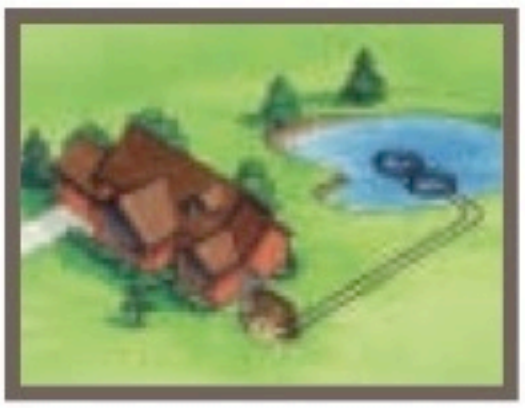
YOUR GUIDE TO

RENEWABLE ENERGY HOME HEATING



Action Renewables
the future of energy, today

Who are Action Renewables?

Action Renewables is supported in Northern Ireland by the Department of Enterprise, Trade and Investment (DETI) and was established in July 2003. It was created in response to European, National and Northern Ireland Government commitment to renewable power as one strand of the policy to combat climate change and environmental pollution and to increase fuel diversity.

The last few years have seen a growing pressure to change the way we generate our electricity. As of 1st April 2005, in Northern Ireland we have new legislation, a Renewables Obligation on electricity supply companies, which requires them to source 6.3% of the electricity they supply to NI customers, from renewable sources, by 2012. The abundance of renewable resource has encouraged DETI to set an aspirational target to provide 12% of the electricity supplied from renewable sources by 2012.

Energy use in buildings, providing services such as water and space heating and lighting, equates to around 50% of Northern Irelands CO_2 emissions. This can be reduced through installing renewable energy sources as a means of providing heat or power e.g. photovoltaic panels and wind turbines.

Action Renewables aims to raise awareness of the issues associated with the use of fossil fuels, the threat of climate change and depletion of our resources and the security of our energy supply. Our key objective is to promote the use of renewable energy for a greener more sustainable future. More and more people in Northern Ireland are choosing renewable energy. Read this leaflet to find out how you can use renewable energy in your own home.

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Presenting the practical side of GSHPs

When it comes to renewable energy heating options for the domestic market, Geothermal energy delivered through ground source heat pumps (GSHP) is fast becoming the homeowners a popular solution. The number of GSHP system installations are moving at a fast pace, offering a wide choice of technology and design solutions for householders needs.

These summary guidelines are provided to answer some of the most asked questions about GSHP systems and to assist homeowners to decide what system is right for them.

Why Install a GSHP?

Why not — the evidence is convincing.

Ask anyone who has had a **well designed** ground source heat pump system **properly installed** in a properly **insulated house** and their enthusiasm will convince you on comfort, cost, and overall satisfaction. GSHPs use tried and tested technlologies – a heat pump is effectively a refrigerator in reverse – the details of the system design and how it is applied to each householder's particular heating requirement will ensure that geothermal energy technology is the most cost effective solution. It is therefore important that potential GSHP users understand the basics of these systems and what influences the design specifications.

So what is a **well designed, properly installed** GSHP system and what do you need to know about the **building options** that are suitable for the best use of this heating source?

Preparation for ground loop

Cost and Efficiency

The GSHP system has heating efficiencies about 60% higher than other heating systems. This makes it one of the most efficient residential heating systems available today and this shows directly as savings on heating bills.

Savings / Costs:

GSHPs save money, both in operating costs and maintenance costs. Not only can investments be recouped through saving on heating costs there is the added advantage of security of supply from your own geothermal energy source. Typical payback on your investment is within 5-7 years.

Although the initial investment for a GSHP system may be higher than for other systems, when you consider the lower operating costs, security of supply and other energy savings, they more that justify the initial outlay costs.

Ask your installer to produce a detailed design and cost estimate of the system so that you can fully assess the merits of installing a GSHP heating.

Co-efficient of performance (COP) and CO_2 savings

A measure of the productiveness of the GSHP is the co-efficient of performance (COP) and essentially the higher the figure the better. The COP is the ratio between the energy required to run the system and the output of the system. When a GHSP system operates at a COP of 3 it means that for every unit of electricity used to run the heat pump you get 3 units of heat equivalent back. COP values of 3-4 are normal for most efficient systems, the recommended lowest value is 2.5. The higher the COP the more efficient the system. Figure 1 below shows how the COP of a system increases, depending on the ground temperature which warms the circulation fluid.

Figure 1:

Ground Temperature °C	COP of an average system
1	3.5
7.5	4
15	4.5

Therefore though heat-pumps can operate down to very low temperatures the efficiency of the system rapidly decreases at these temperatures. This can be offset by using different circulation fluids but it is recommended that source temperatures are kept as high as possible to maximise the system efficiency.

Percentage reductions in CO_2 emissions are usually around 45% for GSHP units as compared with conventional oil or gas boilers.

Another option is that another renewable energy source is used for the generation of the electricity for running the heat pump such as wind or micro-hydro power. Research is currently ongoing in these areas and there have been some small demonstration projects in this area. This option requires a specifically experienced designer and installer and is not yet widely available.

Some companies recommend installing a solar panel for hot water to achieve sufficiently high water temperatures and using the GSHP to supply the heat the water for the under-floor heating only and not the tap water. Each design must be uniquely tailored to the usage requirements and size and design of the house being considered. One problem here is that you may find that the information given by different companies is different depending on what systems they are selling and how these systems can be adapted to the needs. Another factor to consider with a suitable qualified designer, is the potential for the inclusion of additional renewable energy sources in the design options.

Image of a typical heatpump-in-situ

Lifestyle Choice - Comfort

Our maritime climate brings moisture laden winds, which makes the air feel colder on contact, but to which under-floor heating is particularly well suited. This is by virtue of the fact that it heats from the floor upwards, where it is most needed, providing a more comfortable and even heat distribution. Heat is not wasted on the roof space and rising damp is counteracted. Therefore, rather than GSHP being just a choice for the energy conscious and having economic advantages, it offers a potentially better solution to our particular climatic conditions and provides the potential to improve our quality of life.

Nowadays buildings are well insulated and when under-floor heating is used – the head remains cool while the feet stay warm. With conventional central heating, the majority of heat is convected air which rises, making the ceiling one of the warmest places in the room. However, 50% of warmth generated by under-floor heating is radiant heat, where the floor evenly releases heat, which is absorbed by people and objects in the room. With under-floor heating, the room thermostat can actually be set 2–3°C lower than a room heated by radiators and most people find 19-20°C a comfortable and pleasant living environment.

Safety

Ground source heat pump systems are safe and with no exposed equipment outdoors, children or pets cannot injure themselves or damage exterior units. GSHPs have no open flame, flammable fuel or potentially dangerous fuel storage tanks. It is also worth noting that GSHP units are quiet, providing a pleasant environment inside & outside of the home.

Visual Impact, Building Options and Materials

Most of a GSHP installation is underground. Inside the house, the heat pump units are about the same size as a traditional heating unit. The apparent invisibility of GSHPs makes for difficult advertising but pleasing appearance compared with conventional oil/gas tanks, large boilers and radiators. Modern building styles and methods make a good match for this advanced technology. Under-floor heating replaces the need for radiators, thereby freeing up wall-space and leaving the architect more freedom in the placing of doors, windows etc.

Though the idea of tile or stone floors does not often appeal to a home owner in this climate, it creates a surprisingly comfortable home environment, changing the ambiance created by a similar floor if it is not heated. It is pleasant for walking in bare feet and a clean warm surface for children to play on.

For an average home, the laying of the collector and the heat pump installation takes 4-6 months from the initial survey, with 3-4 site days required. Installation is less disruptive when undertaken during building construction. Borehole installation times vary with conditions on site such as the type and depth of overburden, type and hardness of bedrock, and the presence of aquifers. Typical drilling times are one or two days but total installation can usually be completed in two days.

Collector site preparation

Heat Pump set-up

Aim to ensure that under-floor heating pipe-work is laid immediately before the floor screed or final floor covering goes down. This will minimise any potential damage caused by people walking on it. Also, plan for the site to be clear of other workmen when the system is being installed, as access to the whole floor area will be required.

Once in place and tested by the installer, underfloor heating systems require less maintenance than conventional heating systems. Unlike radiators, underfloor heating systems do not have individual valves in each room and therefore there are less components that can potentially fail. Similarly, underfloor heating systems do not have to be bled on a yearly basis.

Heat Pumps are durable and highly reliable. Heat Pump systems contain fewer mechanical components than conventional systems, and all components are either buried in the ground or located inside the home, which protects them from outside conditions. The underground pipe carries a warranty of over 20 years.

The GSHP and most of its associated components (underfloor heating and electric

controls etc.) generally use off-the-shelf materials as the basic materials are the same as for a conventional heating system. Some of the additional materials required are conductive cements and thermally tolerant cements. In addition tiled floors may have to be more widely used for the underfloor heating. The construction methods require no special tools which are not available to most contractors.

Nearly all GSHP system manufacturers offer a warranty for major components that is equivalent to the warranties for conventional heating and cooling systems. Ground loop, plastic pipe manufacturers warrant their products for over 20 years.

Research has shown that ground loops have no adverse effects on grass, trees, or shrubs. However areas should be kept clear of deep rooting trees and natural percolation of rainwater should take place at all times. Vertical loops require little space and do not damage lawns significantly.

Under-floor Heating

Under-floor heating is generally recommended as the most efficient mode of heat transfer from a heat pump system, though modern radiators can also be accommodated. Upstairs rooms can also be facilitated through the use of thermally efficient flooring or the system can be used in a combination of under-floor and/or radiator systems. Under-floor heating systems operate at lower temperatures than radiator systems using the floor as a store of heat that emits slowly over the day. Under-floor heating can be installed in new constructions or as retrofit. Care must be taken in the plans for retrofit as the under-floor heating pipe-work ensemble can be 8 – 10cm thick.

The system is laid down as a series of pipes on an insulated base covering at intervals, covering the floor area of each room as required, these pipes are cemented in place with thermally conductive and resistant cement and covered with wood flooring, tiles and carpet in some cases. Obviously the thermal insulating properties of the floor cover are important for the efficiency of the system in transferring the heat so this should be discussed with your installer/designer and input into the calculations for sizing etc. Ask your installer for detailed costings.

There are many issues which should be addressed by your installer in correctly

fitting under-floor heating and with all other aspects of the design and planning sit down and agree the logic and choices made at all points in the construction. Remember that the long term heating of the floor will have implications for the types of adhesives and cements used and allowances must be made for expansion of the material due to the heating.

If installing an under-floor system with wood, laminated or engineered wood floors, the moisture content of the flooring needs to be considered as there may be extreme drying of the wood when the system ins switched on during the winter months. This will depend on the type of wood or other similar material. Hard woods are more adaptable than soft woods but again the details should be discussed with your installer. Some suppliers recommend that the moisture content of the wood is about 7%.

To ensure maximum efficiency it is vital to insulate beneath the under-floor heating system. This prevents downward heat loss and reduces heat-up times.

Optimising GSHP, After Installation - Usage

The key to optimizing the efficiency and comfort advantages of a GSHP system is the proper matching of the needs of the householder with the type of system installed. Partnering of GSHP with other green energy sources can give added advantages and can be an option to discuss with your designer or installer.

A key component in the process of the installation and running of a GSHP system is the owner usage guideline given by the designer/installer to the person who will run the system. Best practice requires that the designer/installer monitor the system a number of times over the course of the first year of life of the system. This is in order to get a picture of how the system is behaving over a full season cycle – both in terms of fine adjustment of the controls to achieve best efficiency, and also in to test how the source behaves and to determin its optimum operation for the required use.

The heat pump unit needs to be housed in a weather-proofed area. While in operation, the heat pump system is generally inaudible outside the room. Once installed and checked the unit is virtually maintenance free. If just used for heating it will be turned off during the summer. It is recommended that a one year follow-up visit is built into any installation contract to deal with settling in problems. Maintenance once a year requires a check of the refrigerant and circuit as well as normal running current. 45ºC is the maximum running temperature advised for the thermostat with most residential heat-pumps. Where the thermostat is set higher on a continuous basis, the result is inefficient operation and overcooling of the collector area leading to an extended shutdown period to allow the collector area to return to normal temperatures. It is worth noting that the concrete limit temperature is 45º C and above this there is a likelihood of shrinkage cracks. However when the system is properly designed there is no need to set the temperature higher than this level.

Heat control

Unlike conventional radiator systems, each room with under-floor heating is able to have its own thermostat which can be controlled independently, thus saving energy and money on running costs. As standard in GSHP systems the water temperature flowing in the floor is set and adjusted by the end user to suit requirements, but can be coupled with individual room thermostats. Temperatures of the heating fluid are typically adjusted between 35-40°C in spring and autumn to 45°C in winter.

A weather compensation control can be incorporated into the system in which the temperature of the heating fluid is automatically adjusted to suit the conditions. Time and temperature settings can be programmed and little further input is required by the homeowner. The floor warming system will operate at optimum efficiency within the programmed inputs, providing the best possible comfort level at the lowest running costs

Homeowner Checklist

Summary of GSHP Installation process for Homeowners - The following list is provided as a quick reference for the important issues for the homeowner in considering and installing a GSHP system – tick the box when the issue has been considered and/or dealt with by the designer, installer, service provider or yourself.

GSHP Source options checklist

Ground source Loop			Stream source			Soil type check	
Ground source Slinky			Pond source			Rock type check	
Borehole Open			Combinations			Groundwater check	
Borehole Closed						Cost comparisons	

Technology options checklist

Heat pump quality mark			Installer certification			Sizing Calculation	
Designer qualification			Refrigerant specification			Cost comparisons	
Heat Loss calc. winter			Heat loss calc. summer				

Materials options checklist

Insulation - Walls			Window quality			Underfloor heating	
Insulation – Roof			Air tightness			Radiators	
Flooring appropriate			Thermal bridging			Combination system	

GSHP Optimising Checklist

Heat Load Calculation			Ground Temperature			Ground Water Temp	
Cooling Load Calculation						Design COP calculation	

Usage Checklist

Training in usage			1 year data analysis			Actual COP	
Post installation visits			Insurance				

The GSHP System – Some Technical Background

The GSHP system is made up of three main design components: A) The geothermal or heat source, B) The heat pump and C) The heat delivery system. These and other aspects of the systems are detailed below.

Geothermal source options and availability

Northern Ireland is regarded as being very suitable for GSHPs since the ground temperature a metre below the surface is relatively high (even in places such as Sweden, where the ground is extremely very cold in winter, these systems are very popular). With our Atlantic weather the ground moisture content is good, and across Ireland temperatures are as high as 8°–11°C. A closed-loop heat pump system contains a water and glycol antifreeze / refrigerant (non CFC) mix. The different alternatives for collecting the heat from the ground are detailed below.

Horizontal closed-loop collectors

This is the most common type of GSHP system installed in Northern Ireland where the closed-loop collection system is usually buried in soil, though it can also be deployed in surface water sources. In these systems a closed circuit of pipes contains a collector fluid which is warmed to the ambient temperature of the ground (or water) and it is then circulated through a heat pump where the heat is extracted. These types of collectors can be laid as Horizontal Loops or as vertical or horizontal 'Slinky' coil systems. Irish rural conditions have proved to be ideal for this method, since there is usually plenty of room for the collector to be laid out.

As a rough rule of thumb, the ground area required for the collector is at least the size of the floor area of the house or building to be heated. For a 'slinky' system trenches are spaced about 1.5 metres apart while boreholes are spaced about 4 metres apart. Although surface water in Ireland is very abundant in lakes, rivers and estuaries, exploitation with horizontal closed-loop collectors is not common. Streams or lakes have been used successfully for coupling with a heat exchanger and heating system and have the advantage of ease of access but a constant flow of water is essential to ensure constant recharge of the heat.

It is also possible to place a heat collector in the outflow of domestic or other waste-water with an enhanced temperature profile. However domestic grey water is not usually used due to the grease and sludge problem, unless it has been filtered through a puraflow system. These systems can return up to 25% of the energy required to heat the water.

Soil types

In the case of a ground source heat pump system the type of soil in which the collector is placed can have an effect on the efficiency of the system. Moisture in the soil is the main means of heat transfer in this medium and therefore the ability

of the soil to hold moisture controls its heat recharge ability and therefore the amount of heat that is available on an ongoing basis for the collector and therefore the heat pump. During winter, at times of maximum usage, in our climate there is generally plenty of water recharge and the soil can replace the lost heat through seepage of rain and runoff. If the system is being used for cooling it may be necessary for the addition of a groundwater borehole in order to access a more stable source of cooling in summer time. It is recommended that soils in which collector pipes are laid for GSHPs are well drained thick soils so that the collector can be placed at a minimum depth of 80cm to a maximum of 150cm. In thicker soils and special conditions it is possible to have a 2 tiered system with collectors at around 80cm and 200cm. Boggy ground is not a good option for a GSHP as there may be poor flow of water and therefore no recharge of heat in winter and drying out in summer. At the other end of the scale very sandy soil is also not recommended as it will not hold moisture long enough and may even be dry in winter. The suitability of the soil type and thickness in your garden should be discussed with your system designer in advance of any plans.

Vertical borehole closed-loop collectors

In these closed-loop systems a collector fluid is circulated through a tube in the borehole to pick up the ground heat and then through the heat pump. There is no exchange of fluid with the groundwater.

These collectors are placed in boreholes to a maximum depth of 150m. These are commonly used in Sweden and Switzerland where there is very little space and flat ground in which to place a horizontal collector. They are an option in the Irish situation where there insufficient space such as in urban areas, e.g. the Randalstown Health Centre, Co. Antrim. They are not the preferred option in Ireland since they cost more to install and, if they are not properly planned, they can result in over-cooling of the ground around the borehole, to a point where it is very difficult to replace the lost heat.

Shallow borehole source (open loop) heat pumps

Groundwater, utilised as a heat pump source, is accessed by a borehole in much the same way as for normal water supplies. Shallow boreholes with open-loop heat pump sources are a quite common form of larger scale geothermal installation in Ireland. The depth of boreholes is usually between 20m and 50m and they are located in areas with locally enhanced groundwater temperatures or warm springs as in Greece. Shallow aquifers are also used when they can utilises a groundwater karst aquifer. At the UCC Glucksman Art Gallery, drilling into a shallow gravel aquifer produced such high volumes of water at around 12.5 - 13ºC that 30% of the heating and cooling of the gallery is be provided with an open-loop, heat pump system.

Horizontal versus vertical closed collectors

Horizontal installations are simpler, requiring lower-cost equipment. However, they require longer lengths of pipe due to seasonal variations in soil temperature and moisture content and therefore a larger area. Where land is limited, vertical installations or a compact Slinky™ horizontal installation can be ideal. If regional

soil conditions include extensive hard rock, a vertical installation may be the only available choice. Vertical installations tend to be more expensive due to the increased cost of drilling versus trenching, but since the heat collector is buried deeper than with a horizontal system, vertical systems are usually more efficient and use less total pipe. Your GSHP contractor will be able to help you decide which configuration best meets your specific needs.

GSHP Technology Choices – The Heat Pump

GSHP technology is based on the same principles as the average household refrigerator and is known by many other names, such as geothermal, ground-coupled, borehole heat exchangers or GeoExchange systems. The heat pump itself will generally be a well known make and if not, then ask for the certification specifications of the unit and ensure it is certified – the main heat pump certifications which are in use in Europe are the following;

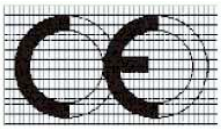
QUALITY CERTIFICATION MARKS

Eurovent Europe

Promotolec Europe

P Mark Sweden

D-A-CH Germany Austria Switzerland



CE Mark Europe

Currently there are many different models of heat pump systems being installed in Northern Ireland by a wide range of different companies who offer a range of solutions. These vary from off the shelf designs to unique renewable solutions for GSHP alone or in combination with other renewables. Though these companies are mostly providing quality products with tried and tested technology, heat pump system design and installation is complex, requiring a broad understanding of issues such as sizing and load calculations and sometimes unique solutions. It is important therefore during the design phase, that the homeowner enquires as to the technical skill qualifications of the designers and installers and request information on previously installed systems. As yet there is no standard certification of designers but installers should be able to demonstrate that they have completed the heat Pumps Installers Training course run by the REIA (Renewable Energy Installers Academy) or the Low Carbons Building Programme (LCBP) regulation UK.

Modern domestic sized heat pump

Residential heat pumps design for installation

The amount of data available on the internet about heat pumps is quite large.
The following is a simple guideline to the points which need to be considered for heat pump installation

Assessing the size of the heat pump required

This is very important and is based on these three factors:

Cost – The larger the Heat pump the more expensive it will be. If it is too big, it will cost too much and will not be fully used. If the heat pump is too small for the heating load it will operate too frequently and supplemental heat will be needed and increase the electric bill. There is also a danger of over-running the system and damaging either the system or the collection area.

Long-lasting – Equipment suffers most wear and tear when it is started up, anything that makes it switch off and on repeately will hasten this. Getting the size right is important to avoid it.

Efficiency – Since this initial part of the operating cycle is less efficient than when it is running smoothly, if it switches on and off too often efficiency is diminished by not getting the sizing right.

Load calculations

The heating and cooling loads must be calculated properly so that the correct equipment can be selected. These loads are based on the following factors:

- The measurements of floors, walls, windows, doors and ceilings.
- Their energy efficiency, e.g. attic insulation, wall lining, double/triple glazed windows, thermal bridging, air tightness, etc.

Weather effects

The contractor must CALCULATE the heating and cooling loads, they must not be estimated. They should be determined for a normal cold winter day and a normal hot summer day. This can be done in a number of ways.
Only the heat load calculation needs to be done if the heat pump is to be used for heating only.

Load calculation methods

A perusal of the results from a Google search will show a number of proprietary ways of calculating loads. Most contractors will use a form supplied by their equipment manufacturer and these are generally reliable.

For example: a 15.5kW output heat pump, which is the average size of heat pump for a dwelling house requires a 3.5kW pump.

U values, Insulation and Heat Loss Calculation

U values measure heat flow through materials. High U-values indicate high heat loss. Values vary for each material and construction method used, the following table gives general figures for some common modes of construction. Values can be quoted in Imperial units (BTU/hr, ft_2, °F) or Metric (SI) units (W/m2, °C). These values are used to help in the calculation of the heat loss from the building.

Whether in new-build or retrofit, plans for construction should look at the options for maximizing the insulation of the building prior to consideration of the installation of a heat pump system. Ground source heat pump systems will reduce your heating and cooling costs regardless of how well your home is insulated. However, insulation is a key factor in gaining the maximum amount of savings from any type of heating and cooling system. A well insulated house in the Irish temperate climate actually needs a very low heat load compared with our continental neighbours and efforts at the planning and design stage should prioritise the best insulation affordable as an essential component of the design. The preference for the installation of a GSHP is a purpose built construction with modern insulation standards. If retro-fitting a GSHP system, insulation and windows should be checked and renewed where necessary to reduce the air leakage from the building and therefore the winter heating requirements.

An energy audit of your home can be carried out by a specialist prior to specification of insulation requirements. These calculations should be done in the initial stages of design so that the required source collector, heat pump and heat distribution capacity can be accurately calculated. A heat loss calculation needs to be carried out by a suitably qualified installer.

A large heat pump room

Further Reading

Many GSHP system designers and installers are available in your local listings. For independent information on GSHP systems please check / visit the following websites.

Action Renewables
www.actionrenewables.org

UK Heat Pump Network
http://www.heatpumpnet.org.uk

Ground Source Heat Pump Association
http://www.nef.org.uk/gshp/

European Heat Pump Network
http://www.ehpa.org

Centre for Alternative Technology
http://www.cat.org.uk

Sustainable Energy Ireland
http://www.sei.ie/uploadedfiles/RenewableEnergy/AbuyersguidetoHP20604.pdf

The Heat Pump Centre of the International Energy Agency
http://www..heatpumpcentre.org

The Geothermal Heat Pump Consortium (USA)
http://www.geoexchange.org

Ground Source Heat Pump Information Centre
http://www.virtualpet.com/portals/okenergy/gshp.htm

Green & Easy, Simple steps to greener living
http://www.greenandeasy.co.uk/information.php?info_id_sent=99&cat_id_sent=14

Notes

Action Renewables
the future of energy, today

Useful Contacts for Further Information

For information on renewable energy in the home
Action Renewables
www.actionrenewables.org

Action Renewables Advisory Service
Freephone 0808 141 2020

For information on Renewable Energy Grants
Action Renewables
www.actionrenewables.org

Reconnect household grants
www.reconnect.org.uk
Freephone 0800 023 4077

For information on Building Control
www.actionrenewables.org/bcontrol.htm
www.buildingcontrol-ni.com

For information on Planning Permission
www.actionrenewables.org/planning.htm
www.planningni.gov.uk

For information on Energy Efficient measures
Energy Saving Trust
www.est.org

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