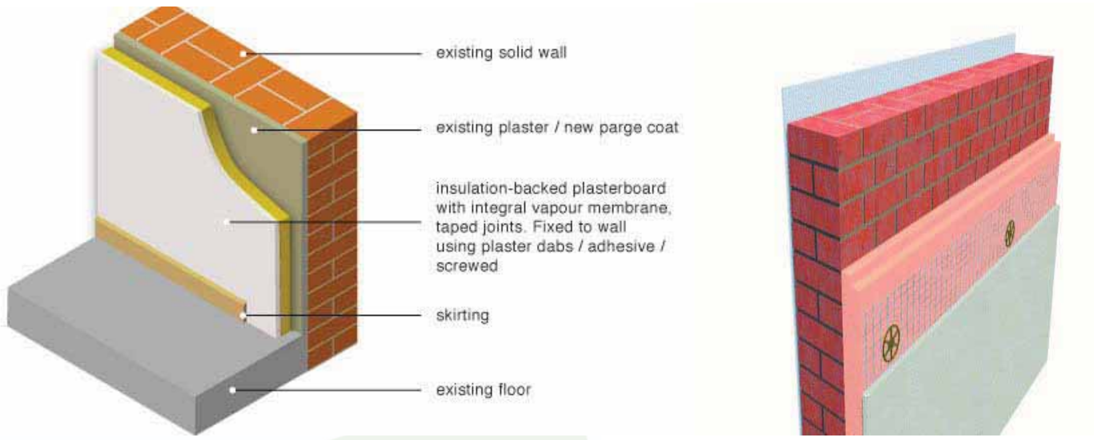


Fig. 21 Internal Wall Insulation (IWI) and External Wall Insulation (EWI)

Within each method, there is a wide range of materials and techniques that can be used. Again, they all have advantages and disadvantages.

9.2 INSULATION MATERIALS

Table 5 - Standard Insulation Materials

Fossil Fuel Based Products	Embodied Energy
Expanded Polystyrene (EPS)	High
Extruded Polystyrene (XPS)	High
Polyisocyanurate (PIR)	High
Phenolic Foam	High
Aerogel	High
Multi-foil	Med/High
Foam ‘Insulated Wallpaper’	High
Natural Products	Embodied Energy
Recycled Newspaper (Cellulose)	Low
Wood Fibre Board	Low
Wool from Recycled Glass	Medium
Sheep Wool	Low
Hemp-based	Low
Mineral Wool	Med

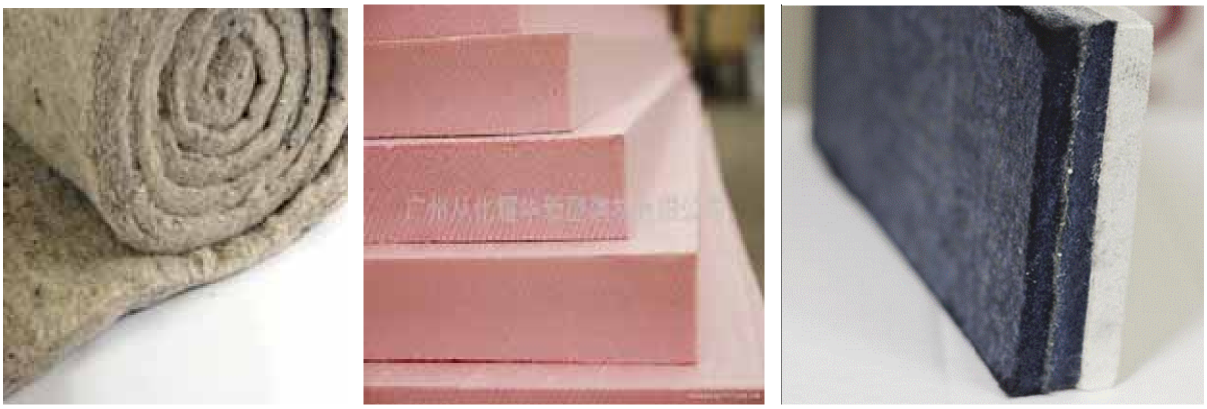


Fig. 22 Sheep's wool, extruded polystyrene and Aerogel

9.3 PERFORMANCE

All materials conduct heat, but some are much better at it than others: metals such as steel and aluminium conduct heat well, whereas wood and rubber are relatively poor conductors. This ability to transfer heat is known as Thermal Conductivity. Materials used for insulation ideally want as low a thermal conductivity as possible, meaning they resist the flow of heat through their structure. Air is a very poor thermal conductor and this attribute is put to good use in most insulation products, which trap pockets of air in a surrounding material.

The insulative capacities of building materials is measured using one of two linked values; The *R-value* or thermal resistivity and the U-value*,* or overall heat transfer coefficient. The *R-value* is calculated by measuring the rate of heat flow through a given area of material for a given temperature difference across the two faces. The usual standard is at a temperature gradient of 24 ^{o}C, at 50% humidity with no wind. The higher the *R-value* of a material, the better it is at resisting the flow of heat.

The *U-value* is most commonly used in the UK and is the figure used in Building Regs. It is simply the reciprocal of R, i.e. 1/R, which means that a low *U-value* indicates better performing insulation.

9.3.1 Thickness of Insulation Required

Table 6 – Required Depth of Insulation to Achieve U Value of 0.35 and 0.3 on Typical Solid Brick Wall

Insulation Material	**Thickness to Reach U = 0.35**	**Thickness to Reach U = 0.30**
Aerogel ™	27mm	32mm
Phenolic Foam	60mm	70mm
Polyisocyanurate (PIR)	65mm	75mm
Extruded Polystyrene (XPS)	80mm	95mm
Recycled newspaper (Cellulose)	100mm	115mm
Expanded Polystyrene (EPS)	100mm	115mm
Mineral Wool	100mm	115mm
Wood Fibre Board	105mm	125mm
Sheep wool	110mm	130mm
Hemp-based	110mm	130mm
Wool from Recycled Glass	115mm	135mm
Foam 'Insulated Wallpaper'	400mm	470mm
(Figures based on published figures for thermal conductivity		

We have already seen that installed insulation must perform as required by building regulations or better.

It is easy to understand that as we increase the depth of insulation that the installation will retain more heat. However, insulation materials perform differently from each other and therefore will need to be installed at different thickness to achieve the same level of heat retention.

It is important to recognise that there is a point beyond which it may not be economical to install a further depth of insulation. It will cost the client money to add the insulation, but the fuel saving may not mirror this cost. This is called 'diminishing returns'.

9.4 SECONDARY WORK AND OTHER TRADES

Installing solid wall insulation frequently involves the removal and subsequent refitting of services and decorative detail. It may be possible for the main contractor to deal with some of these, others will require specialist contractors.

9.4.1 Potential Trades Required

Both methods of solid wall insulation will frequently involve the moving and reinstatement of services such as electrics, plumbing and drainage. Where specialist skills are required, outside contractors will need to be brought in. The most likely trades are listed below, and this subject is discussed in more detail in Chapter 6.

Internal Wall Insulation

- Electrician
- Plumber
- Heating Engineer
- Carpenter
- Coving and Moulding Specialist

External Wall Insulation

- Roofer
- Plumber
- Electrician/Electrical Supplier
- Transco
- Groundworks – drainage and paving

10 Required Levels of Ground Floor Insulation

The levels of insulation ‘required’ in a floor are dependent on two factors:

1. An economic level of insulation to stem heat loss.
2. The minimum level of insulation set by UK building regulations.

More often than not, the minimum legal requirement set by Building Regulations is the greater driver for ground floors. Some clients may wish to go beyond this minimum level to save a greater amount of energy. The benefit of doing this is shown later.

10.1 FLOOR CONSTRUCTION

Construction methods have barely changed over the past decades, except for the gradual rise in u-values required for this element of the house over the years. Crudely, new houses therefore have more insulation in them than older houses and therefore will require less effort to insulate them. We can therefore use a strong rule of thumb that shows that depth of insulation is relative to heat loss in any UK home.

10.2 GENERAL DEPTH OF INSULATION REQUIRED

We have already discussed that installed insulation must perform as required by building regulations or better.

It is easy to understand that as we increase the depth of insulation that the installation will retain more heat. However, insulation materials perform differently from each other and therefore will need to be installed at different depths to achieve the same level of heat retention.

In general, recent research (George, Geens & Graham, BFF, Spring 2006) has shown that solid ground floor insulation as an addition to well-insulated walls and roof, contributes very little to the building's overall thermal performance. The designer should balance the extra benefit(s) attached to installing a new slab with the cost, marginal carbon gains and pragmatics involved.

Calculating the level of insulation in floors is relatively complex when considered alongside other building elements. The heat loss through a ground floor varies with its size and shape and UK Building Regulations require that ground floor U-values are calculated, in accordance with BS EN ISO 13370: 1998. The standard uses the ratio of the exposed floor perimeter to the floor area to take account of the variation in heat loss due to floor size and shape (P/A ratio).

The measurement of the perimeter (P) and area (A) should be to the finished inside surfaces of the perimeter walls that enclose the heated space (unheated spaces such as porches or integral garages should be excluded).

It is always best to use manufacturers tabular representation of U-Values to be sure that you are taking the correct approach. These can be referred through to Building Control officer in order to back-up any decisions made. The following tables are extracts from insulation manufacturers brochures.

Mineral wool roll with conductivity of 0.044 W/mK

Thickness (mm)	**Ratio of perimeter (m) to area (m2)**							
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
100	0.16	0.21	0.24	0.26				
150	0.13	0.17	0.19	0.20	0.21	0.22	0.22	0.23
200	0.12	0.15	0.16	0.17	0.17	0.18	0.18	0.18
250	0.10	0.13	0.14	0.14	0.15	0.15	0.15	0.15

Mineral wool slab with conductivity of 0.037 W/mK & 0.35 W/mK (140mm)**

Thickness (mm)	Ratio of perimeter (m) to area (m2)							
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
100	0.15	0.20	0.23	0.25	0.26			
150	0.13	0.17	0.19	0.20	0.21	0.21	0.22	0.22
200	0.11	0.14	0.15	0.16	0.17	0.17	0.17	0.18
250	0.10	0.12	0.13	0.14	0.14	0.14	0.14	0.15

Polyisocyanurate (PIR)

Thickness (mm)	Ratio of perimeter (m) to area (m2)							
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
75	0.16	0.21	0.24					
100	0.15	0.18	0.20	0.22	0.22	0.23	0.23	0.24
150	0.13	0.15	0.16	0.17	0.18	0.18	0.18	0.18
200	0.11	0.13	0.14	0.14	0.14	0.15	0.15	0.15

Extruded polystyrene (XPS)

Thickness (mm)	Ratio of perimeter (m) to area (m2)							
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
75	0.12	0.17	0.20	0.22	0.24	0.25	0.26	0.26
100	0.11	0.15	0.17	0.19	0.20	0.20	0.21	0.22
140	0.09	0.12	0.14	0.15	0.15	0.16	0.16	0.17
160	0.09	0.11	0.13	0.13	0.14	0.14	0.15	0.15

11 Reducing Demand for Mains Water

Two-thirds (66%) of our water comes from surface sources and a third from groundwater. Sources vary by region, and in London and the South East, groundwater accounts for around 70% of the total water supply.

Demands for water are continuing to rise and maintaining supplies to meet these demands is becoming increasingly difficult.

The water industry draws water from more than 1,500 boreholes, 650 reservoirs and at 600 river abstraction points.

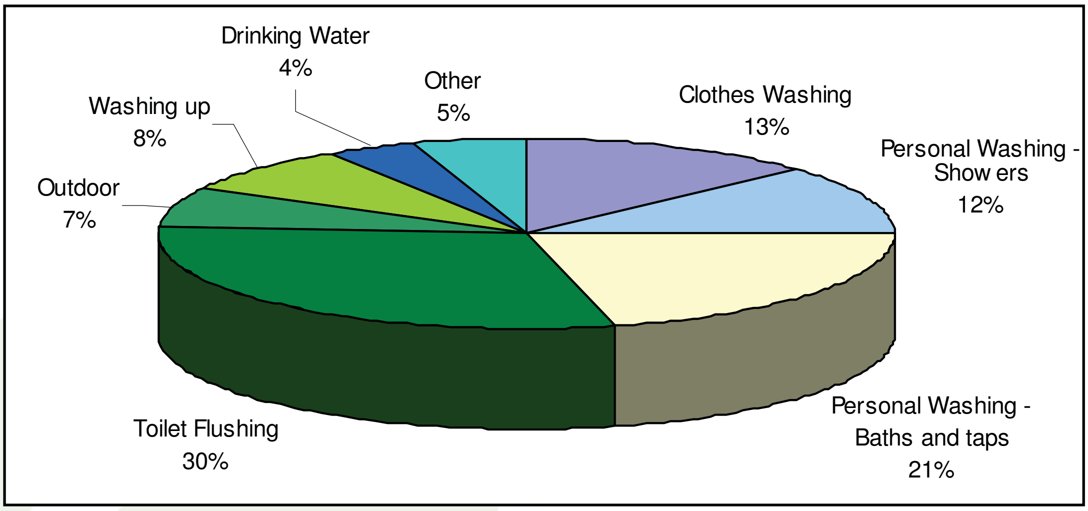
Over the past few years, several water suppliers have reported water deficiencies within their regions. With climate change comes more extreme weather conditions, with drought decreasing the amounts of water available, reducing its quality and increasing demand.

- National average use is 150 litres/head/day (l/h/d)
- Building Regulations - all new build property to be capable of using about 130l/h/d
- Voluntary Code for Sustainable Homes encourages developers to go to more stringent levels of between 120l/h/d and 80l/h/d (becomes mandatory in 2016)

11.1 CURRENT WATER USE

The UK has less available water per person than most other European countries. London is drier than Istanbul, and the SE has less water available per person than the Sudan. Water is scarce in parts of Scotland, Wales and N Ireland and England - large scale drought is already occurring in the UK, with the lowest rainfall, groundwater and reservoir levels for decades.

This chart shows the typical consumption of water for a UK home:



11.2 WATER DEMAND REDUCTION PROTOCOL

1. Reduce the need for water
    - Behaviour
    - Water efficiency measures
2. Seek Alternative Sources of Water

11.3 OPTIONS FOR DEMAND REDUCTION

Opportunites for reducing water consumption in use:

11.3.1 Toilets

30% of average use in UK. Older toilets can use 13 litres of water. Newer duel flush toilets use 6L then 4L for a half-flush

- If the toilet is pre 2001, installing a cistern displacement device (CDD) such as a 'Save a flush' bag or a Hippo. (Free from most water companies)
- (Remember, the bowl may not be fully suitable for the lower volume.)
- Newer dual flush toilets use 6L then 4L for a half-flush.
- The best on the market flush with 4L and 2L.
- Developments are working towards replacing some water with air.

11.3.2 Showers

12% of average use in UK homes. 20% of homes had showers in 1970's, 85% of homes have them now. Shower use affects energy use too – switch from one weekly bath to shower = £20

The trend towards power showers is having a huge impact.
Trend towards more time being spent in the shower.

- Tackling shower duration
  - Timers
- Shower heads:
  - Aerated - 60% reduction
  - Low-flow – 80% reduction

11.3.3 Baths and Sinks

21% of average use. This is driven by lifestyle

Do you leave taps running?

- Washing up
- Cleaning teeth

Options:

- Switch from baths to showers
- Smaller baths
- Tap aerator kits
- Change taps
- Flow restrictors

11.3.4 Washing Dishes

8-14% of average use in UK. It is imprtant to remember that taps are outputting in volume – not just on/off. Washing up with a bowl rather than a tap running reduces demand by 50%.
Dishwashers can use less water than a bowl full; 1970's – 50L; Now – down to 10L

11.3.5 Washing Clothes

15% of average use in the UK.
Usually 50L per wash with the worst use 20L per kg of clothes.

Best use on the market is 7.5L per kg of clothes.

11.3.6 The Garden

7% of average use in the UK with summer rising to over 50% of demand. Sprinklers can use 1,000L per hour!

Choose plants that need less water. This is called Xeriscaping and Xerogardening and plants such as Lavender, Juniper and Sedum can work very well.

Collect rainwater for use – this is better for the plants too!



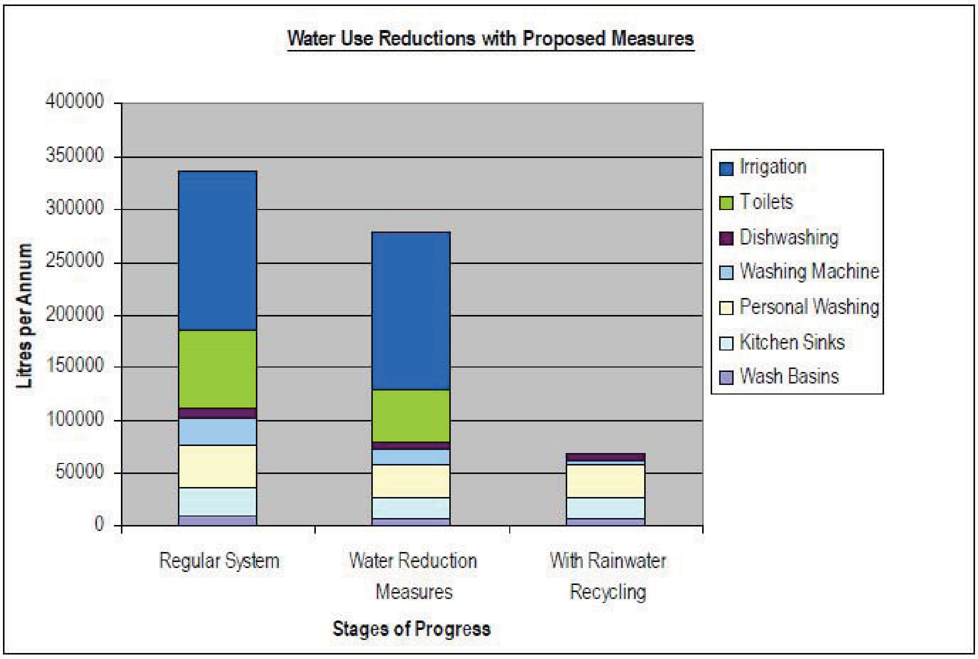

11.4 ALTERNATIVE SOURCES OF WATER

11.4.1 Rainwater

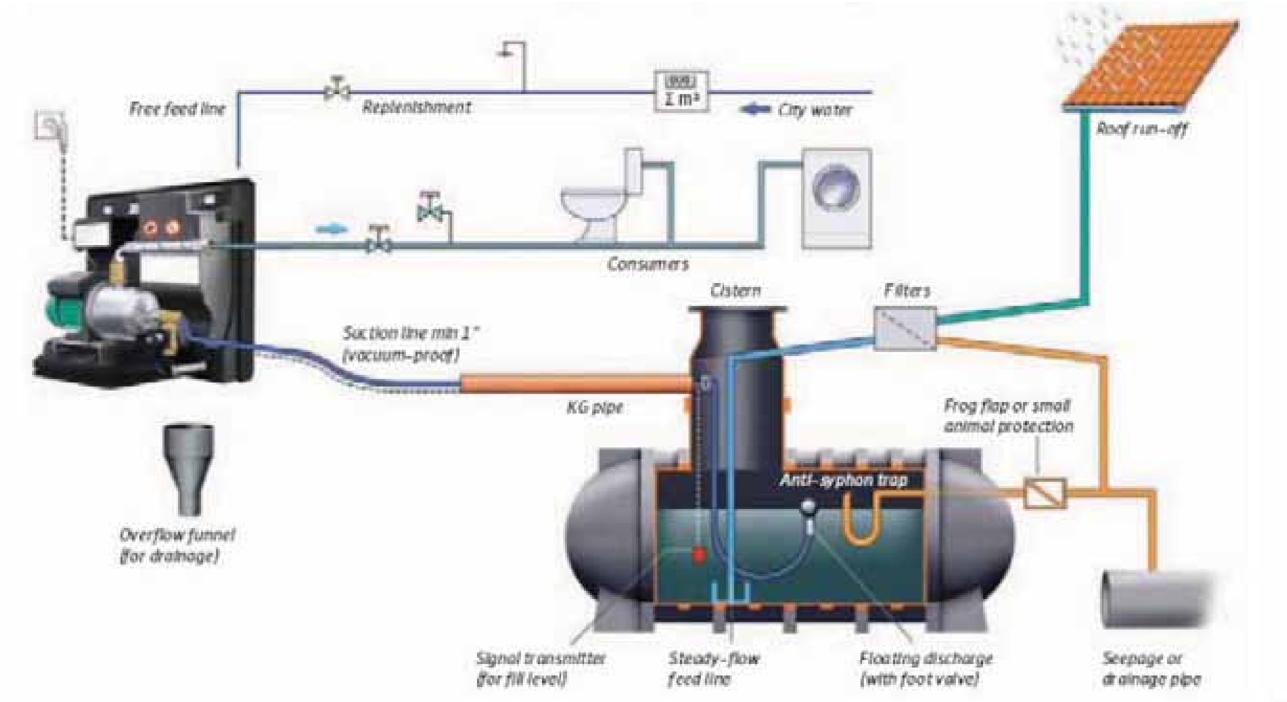
This is the collection and storage of rainwater for use in the home and garden. The use of rainwater is tightly restricted by the 1999 Water Regulations. It can only be applied in the following places:

- The garden
- Toilets
- Washing machines

Example of calculation for a large house:



	Regular System	Water Reduction Measures	With Rainwater Recycling
Litres p.a	336150	278969	68001
% Concumption of Original		83%	20%



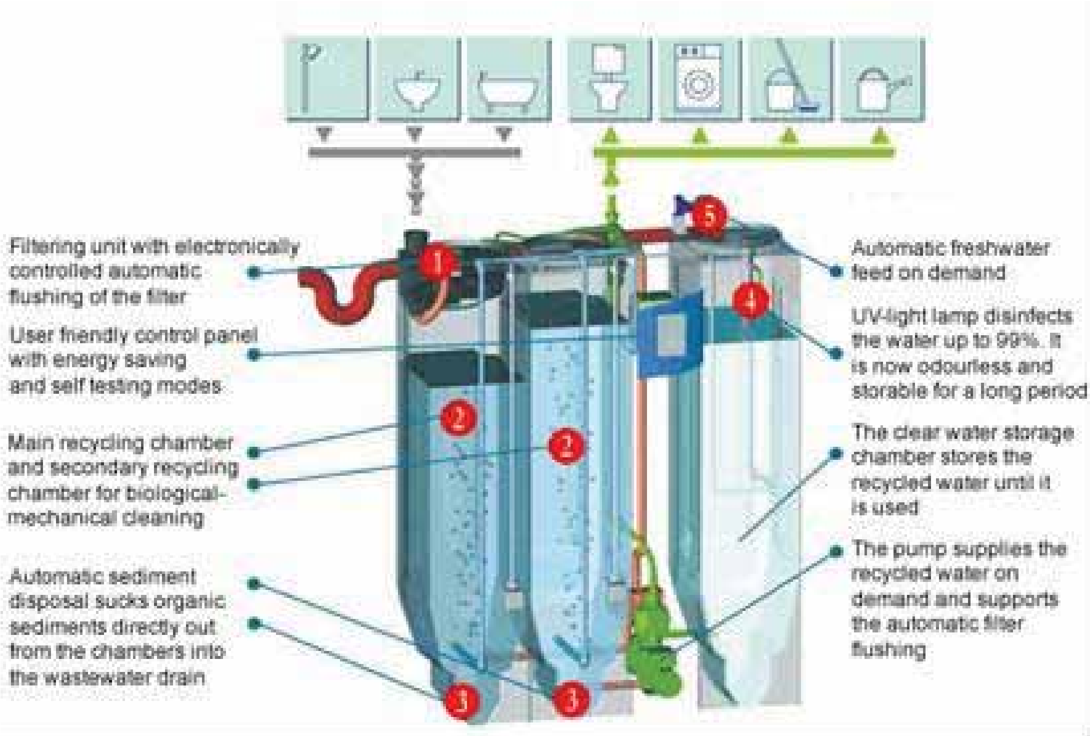
The payback of this system is calculated as follows:

Initial Payout –	**£7,500**
Water Saved per Year -	**150m^3**
Utility Bill Savings of System at Current Water Rates -	**£289.00**
Payback of System at Current Water Rates -	**39 years**
Payback of System at 5% inflation –	**22 years**
Payback of System at 10% inflation -	**17 years**

11.4.2 Grey Water

Grey water is that which is drained from sinks, baths and showers. It can be stored for a short period and used on the garden. Detergents are nullified by reaction with dirt etc.

For it to be used inside the house it must be fully treated to the standards offered by sewage treatment works.



Systems such as this will cost £3200 per dwelling.

11.5 USEFUL ORGANISATIONS

- Waterwise
- UK NGO focused on decreasing water consumption in the UK and building the evidence base for large scale water efficiency.
- Energy Saving Trust
- Kent County Council
- You local Water Company

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