Retrofit sustainability

Targeting net zero carbon emissions

Most of the houses in the UK are old, draughty, poorly insulated houses that have been around a long time and are likely to be around way past 2050 - the date by which the Government has committed the UK to net zero carbon dioxide emissions. The vast majority of the country's almost 27 million homes will need low-carbon retrofits, primarily thermal upgrades and more efficient heating systems. With rising fuel and energy prices fuel independence is also becoming an issue.

What is net zero?

This is a measure of the equivalent amount of carbon dioxide, the primary greenhouse gas identified as contributing to global warming, released into the atmosphere measured over time. Carbon dioxide is not the only greenhouse gas, for example methane is much more harmful by approximately a factor of fifty, but CO_2 is the measure used and quite often emissions are described as the equivalent amount (CO_2^{EQ}) to account for other gases.

Buildings can be assessed for their whole life carbon emissions which is in two parts, carbon emissions as a result of construction of a building and the levels emitted during the operation and use of a building. For the purposes of this report we are focusing on retrofitting of existing buildings so will not be evaluating construction equivalent emissions although it is still a factor, if relatively minor, when carrying out any work and applying materials or equipment.

Net zero carbon emissions is a measure over time and it is important to note that the consumption of electricity does not have a linear correlation to the CO_2^{EQ} emitted. The equivalent rate of carbon emission through use of electricity will vary over time depending primarily upon levels of supply and demand on the national power grid at the time of consumption (assuming a property is not off-grid). Peaks in the users demands are at various times of day, during the week like over weekends or times of year. These demands do not correspond to peaks in supply on the grid. This is increasingly true for renewable energy production such as solar as wind generation which will become more and more prevalent as the energy industry in the UK is increasingly decarbonising as it aims to transition to clean power by 2030.

Balancing – 'demand shifting'

Drawing electricity from the grid at off peak periods when demand is low will minimise CO_2^{EQ} per KWh of electricity used. The importance of balancing energy demand should not be underestimated. Using figures for 2026 the carbon emissions for operating a building can be reduced by somewhere between 25 and 50%. This of course also has a similar effect on energy bills. It is a win for the user/resident, a win for the energy companies and a win for sustainability.

Delivering 'zero' in operation

There are three main factors that contribute towards the CO_2^{EQ} emissions in household usage. The equivalent proportion that each of these factors represents will vary from building to building but in general can be:

- One third is for **space heating**
- One third is for supply of **hot water**
- One third is used by **plug in appliances**

There are other considerations such as lighting but these should be relatively small. For much older homes where the fabric of the building is not thermally efficient the space heating proportion of demand may be much higher, constituting more like three quarters of energy demand.
It is advisable to avoid heating using on site combustion as this is a short carbon cycle that is inefficient, choose a low carbon fuel source and in the long term electricity has the best prospects.

There is no panacea in upgrading older houses to be more energy efficient. Each house has different particulars which will make some technologies more or less appropriate however there are general principles which are good practice to follow.

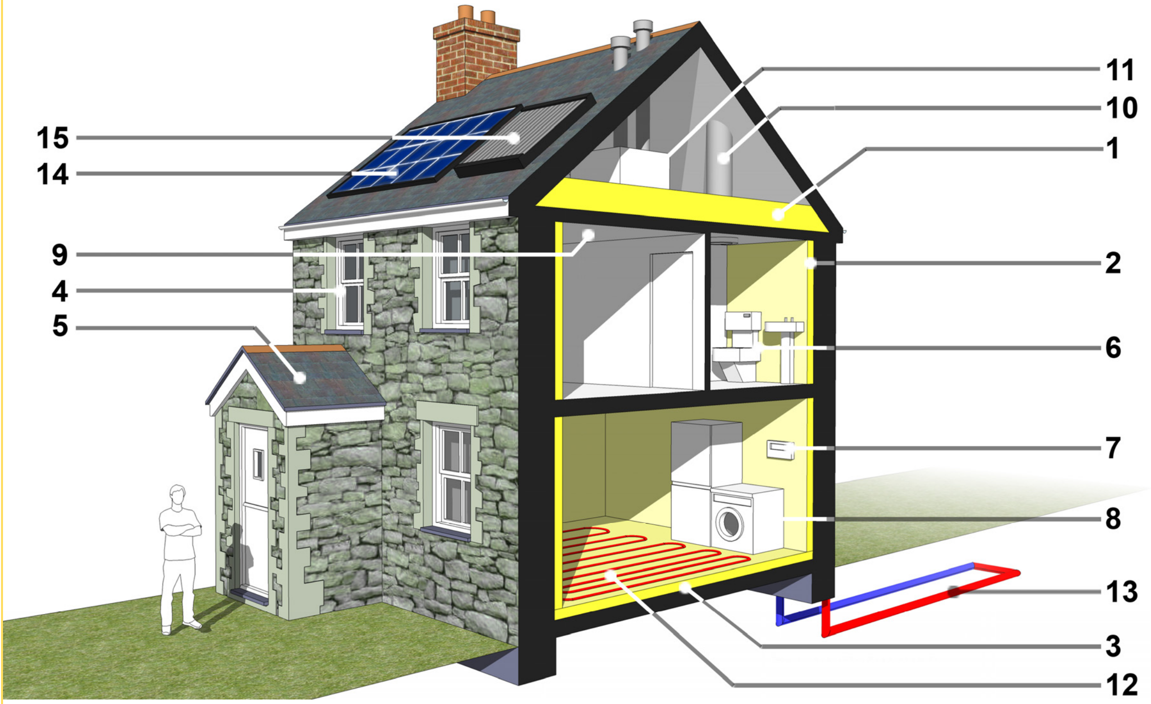
- **Reduce** – minimise losses and demands.
- **Balance** – shift demand to off peak
- **Generate** – maximise efficiency and on site energy

This short guide gives some idea of appropriate measures, some of these may be achievable (some at very low relative cost). This is by no means a comprehensive list of possible improvements and the list of emerging solutions is constantly evolving but the underlying three step strategy will remain the same.

Reduce

A fabric first strategy should be applied when looking to reduce the energy demands of a building. With the design of new buildings this may begin with considering the form factor whereby a lower surface area to volume ratio will create a greater efficiency. This is not really an option for existing buildings but may still be of some relevance if extending. The same can said for limiting the amount of glazing.

When considering a fabric first strategy on how to reduce energy losses and subsequent demands when refurbishing and retrofitting an existing house the performance of the thermal envelope is the best place to start, as well as looking to limit air leakage.



1. Loft/roof insulation.
2. Wall insulation.
3. Floor insulation.
4. Draught free double/triple glazing.
5. Lobby.
6. Reduced flow bathroom fittings and dual flush toilet.
7. Real time energy use meter.
8. Energy efficient appliances.
9. Low energy lighting.
10. Sun pipe.
11. Mechanical ventilation and heat recovery / MVHR.
12. Liquid underfloor heating / UFH.
13. Ground source heat pump (and air source).
14. Photovoltaic panels.
15. Solar thermal collectors.

1. Loft insulation
The first place to look to stop heat loss from a building is through the roof. This is usually the easiest place to start as many roof spaces are easily accessible making this a very quick and cost effective way to reduce heat loss.

2. Wall insulation
Many existing houses have by modern standards an inadequate degree of thermal resistance in the walls. The issue will usually be that either the existing walls are solid or any moderate cavity that does exist is already filled with insulation but not enough to provide a substantial thermal resistance. The solution is an additional layer of wall insulation fixed either internally of externally. A layer of insulation with a rendered or other external finish applied to the exterior of a building may be the easiest and best solution because the layer can have a greater continuity than internal wall insulation that has be worked between internal walls and floors. The issue in much of the West of Cornwall is the protected nature and external appearance of the traditional stone built buildings, this will usually mean the implementation of internal wall insulation is the only option.

3. Floor insulation
Not an immediately obvious place to expect heat loss from a building but once the walls and roofs have been insulated the floors are the next place to look at (particularly if you may also intend to install underfloor heating). Insulating some floors can be quite problematic but where it is done and done properly it is well worth it. Suspended timber floors offer the easiest and quickest means of introducing insulation beneath the ground floor and it can simply be installed between and beneath the existing floor joists. Solid floors are a different matter as it can raise problems when increasing the finished floor level by laying new insulation over existing floors, the alternative is to excavate the existing floor which can be disruptive and costly.

4. Draught free double/triple glazing
Once all of the buildings surfaces (walls, roofs and floors) have been considered the windows should be addressed. Triple-glazed windows and doors are preferable to double-glazed, with a well sealed installation to avoid draughts and air leakage (especially important if you consider installing a Mechanical Ventilation and Heat Recovery system).

5. Lobby
The addition of an insulated lobby to the building can greatly reduce heat losses caused by the user entering and exiting the building besides being very useful in separating the interior comfort of the building from poor weather conditions outside. It may be easier and cheaper to create a lobby on the interior of a building but quite often there simply is not the room to do this.

6. Reduced flow bathroom fittings and dual flush toilet
Fitting reduced flow bathroom fittings such as taps and shower heads, and using a dual flush toilet can greatly reduce water usage as well as demand for hot water.

7. Real time energy use meter
This is not so much a measure to directly reduce energy usage but installing a console that displays the electrical consumption rate throughout the home can be informative. Peaks and high levels of electrical usage may help identify areas where greater efficiencies can be achieved.

8. Energy efficient appliances
Installing energy efficient appliances (A++ electrical) such as washing machines and fridge freezers can further reduce electrical demands. Generally it would be expected to replace these type of appliances after a few years and so may need replacing in your home sometime soon.

9. Low energy lighting
Fitting low energy lights and light fittings can be very simple and mean fitting low energy bulbs in existing sockets or the wiring of new light fittings to take alternative types of bulb such Light Emitting Diodes (LED's).

10. Sun pipe
Natural daylight is mostly preferable in the interior of a building rather than requiring artificial lighting, and the less lights need switching on the better. Windows, glazed doors and roof lights may provide the solution for the majority of rooms but for some internal rooms, usually bathrooms or store rooms, this is not an available option. A sun pipe is maybe an alternative and can allow daylight to penetrate into the heart of a building via reflective pipe work. Sun pipes can also be integrated with a passive means of ventilation which is very useful for bathrooms (not to be used if the house will have a Mechanical Ventilation and Heat Recovery system).

11. Mechanical ventilation and heat recovery (MVHR)
An MVHR system requires the installation of a heat exchanger, usually in the roof space This exchanger will intake outside air and preheat it with the air that is being extracted from the building's interior. A system of pipes will lead from the exchanger to a vent in each of the habitable rooms of a building. This is a very good way to maintain ideally adequate levels of ventilation to all rooms while greatly reducing heat lost by simply expelling warm air. Some of these recovery systems can have an efficiency of 90 to 95%. The important thing is that firstly the building is well insulated and also has been made reasonably air tight else the efficiency of these systems cannot be realised.

12. Liquid underfloor heating
Underfloor heating, as well as being very comforting, is a very good way to heat an interior. Convection currents and draughts are lessened when compared to heating a room using radiators. Also liquid underfloor heating systems run at much lower temperatures than is required by radiators and when set in a heavy floor screed or slab will also create a thermal mass that will provide a more controlled air temperature in the room. A liquid underfloor heating system can be integrated with the hot water system using a thermal storage tank, which can also be integrated with solar thermal panels and a ground source heat pump. A ground source heat pump also works well with liquid underfloor heating as most it is efficient as generating the relatively low temperatures required.
As with the installation of floor insulation into old houses, there is an issue with floor levels when looking at installing under floor heating.
There are electrical underfloor heating systems available and while they are easy to install and provide similar comfort levels to a liquid system they cannot be integrated with the hot water system and there is some question of their efficiency.

Balance

After seeking to reduce the energy demands of a building the balancing of those demands is by far the most efficient step to address next.

Battery storage
There are a few methods but for a property most predominantly reliant on electricity as an energy source a battery which can store electricity, whether that electricity is generated on site or drawn from the grid, can allow the user to decouple when they need to use electricity from when they need to import electricity.
At 2026 figures an estimate of about 2 – 2.5 KWh per occupant is a reasonable working capacity for a domestic battery.

Thermal storage
The very fabric of the building may have a mass that can act as a thermal store but for existing buildings where this is not a feasible consideration the introduction of a water tank for heating and hot water may be an option. Water may be heated at times of off peak energy and then available on demand when needed. The recommended capacity should be around 85 litres for a single person usage and then an increase of 35 litres per person of expected occupancy after that.

Controls
To allow the effective operation of 'demand shifting' requires control. This may be a crude timer to for example run an appliance or heat water at night when energy is off peak. More optimal would be a home energy management system (HEMS) which can analyse household usage patterns and run high energy appliances when grid prices are low by analysing real time of use tariffs.

Generate

It may be possible to achieve an effective net zero carbon emissions target by applying the first two steps – **reduce** and **balance**. Those steps should certainly be addressed first before considering how to generate energy on-site and certainly without balance any generation may prove highly ineffective.
Typical forms of on-site generation are either 'solar' or 'wind' but whatever form they take they should be on site or nearby to minimise distribution losses.

On site generation of energy may be a short to medium term requirement as national energy suppliers work towards decarbonisation and wholesale sustainable energy generation becomes more efficient at larger scales.

13. Ground and air source heat pumps

A ground source heat pump utilises pipes that would be buried in the ground. A mixture of water and anti-freeze circulates around a loop that is either buried horizontally in a trench or if space is limited is buried vertically in a bore hole. Warmth from the ground is absorbed by the loop and is pumped through a heat exchanger and is concentrated to create higher temperatures to heat hot water. Heat pumps do need electricity to run but the heat they extract from the ground is sustainable, and beneath the surface the ground stays at a fairly constant temperature so the system can be efficient throughout the year - even in the middle of winter. A heat pump delivers relatively low temperatures and this makes it a very compatible system when combined with under floor heating.
Ground source heat pumps can also utilise a body of water, such as a lake or river, where a loop or open pipe system can extract warmth from the water.
There are also Air Source Heat Pumps which can be fitted to extract heat from the outside air and generally perform better where air temperatures are warmer. Air source heat pumps can also work in tandem with MVHR systems.

14. Photovoltaics

Photovoltaics or PV's are panels designed to be fitted to the exterior of a building or located nearby, oriented as best as possible so that they face the path of the sun. The panels are made of semiconducting materials in a way that when light shines on the panel an electric field is created. The brighter the sunlight the greater the amount of electricity produced.
Installing solar PV's will reduce the demand for offsite electricity supply and reducing electricity bills. As of 2026 figures a PV array of sufficient size should be about 1.5 to 2KW prebuilding occupant.
The installation of photovoltaic panels may not normally require planning permission, as long as they are below a certain size. If your property is a Listed Building or in a designated area such as a Conservation Area then planning permission may well be required.

HURDITCH architecture

15. Solar thermal collector
Solar thermal panels like PV's are designed to be fitted to the exterior of a building to face the path of the sun. There are two types, evacuated tubes and flat plate collectors both of which are designed to collect heat from the sun and use it to warm water. This water can then be stored in a hot water cylinder or thermal storage tank for use in the heating or hot water system in the house. This is a very simple system and can produce good efficiencies throughout the year although best returns will be during the summer months. As with PV's - solar thermal collectors would not normally require planning permission, unless the building is Listed or is in a designated area where 'permitted development rights' do not apply.

and finally....

> There is no shortage of organisations that can help you work out your house's energy efficiency and decide what to do, from the easy, cheap DIY jobs to the more involved (and more costly). For further advice a good guidance it is worth visiting the Energy Saving Trust website (*www.energysavingtrust.org.uk*).