Saving humanity: an eco house

Introduction

It's crunch time! We must use less of everything, including energy. It might be too late to stabilise the climate. Let's hope not, but the signs don't look good, especially as those who depend on fossil fuels for their vast wealth seem still to be in charge.

In the meantime what can we all do to help? One major source of climate change pollution in temperate and cold countries is home heating. In the UK there are about 22 million gas and just over 1 million, mostly rural, oil boilers that together produce about 14% of the country's CO_2. This compares with road transport's 24% (Department of Transport data 2020).

I have three long-term goals:

- To live comfortably in a warm house at between 21 and 22°C
- To produce no greenhouse gases from my heating
- To save money

The problem is that using less fossil-fuel energy for home heating is neither simple nor cheap. The average house uses perhaps £2 – 4k of energy a year. As you will see below, the cost of changing to new heating will be between £10k and perhaps £50k. Even if your bills became zero such systems will take a long time to pay for themselves, if ever. Bills will fall but usually not to zero.

What then is a government to do to get us to change? Bribe us or force us, that's what. The bribes have started, and stopped again in the past. Bribes are expensive when many people are involved. So the Law will have to step in. At some point fossil fuel boilers will have to be made illegal. Will they have the guts to do that?

Like most of us I want to do my bit to help. This study started out as small bit of research to help me decide what to do about my own heating as my old boiler needed to be replaced. It has turned into a substantial, and for me fascinating, survey of the whole field.

The first step must ALWAYS be insulation

So what is the optimum route for you to save money and pollution and still stay warm? It is most useful to think about an average, existing house without huge windows and having two external doors. Each of the following steps will give an improvement, with the early ones giving most cost effective saving, at the least cost.

- Fit foam around ill-fitting windows and outside doors.
- Get your gas or oil boiler serviced if not done annually.
- Insulate your loft with fibreglass.
- If you have cavity walls get them insulated.

- Replace windows with up-to-date double or triple glazing, especially if they are large. You can do a few at a time, perhaps one wall first then others later.
- Replace external doors.
- If the walls have no cavity then start saving to have internal or external cladding. You could just store away the drops in your bills from the above steps.

The message is **insulate, insulate, insulate.** That will keep you warmer and save you money at modest cost. Stay in touch with how heat pumps develop (perhaps here) and start saving to install one when they have matured. You can build up quite a fund in ten years!

For an average size house:

1. Roofs can be insulated quickly and cheaply with glass fibre in the loft. The cost is a few £100. Don’t use sprayed foam under the roofing felt, which must be allowed to breathe.
2. Windows and outside doors cost more – about £500 a window and £1000 a door.
3. Wall insulation is quite cheap if it is a cavity wall – probably £1000 or less.
4. If there is no wall cavity, thin internal cladding and plasterboard can be used if you can afford to lose a few centimetres off your room sizes. Cost varies but a few thousand is likely.
5. If there is no cavity and rooms are small, cladding has to be fixed to the outside of the house. It is more expensive, though it also modernises the appearance of your house. Cost varies, but a guide is about £100 per square metre. This makes the range from £6 000 for a small terraced house to £20 000 for a large detached one.
6. Floor insulation is really only practicable when houses are new or being totally renovated. It saves the least energy.

What is stupid is that we have a government that keeps changing the rules about grants. What householders and industry need is proposals for grants and timetables that do not change. Although more is better, it doesn’t matter so much how much grant is given, but it must not change on a whim as a political (spit) tactic. No-one sensible is going to spend many thousands when uncertain whether by waiting he or she would have received more help next year. It happened for heat pumps in 2023 when the grant arbitrarily increased by 50%. And the proposed end for oil boilers was delayed from the ridiculous 2026, or possibly for ever if a country house was ‘unsuitable’ for a heat pump.

A word of warning for UK insulators

The UK, and especially England, is obsessed with the past. Many of our houses are old and some are protected against change by being ‘listed’ or are in ‘conservation areas’. No-one wants to see beautiful buildings made ugly but most of the houses are not beautiful, just old. There are reports that some local government committees in charge of ‘planning consent’ are refusing approval to external changes such as solar panels, cladding or new windows. Presumably, rather than letting them be modernised, they are happy to see houses washed away by rising seas, or owners forced to choose between heating and eating. The past is gone. Start thinking about the future – yours and everyone else's.

The kilowatt-hour (kWh)

A kilowatt-hour (kWh) is a measure of energy. It is a kilowatt used for one hour or two kilowatts used for half an hour, etc. The scientific unit of energy is the joule (J), but because our houses and vehicles use so much energy the numbers become silly. 1 kWh is 3.6 million joules. Its use started for electricity but it is now a standard across all energy supplies so you should be able to compare electricity, oil and gas consumption using the same unit. However in the ridiculously chaotic, 'competitive', UK 'market' that the government set up there are no standards for how customers are informed.

A regular check on your daily energy use will show you the effect of the insulation that you fit. Most energy suppliers enable you to do this on their website in some way, if only once a month or quarter. Anyone designing a new system for you will also need that number.

How many kWh do you use for heating and why do you need to know?

If your supplier doesn't provide any useful website information then:

- If you use gas, look at your bill. It might tell you how many kWh you use in a year. If it uses therms multiply the number of therms by 30 to give kWh.
- If you use kerosene oil, find out how many litres you use in a year and multiply by 10 to give kWh. It pays to keep a record of deliveries and oil tank gauge readings.
- If you use wood you are pretty much on your own, but see the section on biomass, giving a rough value of 4 kWh/kg. You'd have to weigh the logs as you carry them in.
- If you heat with electric radiators you probably can't afford to eat.

History of costs

I keep a record of my fuel bills. They are illuminating or perhaps horrifying is closer. Here is an annual average for a successions of years plus some maxima. Divide the oil price by 10 get p/kWh.

	Elec p/kWh	Elec Standing charge	Elec Maximum p/kWh	Oil p/litre	Oil Max
2013	12	25	12.36	70	72.73
2014	11	20	11.78	51	
2015	10.5	16	17.12	41	
2016	9.6	15.5	12.8	39	44.47
2017	12.5	15.5	12.73	41	44.07
2018	12.9	20.6	16.25	51	56.77
2019	15	24.6	15.71	48	54.64
2020	15.4	19.0	15.71	47	48.9
2021	18	20.2	19	41.6	
2022	28	30	37.1	74	
2023	36	38	45.45	67	

Heat pumps, radiators and underfloor heating

Electric heating

Once all or most electricity is made from solar, nuclear or renewable sources it will be green. Then we **must** switch to it for house heating. Forget direct heating by electricity. Heaters called ‘oil-filled radiators’, ‘electric panel heaters’ or similar, will certainly warm your house. I love the misleading advertisements that say something like, ‘Warms your room in minutes.’ Yes, but by how much and at what cost? By one degree from 10°C to 11°C? They are 100% efficient as stated by some dubious suppliers but that doesn’t mean they don’t use a lot of electrity. Your bills will probably be so high that you will need a second mortgage. Fortunately there are now devices that will put three to four times as much heat energy into your house as the electrical energy needed to run them. They are called heat pumps.

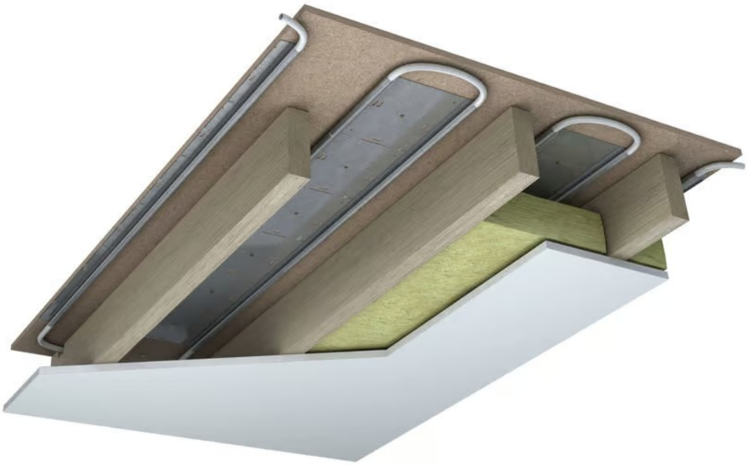
Ground and air source heat pumps

They are reverse refrigerators. They take heat from outside and pump it into your house. You will need to find space for the equipment inside the house as you see in the page on air source. Ground source will be the same inside the house but will have pipes snaking out instead of a noisy outdoor unit. Both types of pump can, in principle, be used in reverse as air conditioning.

Heat pumps are most efficient with underfloor heating, where pipes carrying warm water are snaked around in the top (screed) layer of concrete above an insulating layer. Floors have a large area so can provide enough heat from water at a low temperature. There are now retrofit overlay systems that allow underfloor heating over an existing concrete floor, shown in the first picture, the thickness of which is only 15 mm. It is then filled with a self-levelling resin onto which the flooring can be laid. Being an overlay it could be torn up if and when the pipes needed to be replaced.

https://www.nu-heat.co.uk/case-studies/lopromax-renovation/

There is a version for suspended wood floors on the ground or upper floors, which is shown in this picture.



Heat pump ‘efficiency’

The measure of heat pump ‘efficiency’ is a number called Coefficient of Performance (CoP). This will be from below 3 to about 4. This number tells you how many kWh of heat you will get in your house from one kWh of the electricity used to run the pump. However, colder weather makes air source work less well so read the paragraph about SPF below. The key to pump efficiency is to keep the circulating water to the lowest usable temperature.

The word ‘efficiency’ above is in quotation marks because it is no such thing. No machine can be more than 100% efficient. Those of you who were awake during Physics lessons will no doubt be puzzled. You will perhaps remember, ‘Energy can neither be created nor destroyed.’ How can 1 kWh of electricity become 3 or 4 kWh of heat? The extra heat energy isn’t produced by the pump but comes from the air, which the pump cools. A heat pump is a machine and will itself waste energy by doing what it does. If the electricity is green’ it doesn’t matter as there is no atmospheric pollution. The laws of thermodynamics are not broken. The key word is ‘entropy’, but let’s leave it there. If, like me, you really want to know then put a bag of ice cubes on your head and read about the science of entropy here before long.

Radiators and water temperature

If you have to use radiators, then you will need larger ones. This is because you will need to set the temperature of the water in them perhaps to between 40 and 50°C rather than the 60 to 75°C that you currently use. Underfloor heating only needs 25 to 35°C. All of those temperatures will depend on the particular house being heated so you need an expert designer. The 40 to 50°C water temperature requires a larger surface area of radiator in contact with the air that it is warming. The difference between underfloor 35°C water temperature and the 50°C for the radiators is that the heat pump has to work harder. This reduces its CoP, increasing electricity consumption and hence the running cost.

Pipe sizes

There are many sizes for the copper pipes that carry the hot water to our radiators, ranging from 8 or 10 mm microbore to 15, 22 and 28 mm standard pipes, amongst others. It depends very much on the layout of a particular house but it is likely that lower temperature radiators will require larger pipes feeding them. In any case the 15 mm pipes on an old system might well need replacing. When you plan the new pipe layout remember that every bend reduces the flow so use the straightest routes you can.

Seasonal performance factor (SPF)

The lower air temperatures and hence poorer performance of air source in the winter months means that CoP is not always a good guide. It is best to use a different number, called seasonal performance factor (SPF). The number means the same as CoP but is averaged over a whole year. A recent study by Catapult found that SPF median was 2.8 and dropped to 2.44 if only measured in cold weather. *https://es.catapult.org.uk/news/*

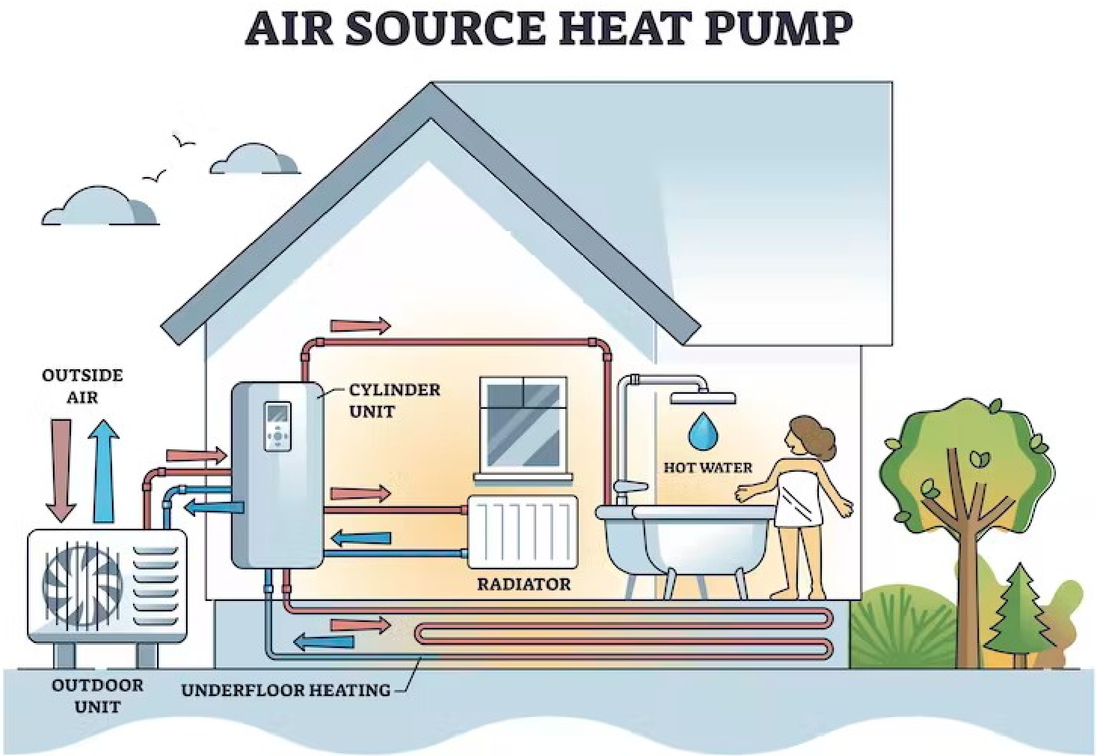
What’s best?

In order of preference these are the options:

1. A new house with all of the above insulation, a ground source heat pump, electric and thermal solar panels and a battery to store overnight electricity needs.
2. A total house renovation to the above standard.
3. An existing house with insulation to the roof, walls, windows and doors, and ground source heat pump.
4. Number 3 but with air source

Air source

At perhaps £15k this is the lowest cost type of heat pump but is less effective overall. Heat is extracted from the air outside. When that air is very cold the extraction works much less well and might not work at all. So when you need heat most you get it least efficiently. Some people keep their gas or oil boilers to top up when needed. The picture on the next page shows you what it looks like.



Picture with thanks to catapult

Good news for air source?

In late 2023 Samsung announced a new air source heat pump called EHS monobloc at about £7k. They say this copes better with cold climates and has a CoP of between 4 and 5. It is quieter at about 50 dB(A) at 1 m and can heat water up to 65°C so does not require larger radiators nor pipes. The word monobloc means that there is no indoor unit. At the same time Panasonic announced a CO_2 heat pump for hot water that has a CoP of up to 6.1 and a water temperature of 80°C. We can dream!
https://www.pv-magazine.com/2023/10/12/panasonic-introduces-heat-pump-hot-water-system/

Even now, at the start of 2024, there are new 'hotter' heat pumps. Take a look at *https://www.bbc.co.uk/news/business-67511954*

Ground source (and water source)

A metre or so down, the ground is always warmer than the surroundings. The further down you go the warmer it gets. Underground pipes are laid coiled in deep trenches or spiralled down in drilled holes upwards of 30 m deep. They collect heat in liquid that is pumped to the unit in the house. This is by far the best solution but is of course the most expensive. An average house might be at least £30k once all costs are included. The heat underground stays pretty constant all year so ground source works equally well in the cold months.

How much space does a ground source heat pump need? We look at the factors
Article by Robin Whitlock published on homebuilding.co.uk June 2023

Working out whether your home has enough space for a ground source heat pump is an important first step. We explain how much space they need in must-read guide for those considering this heating option. How much space does a ground source heat pump need is one of the main considerations you might have when weighing up your heat pump options. The answer initially depends on what size system you require, with larger, less well-insulated homes generally needing more space as their heat demands are typically greater.

However, the answer should also take into account the type of ground source heat array you choose — either vertical, that is to say utilising a borehole, or horizontal, which uses collectors laid in trenches. While the vertical arrays take up less space and are an option for those smaller gardens, they are also considerably more expensive. For this reason, most people installing ground source heat pumps will opt for the horizontal version.

The space needed for a ground source heat pump will depend on a number of factors, including, as previously mentioned, the type of ground array.
For a horizontal-based slinky system, you will need around 10 metres of trenching per kW of heat pump. A space around 5m wide should be maintained between trenches, too.

For projects with less outdoor space, you may need to use vertical boreholes, which only require around 150mm of space per borehole – but they could be as deep as 60-200m – and typically spaced between five and 10 metre apart. Once the installation is complete, the ground will be made good and you can continue to use the space as normal.

The space needed for a ground source heat pump will also depend on the total heat load requirement of the property. David Billingsley, Sales Director at ground source heat pump manufacturer Kensa Heat Pumps agrees: "The heat demand of the property will determine the size of the heat pump needed."
A further factor which is important when it comes to the space required by a horizontal array, or depth of borehole required, is the geology and water table. For this reason, a geotechnical site investigation is needed in order to establish what is known as the Coefficient of Performance (CoP) before installing ground source heat pump. This investigation will cover things like the surface and sub-surface temperature, the thermal properties of the soil, the water table level, the ground water flow direction and the type of soil on the site. These local geological factors will then determine the type and size of the ground collector.

Horizontal slinkies seen inside a trench (Image credit: Kensa Heat Pumps)

What area of land does a horizontal array ground source heat pump need?
[Dimensions made exclusively metric]

In the case of horizontal ground arrays, the amount of land required is usually around two and a half times the area taken by the house. So as a gauge, according to Thermal Earth, a detached new build house with four bedrooms occupying around 150 m^2 will need about 360 m^2 of land for a horizontal ground source heat pump array. *https://www.thermalearth.co.uk/blog/how-much-space-for-a-ground-source-heat-pump*

However, buildings in the UK vary quite considerably in terms of their size, age and type, and that means that the amount of heat required to keep them warm also varies. A home built to modern Building Regulations standards will require much less heat than an older period property of the same size, as the latter is likely to be less well insulated and may have features such as single-glazed windows.

Asked what size ground source heat pump a home might need, the Heat Pump Association (HPA) highlighted a recent case study of the conversion of a 200-year-old barn in North Yorkshire. "The project required the installation of two NIBE F1145 – 12kW ground source heat pumps with a 200 litre NIBE VPB hot water cylinder and 200 litre UKV buffer cylinder. 1500 metres of pipe was laid in the paddock adjacent to the Duttons' [homeowners'] home which, whilst labour intensive, generated the required heat so that they could enjoy ambient temperatures throughout the day and night."
For context, most ground source heat pumps use collectors that are laid in trenches 100 metres long, accommodating pipe that runs 100 metres away from the property and 100 metres back. The heat load of the house dictates how many trenches are required.

“Ground source heat pumps take up very little space once installed,” says David Billingsley, Sales Director of Kensa Heat Pumps. “Inside the property, you will have the unit which is often similar in size to a small fridge. The heat demand of the property will determine the size of the heat pump needed."
You will also need a hot water cylinder. Some heat pump units feature an integrated hot water cylinder and could be the size of a large fridge-freezer.
[End of Robin’s article]

Water source

Water is excellent at storing heat energy. Some buildings are heated from a nearby lake or river using a heat pump. An early example was the Royal Festival Hall in London, built as part of the 1951 Festival of Britain, that took heat from the Thames. However a new government, resentful of the success of the project set up by the Labour one, stripped out all of the equipment as soon as the festival was over and switched to fossil fuel heating.http://www.independent.co.uk/environment/climate-change/exclusive-renewable-energy-from-rivers-and-lakes-could-replace-gas-in-homes-9210277.html

Practical problems that have emerged with heat pumps.

- Installation cost
- Noise from the equipment, especially with air source when houses are close together
- Present criminally high cost of electricity, but will it ever come down much?
- Lack of places to put large radiators
- Might need repiping with larger diameter pipes
- No place to put the internal equipment in a small house or flat, especially if you currently have no hot water storage tank
- Lack of installers. Government dithering puts people off retraining
- Lack of repairers for the same reason
- Routine servicing is about double the cost of gas or oil boilers
- Unreliability that is inevitable with a new technology
- Failure to achieve comfortable temperatures
- Might need to be run continuously as it warms the house less quickly.
- Much poorer performance in cold weather for air source, with a CoP or SPF as low as about 2.5

That list sounds very negative, and it is. Hopefully things will change. The price of electricity will surely fall to a less absurd level? Maybe not. The bugs in the heat pumps will be ironed out as many more are made and the equipment and servicing will become cheaper. People will be trained to install and maintain the equipment. It’s like electric cars. They are brilliant to drive but have temporary problems of range and charging that rule them out for all except people who only ever stay in cities.

District heating by heat pumps

I have seen references to heat pumps being used for estates of houses, called district heating. It makes sense, as with heavy machinery you could go deeper and warmer with ground source. I wondered about how a householder would be charged for heat used. Then I realised that a water flow meter and incoming and outgoing water temperature readings would give an accurate measure.

Large domestic district heating systems are currently only found abroad. Flensburg in Germany and Stockholm have systems that cover the entire cities through a network of large pipes. In 2023 Scotland launched a scheme for city dwellers to avoid the need for lots of noisy and expensive air source pumps.

Homebuilding and Renovation magazine carried an article in December 2023 saying the Leeds City Council will heat 247 of its houses and flats with communal heating run by high temperature air source heat pumps to replace electric storage heaters. The installers Cenergist think that 52% reductions in bills are probable, together with net zero carbon emissions. Allowing for the cost of the conversion being added to the heat cost, that would make the CoP not much more than 2. Presumably that is because of the use of high water temperatures. There is no mention of insulation so we must hope that the residents do not shiver.

Biomass boilers

For people with the space biomass might be considered. A boiler burns cut and dried wood, wood chips or manufactured 'logs' made from sawdust or straw. Though the boilers produce CO_2 they are regarded as green as the fuel is from plants that can be regrown and so absorb the CO_2 again. Wood chips need a large hopper for the fuel that is then usually moved to the nearby boiler by a screw feed. Natural or artificial logs are fed manually and could become a burden. Biomass might suit some people with plenty of space. One big benefit is that the high water temperatures mean no major work is needed on pipes and radiators. There are now strict rules about burning wood in towns and cities, that might be a threat to biomass in the future.
https://www.gov.uk/apply-boiler-upgrade-scheme/check-if-youre-eligible
Biomass: *https://energysavingtrust.org.uk/advice/biomass/*

As a rough guide the energy density of dry industrial wood is 19 MJ/kg and domestic wood logs at 20% moisture content is 15. This is about 3 times less than kerosene heating oil at 46.2 MJ/kg. Converting to kWh/kg this gives wood at 4.2 and kerosene at 12.9. Remember that kerosene is about 0.83 kg/litre hence the roughly 10 kWh/litre used above. My calculations suggest that running a 12 kW boiler for 16 hours a day (192 kWh) would require about 45 kg of wood per day. If burning logs that is quite a burden.

The above data came mostly from a spreadsheet published in the National Statistics publication Digest of UK Energy Statistics (DUKES) produced by the Department for Energy Security & Net Zero. In other words probably correct. Hopefully my calculations are too.

I once read that to be self sufficient for wood to heat your house, you need about 4 acres of mixed woodland. This is about 1.6 hectares. Would such an area create the wood needed for the above system? Assuming heating for eight months a year at 45 kg per day this needs about 11 tonnes per year.

An excellent website at Napier University gives data for 'timber increments' in m^3 per hectare. That means how much mass of timber is grown in an average year. For fairly fast growing trees, this ranges from 12 to 20 so let's take an average of 16. At wood density of about 700 kg/m^3 this gives about 1.6 x 16 x 700 or 18 000 kg or 18 tonnes. Allowing for varied growth of different types of tree this is about right then. Do schools still teach children how to judge whether a calculated number is 'about right'?
https://blogs.napier.ac.uk/cwst/speed-of-growth/

Price per kWh

Electricity, gas and oil are easy but for wood we are in difficult territory. To complete the comparison of fuels I needed to find out the cost per kWh for the different forms of biomass fuels. If you have a source of free wood you obviously don't need to read any further. Most people don't. So what sort of cost are we talking about?

There are cut tree logs, artificial logs made out of sawdust or straw (sometimes called briquettes), wood pellets and wood chips. For tree logs and chips the variables are moisture content, wood density and energy per kg. Briquettes and pellets don't vary much. Then of course there is price. Suppliers vary in price and some sell by volume rather than mass, or even by the vague 'bag full'. Just to be confusing, in the US wood is often measured in cords, whatever they are, so that data was useless.

In the end I gave up, at the point where my brain started to boil. I took an average of quoted figures from a variety of sources including universities, companies and government data.

My comments in italic

Fuel	Average Cost in Great Britain (pence per kWh)
Wood	9
Gas	10.3
Oil	9.2 *in January 2024 it is about 7*
LPG	12.1
Electricity (Standard Rate)	34 *in January 2024 it is around 29*

Of course an electric heat pump's CoP of about 3 means that electricity will cost around 10 p per kWh of heat.

Grants

As I said earlier there might be grants available to help you with the cost. Be profoundly skeptical. There might be conditions that make it a bad deal, such as what companies you may choose. Remember it is a politician's idea. I love the poster that shows Kermit the Frog and says, 'Vote Muppet. You'll get one anyway.' Unfair on Kermit though. Anything run by a government will change arbitrarily and will most likely run out of money before it runs out of need, so beware!

In late 2023 in the UK you can get £7500 towards the cost of a ground or air source heat pump or £5000 towards a biomass boiler. The last is lower because the high water temperature means that there is less, or no, work to do to the pipes and radiators. Usually when grants increase in value the total amount of money available does not, so fewer people can get a grant. The message is if you are sure it's what you want to do, get in first. "First in line stands right behind me!" (Pat Boone, 'The Main Attraction'!)

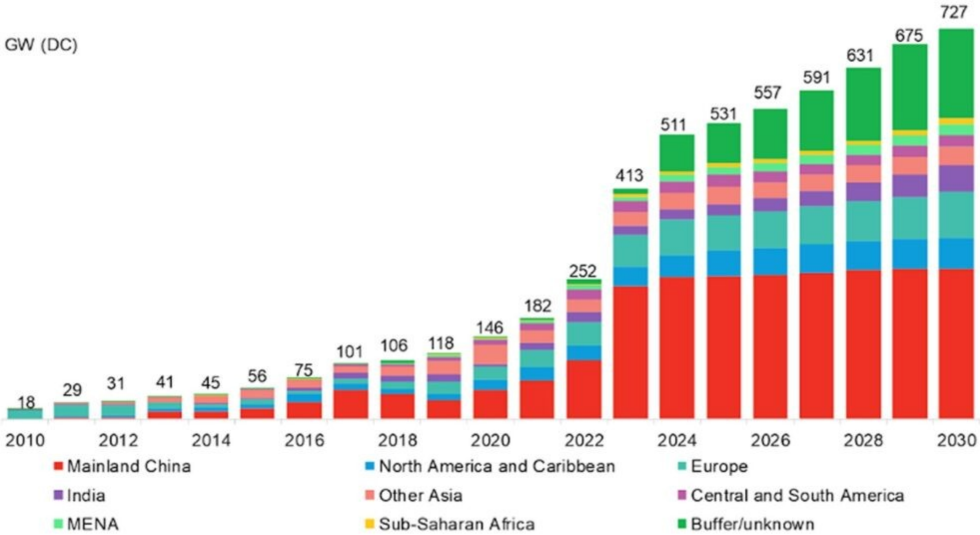
Solar panels and batteries

There are two types of solar panel. The first kind, cheap water heating panels, can warm your stored water but they need plumbing in to your hot water system, and you need a hot water storage tank. The second kind, electric panels (called solar photovoltaic, solarPV or just PV), can partly or wholly power your heat pump during the day. You can add a rechargeable battery to power up your house when it is dark. Costs are falling. 4 kW of electric panels and a 6 kWh battery are about £6k each at present. Batteries need to be replaced eventually, perhaps after ten or fifteen years. We don't yet know. Some suggest that it might be possible to re-use batteries that have become too old for car use, which will be cheaper. Prof Paul Christensen says don't. Look at the YouTube video https://www.youtube.com/watch?v=AIXTP-TgPEw of his presentation at Green Fire Safety Conference in May 2023 in London.

You can store any surplus of electricity from your PV panels for overnight use. Before, or instead of, installing PV panels you could charge the battery from the grid overnight and get half price electricity for use during the day. Typical prices per kWh in December 2023 are day rate 36 p and night rate 14 p. That compares with the all-day rate of 27 p. In the summer months when you take little or no electricity from the grid the criminal 'standing charge' could become significant. When we buy something from a shop, do we have to pay an extra charge for the roof, the display stands and the floor tiles? What a con!

If using lithium batteries, in order to prolong their lives you should not let them regularly to run down below about 20% charge. My daily usage is about 10 kWh so, to be on the safe side in dark winter fog, I would need to get a battery of at least 12 to 15 kWh. Having seen Prof Cristensen's video I have decided to wait for a non-lithium battery. I had planned to put a lithium one in a well detached workshop. Now I'm not fitting one at all.

In November 2023 BloombergNEF reported that, globally, solar photovoltaic panels are increasing rapidly as shown in the picture. By the end of 2023 installed capacity should be 413 GW (gigawatts). As you see China leads. This is set against global electricity consumption of 4.4 TW (terawatts) from fossil fuels and 3 TW from other non-fossil sources, giving a percentage figure of 5.6%. A TW is a thousand GW. However it is a good start. The price of solar panels has dropped to about £0.08 per watt which should encourage more householders to install them, so perhaps the 2030 estimate of 727 will actually prove to be higher.



https://www.pv-magazine.com/2023/11/29/new-solar-installations-to-hit-413-gw-this-year-says-bloombergnef/

Planning consent

I wanted to install a domestic array of photovoltaic solar panels. The panels have to be on the ground for reasons I won't bore you with. The array and battery would have cost me many thousands and I would never have got the money back in savings. But I would save some money and, in a county rapidly being eroded by climate change, I thought it was a public-spirited thing for me to do. I intended in due course to change to a heat pump, partly powered from the array, if that proved practical.

After an enquiry with my local district council's planning department it seems that if they were on the roof I would not need planning permission, but on the ground I do. I then discovered that that was only true for flat roofs. Solar panels on a flat roof? The council's planning department has a well-founded reputation for being the worst in the country.

Planning permission is a time consuming and expensive process. The arbitrary rules invented by the council make no sense at all. Note that through council tax I have already paid the salaries of council employees and now I would have to pay them again.

What change would I make? For all eco-friendly changes, such as solar PV, there should be an automatic right to approval, though the change must be notified to the planning department. Only a sound reason found during a prompt and **free** visit by an independent planning surveyor could change this.

The upshot is that I have abandoned the idea of solar PV. The money that I save will pay my electricity bills for much more than ten years. I will continue to use my oil boiler until the threat of jail looms. It seems that the jobs-worths ('its more than my...') would rather see my county under water than modernise their thinking. In any case the rich and powerful are doing their best to stall moves aimed at avoiding climate disaster so in reality why bother? Take a look at COP28. The most sensible thing anyone has said lately on the subject is Greta's, 'Blah. Blah. Blah.'

Eco (EPC) rating

When you sell or rent out your house you have to get a rating, called an Energy Performance Certificate (EPC) from A to G (good to bad). Having a good rating might well increase the value of your house. If the current proposed rules become law, and you plan to let your house it must have a rating of C or better.

I was shocked, though not surprised, by an article in Homebuilding and Renovating magazine of 11 September 2023. It said that currently an assessment for the EPC for an existing house is done by just looking at the house using a 'simplified' version called RdSAP, Reduced Data Standard Assessment Procedure. No measurements are made. Any genuine existing data gathered by the house owner and improvements such as insulation, new windows or a heat pump are ignored. One of house owners mentioned in the article said, 'The RdSAP EPC is not worth the paper it is printed on. We still have all evidences for the original EPC (including the original EPC) such as invoices, photographs, air tests, full SAP calcs etc. The 'assumed' energy consumption figure is almost double the real world figure. The property has been well maintained, and no alterations to the building fabric carried out since the 'as built' tests, checks and calculations were completed. RdSAPs appear to be pseudo-science and have no real validity regarding energy performance;

you should not be permitted to issue certificates based on these using the nomenclature EPC.

Other ways to save energy in the house

It is little to do with heating, but light emitting diode (LED) light bulbs use much less electricity, because they do not get very hot. So if you still have any fluorescent, filament or halogen bulbs it's a good idea to change them to LED. The only place I have found where LEDs rapidly fail is in the heat on my cooker hood, so I still use halogens there. LEDs waste about 10% of the electricity as heat, filament incandescents about 95% and halogens 80 to 90%, though of course it heats the house a bit.

All new electrical equipment uses very little electricity in standby, so ignore the nonsense about switching off at the mains socket to save energy. On standby, most equipment uses 0.4W by EU law, which costs less than 2p a year. You will burn more muscle energy getting up to switch off. By doing such things as replacing and recycling ancient inefficient equipment, changing all bulbs to LED, only putting the correct amount of water in an electric kettle, and switching off working things like TVs when not needed, you will save money. I reduced my electricity consumption by just under 50% in three years.

And finally the ultimate eco house – the passivhaus

The ultimate eco house is one where we recycle heat generated in the house by the heating system, cooking, electrical equipment and our bodies. The house is highly insulated and sealed against air leakage. It is tested by being pumped up to a higher pressure and watching how quickly the pressure goes down. The air in the house is kept fresh, as the stale warm air is pumped out through a heat exchanger. This warms the outside fresh air coming in. The equipment is substantial as you see from the picture, and needs a plant room. Such a house is called a passivhaus and is usually only practicable for a new build.

Plant room

Mechanical Ventilation Heat Recovery system

- boiler if used
- heat pump, sometimes called a hydrobox
- hot water cylinder
- central heating manifolds to supply radiators or underfloor
- electrical board
- inverter for photovoltaic solar panels
- battery storage
- water softener.

What to do for now?

Though I hate to say it, it is probably best to stick with gas or oil for now. Until most electricity is generated from renewable sources such as tidal, sea wave, river or dam turbines, geothermal, solar panels, windmills or nuclear, using electricity isn’t wholly ‘green’, especially in the dark in calm weather. The present ridiculous prices for electricity might come down or probably will not come down much. I have recently replaced a thirty-five year old oil boiler with a new twin condenser one that uses a lot less oil and electricity. By the time the seven year warranty runs out I might be willing to go heat pump. Or not.

Until the other day there was an insane timetable for replacing oil and gas boilers. The former was 2026 and the latter 2030. So anyone whose boiler broke down beyond repair after those years would have been forced to switch to a heat pump. For some houses this would be relatively easy but for many would mean major, lengthy and very expensive changes to the house, as you have seen in this article. Even that assumes that there would be designers and installers available to do the work speedily. Imagine a relatively low income family being told to freeze and do without hot water while finance, and system design and installation, is arranged. It could be months or never.

Fortunately in a rare bout of sanity the government has moved the dates further into the future and not made it mandatory for all. Now people can spend a lot less money on insulation first. This will free the householders or landlords to schedule the changes as installers and better equipment become available.

Please politicians, subject your ideas to testing by people who know what they are talking about. You don’t. We ‘common’ people, professionally qualified or not, are much more clever and knowledgeable about the real world than you. Like electric cars, we all want to change to environmentally sound heating, but only when both are practical propositions.

Conclusions

Well, that was a marathon but it was for me a very satisfying study! There were many surprises.

The first and over-riding conclusion is **INSULATE! INSULATE! INSULATE!**

Secondly, and surprisingly, the fuel costs of the various forms of home heating are roughly the same at about 7 to 10 p/kWh, though of course they each change separately over time.

Third. If the new generation of heat pumps prove themselves and give CoPs of five or more then they will be the cheapest form of heating even if you still have to buy electricity. Of course as demand for oil and gas falls their prices will fall, but by then we will hopefully all have heat pumps and be cosy in our insulated houses. Very likely many of us will have PV panels and wind turbines for free electricity, and batteries to store it.

Fourth. The installation costs of the different types of heating system vary wildly so do your research. Don’t be taken in by offers sent to you by email or on the web in general and definitely don’t take advice from ‘influencers’. Find good local companies and insist on visits and formal specifications and quotations. After reading the information here you now understand them and will be critical about what they tell you.

Sources

Magazines and websites

Biomass: https://energysavingtrust.org.uk/advice/biomass/

Biomass: https://www.boilerguide.co.uk/biomass-boiler

Catapult energy systems: https://es.catapult.org.uk/

Forestry data: https://www.forestresearch.gov.uk/tools-and-resources/statistics/statistics-by-topic/timber-statistics/timber-price-indices/

Ground source pump example: https://www.thermalearth.co.uk/blog/how-much-space-for-a-ground-source-heat-pump

Homebuilding magazine: https://www.homebuilding.co.uk

Hot water air source: https://www.pv-magazine.com/2023/10/12/panasonic-introduces-heat-pump-hot-water-system/

Progress of solar PV worldwide: https://www.pv-magazine.com/2023/11/29/new-solar-installations-to-hit-413-gw-this-year-says-bloombergnef/

Lithium battery dangers: https://www.youtube.com/watch?v=AIXTP-TgPEw

Log prices: https://www.grampianlogs.co.uk/prices/

Retrofit underfloor heating: https://www.nu-heat.co.uk/case-studies/lopromax-renovation/

Upgrade grants: https://www.gov.uk/apply-boiler-upgrade-scheme/check-if-youre-eligible

Water source heat pumps: http://www.independent.co.uk/environment/climate-change/exclusive-renewable-energy-from-rivers-and-lakes-could-replace-gas-in-homes-9210277.html

Wood growth speed: https://blogs.napier.ac.uk/cwst/speed-of-growth/

Last edit 14 January 2024