ecollection

Notes on energy in housing

by Elvin Ibbotson

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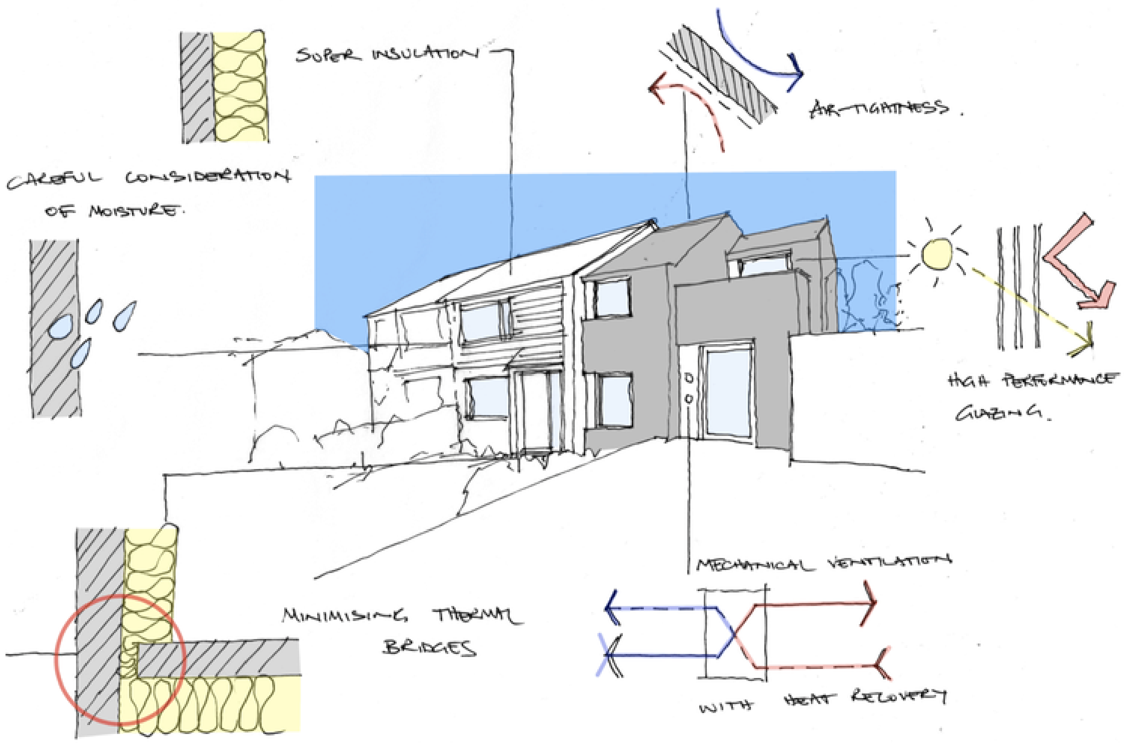
Introduction

This is a collection of my blogs on eco topics - ecological ideas for saving energy and helping save the planet - in the context of building and, specifically, housing.

The rate of change in this area is quite fast (though nowhere near fast enough) and some of what I wrote a year or two ago will already be out of date, so I have noted when the blog post was published and, in some cases, added some additional content or made some small changes to the text.

Certain themes keep recurring throughout but with different emphasis or context. This is not intended as an authoritative and exhaustive investigation of all the factors and options in designing or retrofitting for low-energy, climate-friendly buildings. On the contrary, it is about my own experience, knowledge and opinions. Other people will have different experience, different fields of knowledge and different opinions. But if you are interested and keen to find out more, read on.



Building backwards

Look at pretty much any new housing development and it probably looks like this; traditional, familiar materials and forms - bricks, tiles, small windows, maintenance-free pvc pretending to be wooden window frames and iron gutters. Look around the show house and you're likely to see heating radiators below the window cills and a gas boiler in the utility room. The houses will be a selection of a few standard plans, probably given variety by varying brick colour or extra cladding materials. It matter not a jot which way they face and the chances are that behind the brick is a timber frame.

Because the houses have to comply with building regulations controlling energy conservation the houses will be very well insulated and airtight, but those small windows, designed to minimise heat losses, are of little use when it comes to grabbing the free heat available from winter sunshine, while the airtightness is a nonsense when every kitchen, bathroom and utility room has to have an extract fan to avoid condensation by throwing out the expensively gas-heated air.

Britain needs hundreds of thousands of new homes and needs to reduce its carbon footprint. Heating homes is one of the biggest users of energy. It is madness to be heating brand new homes by burning fossil fuels, but the house-builders need to provide houses that will sell and build them cheaper than their competitors. They have to comply with planning policies and building regulations but they do so at the minimum possible cost and they go no further than they have to towards low carbon, energy-efficient homes. We are building thousands upon thousands of backward-looking, out-of-date houses and adding to the existing housing stock of inefficient homes which are difficult and expensive to retro-fit and upgrade.

Carrot and stick

There are plans to make all new homes carbon neutral in due course, but the knowledge, techniques, materials and technology are all there to do it now. Meanwhile we just keep churning out yesterday's homes.

Look at one-off architect-designed houses and the best of social housing and you will see what could easily be rolled out to everyone. There is a raft of measures that can make homes radically more energy efficient. Building regulations recognise them and they can be factored into the required energy calculations (allowing larger windows, for example, if the solar gain offsets any reduction in insulation) but these measures are not mandatory, and until they are they will be the exception rather than the rule.

There would be no difficulty in improving planning policies, building regulations or both to make it difficult to avoid building efficient low-carbon homes. As we see everywhere, widespread adoption of technology causes costs to tumble, and the minimal additional initial costs would apply to every house-builder so avoiding the current 'race to the bottom'. It would be easy to make low-carbon design ubiquitous in new homes by a carrot-and-stick approach: encourage using subsidies and grants and by making planning permission easier for green approaches, while stepping up regulation to make it difficult to avoid using them. High levels of insulation are a given in modern building, thanks to building regulations, though even better performance is a good thing, but the most useful additional energy-saving approaches are outlined below. There are others - wind energy and rainwater harvesting for example - but these are probably not so well-established or effective. Some improvements are possible to existing houses - photovoltaic solar panels in particular are a common sight, fixed over roof tiles - but some are difficult to retro-fit and all are better incorporated into the original build. Retro-fitting may be the best approach for the existing housing stock but every new home built should be designed to incorporate some or all of the following measures.

Passive heating

Windows inevitably lose more heat than the walls they're in, even the most efficient triple-glazed argon-filled windows. But windows let the sunshine in and warm houses up. In the winter too much glass can drain heat away but in the summer it can cause overheating. Thoughtful design can turn these problems into positives but building regulations and lack of imagination means houses now have smaller windows and darker rooms than those built back in the 1960s.

In summer the sun rises in the north-east and is very high in the southern sky at midday before setting in the north-west. In winter, though, it rises in the south-east, remains low in the south at midday and sets in the south-west. Large windows on the south side of a house soak up the winter sun when its heat is welcome, but need shade from roof overhangs to avoid overheating when the summer sun is high in the sky.

Landscaping can help - deciduous trees will shade south-facing windows in summer but lose their leaves in winter to let the sunshine in. East and west- facing windows need care to avoid excess heat in summer mornings and evenings, while windows on the north side will always waste heat in winter. This is not rocket science. It is not difficult to design homes to be light with generous expanses of glass (saving on artificial lighting) without pouring out heat in cold weather, but orientation is critical and this is something that is ignored in 95% of new housing.

Solar panels

Almost all our energy (geothermal energy being the exception) comes from the sun and the most direct way to harness it is using solar panels. Thermal solar panels which heat hot water for our bathrooms and kitchens have been around for years but are now outnumbered by photovoltaic panels which generate electricity. Subsidies including the feed-in-tariff and renewable heat incentive have helped drive installation and numbers have brought down costs so the subsidies can be phased out as improving efficiencies and falling capital costs make solar panels viable without financial incentives. This is all free energy and should be included as standard in every new home built. Of course, the most sunshine tends to occur when we least need the energy to heat and light our homes, but what we don't need is fed back into the grid and lessens the amount of fossil fuels needed by power stations. As we switch from petrol/diesel to electric cars these can be charged for free, while the same battery technology is available for domestic use, so the power generated when the sun shines is available after dark, and is being installed in vast energy banks (often using disused power stations) to do the same on a bigger scale and over longer timeframes.

Heat-recovery ventilation

Building regulations mean that new homes are much better insulated than before, so less heat is lost through walls, windows and roofs. Consequently, the bulk of heat loss is what is known as ventilation loss - simply throwing out warm air. The absurdity of extract fans in airtight buildings has already been mentioned, but ventilation is essential to keep air fresh and avoid problems like mould. The answer is MVHR or mechanical ventilation with heat recovery. It's a mouthful but is actually very simple. MVHR is widely used and is cheap and well-proven technology but is not widely understood and is ignored by house-builders. In a typical system a box housing a couple of fans and filters sits in the roof space with air ducts leading to discreet outlets in ceilings or walls. Warm, moist, stale air from kitchens and bathrooms is extracted and fresh air from outside is gently fed into living rooms and bedrooms. But the trick is to pass the warm, stale extracted air through a heat exchanger where most of the heat is transferred to the fresh, filtered air being brought in. Typically, the fresh air coming in will only be a degree or so cooler than the heated air being expelled. Almost all of the energy remains in the home. Extract fans are not needed and the air is kept fresh without having to open windows in cold weather.

Heat pumps

Traditional heating by burning coal, gas or oil is easy to understand but wasteful. At worst, most of the heat goes up the chimney but even the most efficient systems produce much less useful energy than is consumed. Heat pumps, though, can produce two or three times as much useful energy as they use. Rather than producing heat directly they use a compressor to transfer heat from outside the home to inside. An air-source heat pump, for example, cools a lot of the outside air by a few degrees and uses the heat gained to give a much bigger temperature rise in the primary circuit of a heating system. Heat pumps work best with the lower temperatures needed for underfloor heating, removing the clutter of wall-mounted radiators. They use clean electricity (increasingly from sustainable sources) and, since the principles involved are similar to a fridge, may also be able to provide cooling as climate change brings higher summer temperatures. Like the other technologies, heat pumps are well-proven, widely used and getting cheaper, but you won't find them in a typical new home.

Money talks

There are financial incentives to encourage homeowners to be greener. The Renewable Heat Incentive gives quarterly payments over seven years for heat pumps, thermal (hot water) solar panels and bio-mass boilers; grants support upgrading thermal insulation and replacing old, inefficient boilers, and long-term incentives to encourage the use of photovoltaics have been so successful in building take-up and lowering costs that they have were steadily reduced then discontinued. These are piecemeal incentives equivalent to encouraging the purchase of electric vehicles by offering cashback - already being scaled back and no doubt due to discontinue as EV prices fall and fossil fuel prices rise. But the main drivers (no pun intended) for reducing pollution from vehicles are taxes on fossil fuels and road tax discounts for cleaner vehicles (or penalties for dirty ones, if you prefer). Taxation can be easily used to drive down pollution from vehicles, but taxation is not being used to clean up housing.

New houses are being built without energy-saving features because they would increase the purchase cost and impact sales, and even if all new houses were more energy-efficient, the vast bulk of housing is old and most of it is anything but energy-efficient. The way to focus people's attention on the need for energy-efficient homes is by a direct attack on their wallets.

A new report by the government's Science and Technology Select Committee suggests increasing stamp duty for badly-insulated homes. This is a novel idea but is a very low-key one too. If stamp duty - basically a purchase tax for houses - took into account not just the value of the property but its energy efficiency, well-insulated homes with features like solar panels and MVHR would gain a price advantage. Owners would be more likely to go green so their house was more saleable and old, unimproved, energy-wasting houses would be hard to shift.
This measure would do a great deal to green the country's housing stock, but would only apply when a house was sold. Taking it further the costs of owning (rather than buying) a home could be addressed by taxation.

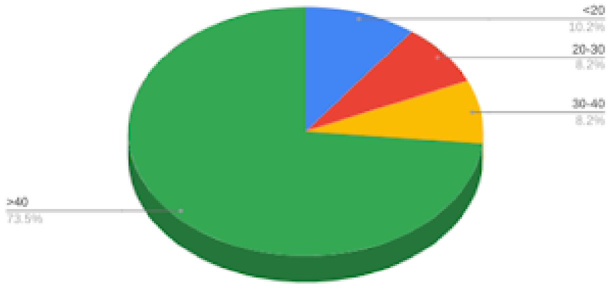
Green energy (solar and wind for example) are subsidised to encourage adoption, but as the subsidies are scaled down generators should be increasingly taxed for using fossil fuels. Homeowners' running costs extend beyond the price of fuel: council taxes are big bills but are just based on building value and on local authority budgets. An element of property tax could be based on the home's energy efficiency (just like road tax for cars) so big, old, draughty, badly-insulated houses became costlier to keep while a zero-net-energy eco-house paid nothing, just like an electric car pays no road tax.

first published July 2019

Care for the aged

In the 1960s the first rules appeared in the UK Building Regulations aimed at limiting heat loss in new buildings. With our climate more energy is required to keep buildings warm in cold weather than to cool them in hot weather. This is the case particularly in housing where houses have been built with central heating since the sixties but air conditioning is still the exception. With global warming this balance may be starting to change. To give ourselves a feel for the scope of the issue, here are some (approximate) numbers.

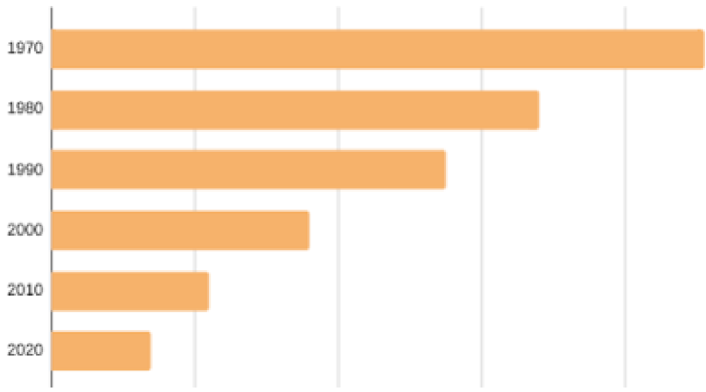
Number of houses in England: 25M of which,
to the nearest half-million...
less than 20 years old: 2.5M (blue)
20-30 years old: 2M (red)
30-40 years old: 2M (yellow)
>40 years old: 18M (green)



Only 10% of houses can be described as new. Around 60% are owner-occupied, the rest rented or shared ownership. This ratio seems not to change much with the age of the house.

Maximum allowable U-value (rate of heat loss) for external walls and typical heating load (for a 3-bedroom house) for new houses built in...

year	U-value	heat load
1970:	1.6	9.1kW
1980:	1.0	6.8kW
1990:	0.6	5.5kW
2000:	0.45	3.6kW
2010:	0.3	2.2kW
2020:	0.18	1.4kW



Simplifying a little, if all 25 million were similar three-bedroom houses then, from the broad-brush numbers above, new houses - those built since 2000 - use less than 4% of the total energy needed to keep our homes warm. A house built before 2010 typically needs twice as much heating as one built now, and by 2050 houses already around in 2010 will be at least 40 years old and will comprise more than 70% of the housing stock.

That's enough statistics for now. The lesson is that older houses use more energy and houses last a long time so most of them are relatively old. So even if all new houses were required to be 'zero carbon' from tomorrow (which begs the questions 'What exactly does that mean?' and 'How can it be done?') by 2050 less than one-fifth of houses would meet this standard, saving relatively modest amounts of energy compared with leaving the requirements at today's levels.

To make a big difference, quickly, then we must address the energy needs of older houses. In the 1960s this was done by levelling whole districts of terrace houses and replacing them with tower blocks and maisonettes. This is not going to be repeated and nor should it: making things well and making them last is more sustainable in housing in other areas. A far better strategy is to improve old buildings, reducing their energy needs, making them more comfortable and cheaper to run while increasing their value and helping save the planet.

The energy-saving regulations mentioned above were mainly concerned with fabric heat loss - through walls, roofs, floors and windows and doors - and this is still what most people think of: loft insulation and double glazing. But there are other equally important aspects. The shape and orientation of houses and positions of windows can make big differences to both heat loss and passive heating. And as increasing levels of insulation reduce fabric losses, ventilation losses - throwing energy out of the extract fan or draughty door - become increasingly significant. Warmer summers already seem to be making overheating more of a problem and if this continues we may see air conditioning more widely used. Here too, factors like orientation, shading and ventilation can lessen problems without having to use even more energy for cooling.

Reducing a house's carbon footprint means not just reducing its energy needs but ensuring the minimum CO_2 emissions associated with that energy. Back in the 1960s again, most houses were heated by burning coal, but central heating was the coming thing and to this day, the vast majority of even the newest houses have hot-water radiators and gas boilers. Switching to electricity can reduce carbon as an ever-increasing proportion is renewable, and including photovoltaic solar panels on every new house would increase the renewable ratio.

To make a significant mark on the carbon footprint of our housing stock in the short-to-medium term we need to devise ways of improving existing houses so how do we do this?

Planning

With existing houses we cannot pick them up and turn them round to face south, but if significant alterations are planned, we can plan extensions or demolitions to make them more compact with the minimum external envelope for their internal space, while adding or enlarging south-facing windows will provide more cool-weather passive heating and shading windows from full summer sun with roof overhangs or deciduous trees will help avoid overheating. If roofs are being altered, south-facing slopes are best for adding solar panels.

Insulation

This is the classic approach to energy saving. Most older houses will already have loft insulation, double glazing and, often, cavity-wall insulation. We need to double down on this: when replacing windows go for argon-filled triple glazing; converting lofts, max out on roof insulation; for old houses with solid brick walls add internal or external insulation; if possible, insulate below timber ground floors and always below new concrete floors.

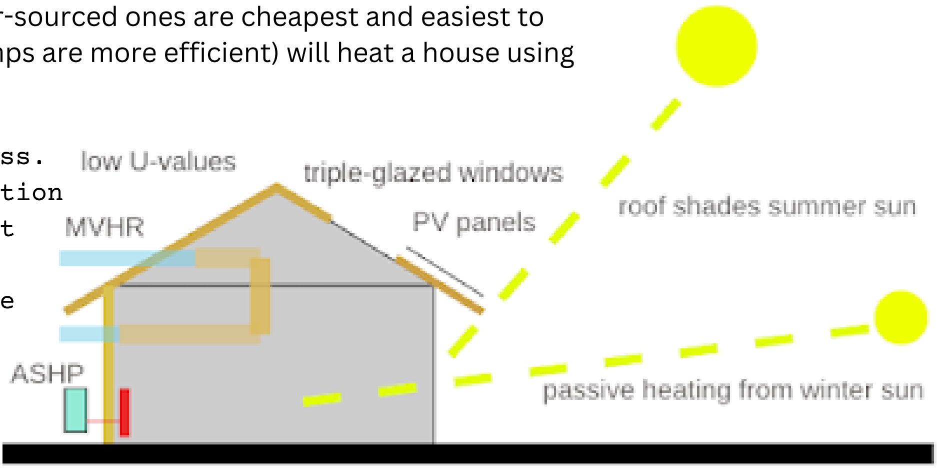
Ventilation

Insulation reduces fabric heat losses so ventilation losses become more significant. Pay attention to sealing gaps, draught-proofing and air leakage through wooden floors. Building Regulations require air-tight houses but also extract fans to through heated air out! Whole-house mechanical ventilation with heat recovery (MVHR) or extract air heat pumps (EAHP) recover all the heat from extracted air and feed it into the heating and hot water systems.

Photovoltaics
Solar panels, preferably on south-facing roof slopes, generate free electricity and any spare goes into the grid, reducing the need for power stations. If you have an electric car or a 'solar' battery you can make use of all the energy you generate.

Heat pumps
Most houses have gas or oil-fired boilers or burn solid fuel for heating. Fossil fuels are far too valuable to simply burn and should be reserved for when there is no practical alternative and where valuable byproducts can be extracted. Even wood-burning stoves or wood-pellet boilers are constantly pouring CO2 and other pollution into the atmosphere. If the house is well enough insulated its energy needs might be met by a small heat pump extracting heat from ventilation air. In other cases a dedicated heat pump (air-sourced ones are cheapest and easiest to install though ground-source heat pumps are more efficient) will heat a house using renewable electricity.

Low U-values means less heat loss. Thanks to high levels of insulation doors and windows lose more heat so triple-glazing helps. Photovoltaic solar panels reduce the load on power stations. South-facing windows warm homes in colder months while roof overhangs limit overheating. Heat-recovery reduces ventilation heat loss and heat pumps reduce energy needed for heating.



All these measures should be incorporated into every new home built but some may be difficult to implement in existing houses. They all cost money and naysayers will say the energy saved will never cover the costs, but the technology is getting cheaper in real terms all the time, while energy costs rise relentlessly, and £10,000 spent this year will seem like a bargain in five years time, so payback time calculations need to take these inflationary effects into account. Plus, improvements like this will enhance property values. Look at all the options and do as much as you can to care for your ageing home.

first published September 2021

Hydrogen hype

So gas heating will be phased out. No gas boilers in new homes from 2025 and you will not be able to replace your gas boiler from 2035. Two options are being talked about as greener alternatives: heat pumps, running on clean electricity, and boilers adapted to burn green hydrogen.

To clarify: by clean electricity I mean electricity from wind or solar farms or from nuclear power (not very clean, since you have some very difficult waste to deal with, but at least there's no CO2 being produced); green hydrogen is made from water by electrolysis (or possibly from bio-waste, trapping the carbon) - NOT so-called grey hydrogen which is made from fossil fuels and produces CO2 or even blue hydrogen (same but the CO2 is captured).

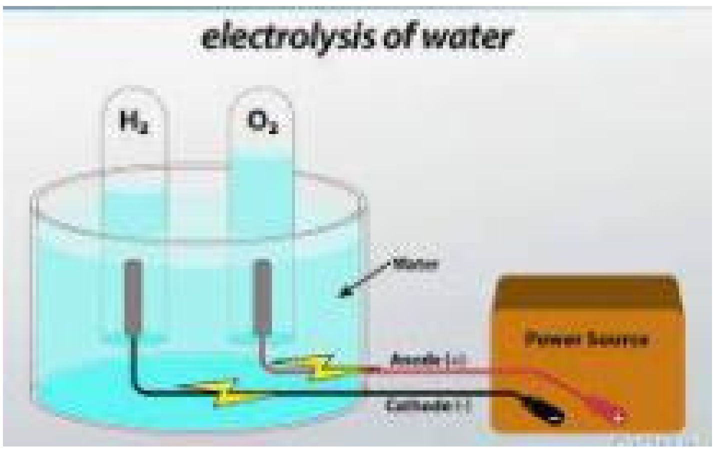
The idea of simply switching our gas boilers over to hydrogen is an attractive one, especially if (i) you already have a boiler (and most of us do) and they've told you it will just need a couple of replacement parts, whereas heat pumps apparently cost £10000 plus and don't produce as much heat, or (ii) you happen to be running a gas company and can see yourself having to maintain thousands of miles of underground pipework and pumping stations for as long as anyone still has a gas boiler, even thought you are losing customers every day as they switch to heat pumps, and then you end up with a nationwide network of utterly useless infrastructure.

So, politicians, journalists and the bloke in the pub can all see the benefits of hydrogen, especially since there is the odd day when it's very windy or sunny and those wind/solar farms are churning out more electrons than we can use. Use the surplus power to turn some water into hydrogen and you've got yourself a tank full of free fuel.

Water is H2O - hydrogen and oxygen - both good gases: one we need to breath, the other is an energy source.

You probably did this at school - passing an electric current through water and collecting hydrogen and oxygen - the magic of science!

This is a great way of using surplus power from renewables and storing the energy as hydrogen which can then be used as a clean fuel releasing energy and producing water to complete the cycle. The only problem is that electrolysis needs a lot of electricity.



Similar sentiments apply to powering cars. Petrol and diesel are bad but then battery-powered cars are expensive, have limited range and take forever to charge, but hydrogen...

But then if you are take the time to research it you see that it's not actually all that simple. Online news source Recharge recently published this comprehensive take-down of the idea of using hydrogen for heating our homes or fuelling our cars:

The hydrogen molecule is very much smaller and lighter than the hydrocarbons in natural gas and this raises many issues concerning, pressures, leak-proofing, pumping pressure, etc.; and hydrogen only has around one third the calorific value of gas, so three times as much is required. These are some of the technical problems easily overlooked. Of course technical challenges can be overcome given enough effort and expenditure, but what concerns me more are the simple logistics.

Gas comes to our homes through pipes under the street fed from bigger distribution mains radiating out from pumping/routing stations (equivalent to electricity substations). Most boilers will apparently run on gas with a small percentage of hydrogen mixed in, but to run on pure hydrogen we will need new boilers or new burners and control electronics in our old boilers plus, most likely, some improvements to the gas pipework into our homes. With hundreds of streets and perhaps thousands of homes being supplied from one substation, it is obviously not possible to switch houses or even streets over to hydrogen at one go. If we are not to be left without heat of cooking facilities, the switch will have to happen in a single day. Unless everyone can have their boilers (and hobs and ovens?) converted to somehow run on natural gas and then, overnight, on hydrogen, whole neighbourhoods and thousands of houses are all going to have the heating engineers in on the same day!

Now I am not dissing green hydrogen. On the contrary it is one of the most crucial components of a transition to a zero-carbon future. It's just that I think there are many better ways to use it than heating our homes. Energy is lost in converting surplus green electricity to green hydrogen by electrolysis; more is lost pumping it through the distribution networks; and the boilers themselves are rarely more than 90% efficient. Heat pumps on the other hand are readily available right now, use the green electricity directly and have efficiencies of around 300%. Similarly, we are already driving battery electric cars and vans (BEVs) which we can refuel at home, or at one of a rapidly growing network of charging points, directly with the electricity the motors need, but there are hardly any hydrogen pumps at filling stations, and having converted electricity to hydrogen the cars then require fuel cells to convert it back to electricity to actually run the vehicle.

Green hydrogen is one way of storing energy - as an alternative to battery farms, hydro-electric, gravity stores or other methods being developed. It may help us wean industry away from fossil fuels for energy-intensive processes like steel or cement manufacture. The shear weight of lorries and the distances they travel may make hydrogen+fuel cells a more practical approach than batteries. Similarly for shipping and for aviation where the weight of batteries is a major obstacle. Also, as well as hydrogen, electrolysis produces oxygen - another very useful commodity. So there is a great future for green hydrogen and applications that will make use of every kilogram that can be produced from surplus wind and solar. But heating our homes and powering our cars? I don't think so.

first published October 2021

The trouble with heat pumps

"*Heat pumps don't provide as much heat as boilers.*"
"If you get a heat pump you'll need bigger radiators."
"Heat pumps are too expensive."

You have probably seen and heard comments like these lately from people who know something about home heating, and what they say has some truth to it, but there's telling the truth and there's telling the whole truth. Boilers do have a bigger heat output than heat pumps. Boilers are typically from 25kW up while heat pumps may be 5-15kW. But how much heat do you need? A modest size well-insulated house might only lose around 2kW even when it's well below freezing outside, and even most bigger, older homes are unlikely to need more than 10kW.

Let's take a heat load of 5kW in the coldest weather for a typical house. Over 24 hours this is 120kWh of energy. A 25kW boiler can provide this amount of energy in less than five hours and can circulate very hot water round the radiators to heat the space reasonably quickly. A 5kW heat pump, though, would need to run all 24 hours and would not get the water as hot as a boiler. This is where the 'bigger radiators' comment comes from. But though the radiators wouldn't be as hot, they will be warm all day and not just five hours. This is in the coldest weather - usually less than two weeks a year. Most of the year, heating systems are running well below capacity if at all.

Both systems provide 120kWh of heat on the coldest days. How much energy do they need to do this? The latest gas boilers are very efficient - around 90% - so will use perhaps 135kWh of gas. Heat pumps use electricity (and a little magic) to borrow heat from the outiside air, the ground, or occasionally a watercourse, raising its temperature to heat the home. They can provide around three times as much energy as they consume - 300% efficiency - so 120kWh output would need only 40kWh of electricity. Leaving aside the matter of the climate - the reason we are being encouraged to switch to heat pumps - and the pros and cons of burning fossil fuels or using clean renewable electricity, heat pumps are way more energy efficient. What about cost? Gas boilers have have been sold in vast numbers for many years and are pretty cheap, but heat pumps are relatively new and there aren't many around yet, so they are relatively pricey, but as numbers increease prices will fall. Gas is very cheap in the UK - currently less than 4p/kWh - while electricity is overpriced at around 16p/kWh. This gives us <£5.40 for gas or £6.40 for electricity.

So there we have it. The trouble with heat pumps is that they are not a simple 'fit and forget' replacement for boilers. They are best in homes designed for them - well insulated, airtight and with underfloor heating - though they are capable of heating older houses with radiators provided they are used in the right way: always available and controlled by thermostat to keep homes at constant comfort temperatures.

The trouble with many sceptics is that they cannot think beyond on/off boilers and red-hot radiators, and need to adjust to other ways of delivering heat.
And the trouble with energy prices is that climate-destroying fossil fuels are much cheaper per unit of energy than electricity - increasingly provided by renewable sources. Fossil fuels must be taxed to both incentivise and finance a transition to clean, renewable energy.

first published November 2021

Life in an eco-house

We built a new house six years ago and it would have been hypocritical to do anything other than go down the eco route. So here's a brief account plus more detail at the end for those who want specifics.

How it started

We had been living in a house we converted from a cowshed back in 1980 and we had about a hectare of land including a small wood we had planted. We were able to get planning permission to adapt and extend an outbuilding to create a single-storey two-bedroom house with a footprint of 100 sq.m. The build took just over six months from bringing in the digger to shifting our belongings in September 2015. We sold our old house with most of the land, keeping the woodland and felling a few trees to create a garden area.

The house is approximately 40% conversion of the original brick outbuildings and 60% new build exension using timber frame, insulated to well above minimum Building Regulation requirements and designed from the start to be energy efficient and 'eco'.

The **systems** include underfloor heating powered by an air source heat pump, thermal and photovoltaic solar panels and mechanical ventilation with heat recovery, all in addition to the usual mains drainage, water and electricity supplies. There are no special water recycling measures but water butts collect water for the garden and the overflow keeps two ponds topped up.

Having our own supply of firewood and having been reliant on a wood-burning stove to keep us warm in previous winters, we included a small wood burner in the living area, and aside from the energy systems we included a central vacuum system and a boiling water tap to make life more convenient.

How it's going

We had to make a mental adjustment at first, coming from a rather draughty older house with an oil-fired boiler and hot-water radiators. We soon learned that heat pumps and under-floor heating work better with a hands-off approach. Basically the system is on from 6am to 10pm seven days a week all year round. Once we had calibrated the thermostats we could basically forget it. The controls switch the heat pump and heating loops on and off as needed completely automatically, keeping the house at a comfortable temperature day in and day out. The MVHR runs constantly 24/7 ensuring a supply of fresh filtered air pre-conditioned using heat recovered from the extract air. We did turn the heating off the first time we went away in the heating season, programming it to come back on the day before we returned. Never again! It took two or three days to warm the house up again.

top: air-source heat pump (with wooden louvred screen),
middle: MVHR,
bottom: hot water tank, pumps, ASHP buffer tank, thermal solar pump, PV inverter and controls

Over the first year we used about as much electricity as we had in our old house, but this was our total energy expenditure whereas the year before we had been spending more than £1000/year on heating oil and still struggled to keep warm in the winter.

After a hiccup at the start, when the engineers had to be called to fix a delivery fault with the heat pump it has run reliably for over six years with only minimal attention. We did get it checked after three years and it was running 'just like new'. Similarly, the MVHR is pretty much 'fit and forget' - we just need to clean the filters once a year or so. The ASHP hums away outside the bathroom when it's running but is barely audible from inside, and the house has to be very quiet indeed to be able to hear the MVHR, unless it's turned up to 'party' mode.

Back in 2015, the idea of controlling and monitoring house systems from a smartphone was pretty new. We had apps for the MVHR and the heating and I can check and adjust the ventilation system from my phone but never really need to. I can adjust the six thermostats from an app but not the heat pump side of the system. The PV inverter will log data to a USB stick but doesn't have an app as I believe is the norm today.*

The only system that has given any trouble is the thermal solar panels which needed attention several times over the first six years. First, their output wasn't appearing on the controller display, then a failed air-release valve leaked fluid in the plant room, and most recently a leaking connection caused a loss of pressure shutting the system down. The heating engineer tells me they rarely fit these panels now, opting instead for a simpler approach which uses surplus power from the PV panels to heat hot water. The thermal panels are very effective when they work, but the electrical approach would be more reliable and makes sense since the house normally uses very little electricity when the sun is strong.

We light the wood burner maybe four or five times a year - mainly for the glow of the fire - but after an hour or two it can get too warm.

I had hoped the central vacuum would be much quieter than our old Henry, being housed in a cupboard in the car port, but it turns out most of the noise is the air being sucked up. It is, though, much less hassle and only needs emptying about once a year!

The boiling water tap is so much more convenient than a kettle and doesn't seem to use any more juice, but I did have to replace the boiler/reservoir after about six years - more expensive than a new kettle!

I have kept a log, since moving in, of energy use and system performance and so can draw some conclusions about how the house is performing. There are some figures in the next section.

In conclusion, I can say the combination of super-insulation, orientation and design for passive heating, heat pump, solar panels, heat recovery ventilation and automatic controls works even better than we could have hoped. I'm biased of course, but I think all new houses should be built this way.

Numbers

When we designed the house the SAP (standard assessment procedure) calculation estimated the maximum monthly heating requirement to be around 1680kWh plus 190kWh for hot water and the heating engineer specified a 5kW heat pump, the smallest in the manufacturer's range and capable of producing 3600kWh over thirty days.

Over the last twelve months the heat pump has used 4292kWh of electricity to produce 7513kWh of heat - mainly for space heating but a fair proportion for domestic hot water. Averaged over the year this is 20.6kWh heat using 11.8kWh electricity per day - an average heat output of 860W and electrical consumption of 490W. At 15p/kWh the cost of heating and hot water for the year was £644.
The maximum monthly heat requirement was in January - not quite the highest ever but quite close. Over the month the heat pump used 710kWh of electricity to output 1057kWh of heat - a daily average of 34.1kWh heat from 22.9kWh electricity or 1.42kW output from 950W input.

The thermal solar panels heat the domestic hot water when the sun shines but were out of action due to faults for several weeks and produce very little heat when skies are overcast. When they were working, they produced 1070kWh of heat over the year - a little less than half the estimated requirement - with the heat pump supplying the rest.

Over the same twelve months, the PV solar panels produced 1666kWh of 'green' electricity, an average of 4.56kWh/day. Taking the average time the sun is above the horizon as twelve hours per day, this is an average of 380W. It was not the sunniest summer and the peak monthly output was 261kWh in April. The panels are partially shaded by trees (especially summer mornings) and the neighbours' house (in the winter months) so the output is less than it could be, but the theoretical 3kW output is clearly not a good guide to real-world performance.

On the whole, solar panels produce the most electricity when you are least in need of it. Excess is fed into the grid and so helps reduce overall emissions, but we now have an electric car and try to charge it when the sun shines, to make the most of the free electricity. I am also looking into the viability of a solar battery.* Using surplus PV output to heat the hot water, as an alternative to thermal solar, is another way of storing energy.

Manufacturers claim that heat recovery ventilation can save 90% of ventilation heat losses. I have no data for the performance of our system but looking at the app right now I can see that the outside air is at 11C, the air being extracted from the kitchen and bathrooms is at 23C (the sun is shining, supplying passive solar gain) and the fresh air is being warmed to 21.6C before being distributed to the living room and bedrooms. So I think the 90% claim is probably justified and the heat saved is certainly far more than the energy needed to run the fans.

The capital costs in 2015 were... air-source heat pump: £6837; thermal solar panels: £2980; heat recovery ventilation: £4593; PV solar panels: £7340; and associated electrical work: £1700; total: £23450. This was less than 12% of the total build cost.

Nitty gritty

The conversion part of the house has new floors and windows and is completely dry-lined and insulated using mineral wool and PIR board insulation, breather membranes and foil vapour barriers, The new-build part uses Kingspan Tek SIPs (structural insulated panels) for the walls and roof. No steel is used but there are glulam beams supporting the roofs. The Tek panels comprise sheets of OSB (oriented strand board) bonded each side of expanded polyurethene insulation, lined with foil-faced PIR and plasterboard internally and clad with Siberian larch to the walls and concrete tiles on the roof, over a breather membrane. The site sloped so floors are mainly solid concrete with a suspended 'beam-and-block' floor over about one third of the new build. Over these is 150mm PIR insulation and a screed incorporating underfloor heating pipes.

Doors and windows are all triple-glazed Velfac - wood inner frames with the glazing in powder-coated aluminium sashes - plus one triple-glazed Velux roof window. The house was designed to make the most of passive solar energy. Most of the glazing is south-facing with two windows on the east side to take advantage of the best views and the morning sun, a little facing west for the evening sun, and the bare minimum on the north side. Building on the edge of the wood gives some shade from the heat of the summer sun while, once the leaves have fallen, winter sunshine provides warmth via the south-facing windows. This sun falls mainly on the concrete floors which help store the heat. Half the south side of the house has roof overhangs to shelter the patio doors and give some shade from midday summer sun, reducing overheating, while the winter sun is lower in the sky and so can shine right in to warm the house.

The conversion has tube-type thermal solar panels on the south slope of the roof which provide plentiful hot water when the sun shines and the system is working (see below) while there are twelve 250W photovoltaic solar panels on the new-build roof, providing a theoretical 3kW of free energy.
A 5kW air-source heat pump (ASHP) provides the heat for the underfloor heating and heated towel rails, and for domestic hot water when the sun isn't shining. Each space has its own thermostat - there are six 'stats controlling seven heating loops - so we can set different temperatures and programmes for each space. We have the thermostats set to 21C in the living/dining/kitchen areas and bathrooms and 20C in the bedrooms, and a minimum of 18C during the night.

The house is very leak-proof (thought we have opening windows for mainly summer use) and ventilation is provided by a whole-house mechanical ventilation unit with heat recovery (MVHR) via a heat exchanger. This sits in a plant room in the roof space along with the hot water storage cylinder, the solar inverter, expansion vessels, pumps, and assorted ducts and pipes. The mechanical ventilation means windows don't need trickle vents, the kitchen and bathrooms don't need extract fans, and we have filtered fresh air even when the windows are all tightly shut.

Batteries with the
inverter above,
the car charger
(and an e-bike)

*postscript

first published November 2021

In 2020 we bought a small electric car, fitting a charging point in the car port and charging the car from grid electricity supplemented by power from the PV panels on sunny days. Our electricity usage went up but then we spent far less on petrol!

About a year ago, we decided to install ‘home’ or ‘solar’ batteries. Again, these are sited in the car port. Installation of both car charger and batteries was very straightforward: there is an easy, direct cable route in the roof space from the car port to the consumer unit and the batteries connect to the PV wiring just above, in the plant room. Our PV system’s inverter is not a hybrid type so a separate inverter was needed for the batteries, but this comes with a smartphone app which gives excellent control and information both for the batteries and the solar output.

The batteries charge using any surplus power from the solar panels which only need to feed into the grid once the batteries are fully charged (at a little under 10kWh) and the household electrical needs are met. They can also be programmed to charge from the grid, so we switched supplier to access the Octopus Go tariff which gives us low-cost nighttime electricity to charge the batteries and/or the car. The result is that we spend less on electricity, and demand on the grid, especially at peak times, is reduced. Octopus are very innovative and are introducing clever ways of using electricity flexibly to balance out demand, reduce costs and lessen the need for fossil-fuel generation.

A further advantage of the batteries is a stand-by output which provides back-up power for essential circuits in the event of a power cut (and, with overhead electricity cables in our rural location, power cuts are not unusual).

Care for the aged - for example

In Care for the Aged I wrote in broad terms about the importance, in tackling the climate crisis, of making our existing - and ageing - housing stock more energy efficient. Here I will get much more specific and discuss the practicalities and nitty-gritty.

I spent my childhoood in a neighbourhood on the south side of Sheffield. We had a primary school, a park, shops, a public library, two cinemas, the family doctor, several churches and chapels, a chippy and a couple of pubs all within walking distance. Our housing estate comprised several streets of identical semi-detached houses, most built of ugly faux-stone concrete blocks, with a few of red brick, with bay windows on one or both floors. Built, I think, just after World War II they were a first step into home ownership and lower-middle-class status for working-class families like mine. These quiet streets where kids could play safely, with everything people need nearby, off-street parking and a half-hour bus ride (quicker still on the 'supertram') into the city are still good places to live. The houses are soundly built - not spacious but not cramped either - and have good size gardens. They have many more years of life but need updating to suit modern needs - particularly in terms of energy saving.

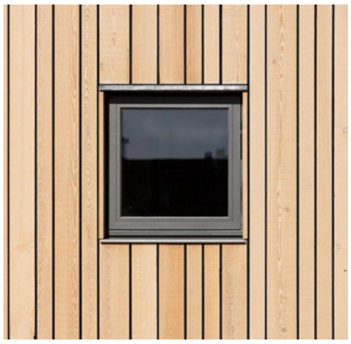
The construction is brick/blockwork cavity walls, tiled roofs, suspended timber floors and wood windows. The house in the middle of the picture was rendered not because of damp problems but because our neighbour's son was a plasterer! By now, most houses have new windows - typically double-glazed uPVC and will have some glass-fibre quilt in the roof and cavity-fill insulation along with new kitchens and bathrooms. Originally heated just by open fires with a back boiler in the kitchen range for hot water, most will now have gas boilers and radiators and most of the chimneys will be disused. Few, if any, will be anywhere near current standards of energy efficiency, but I will suggest how this problem might be addressed.

Insulation

Starting from the top, the roofs of these houses are easy to insulate, and most will have had glass wool laid between and over the ceiling joists. Sufficient insulation here will minimise heat loss via the roof. The roof access hatch should also have insulation and draught stripping.

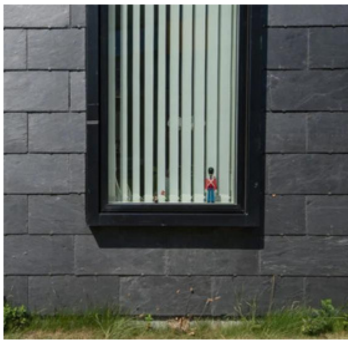
The external walls are a major route for heat loss. The cavity-wall construction provides a small improvement over solid brickwork but its main function was to reduce damp penetration. Many houses will have cavity-fill insulation but this will still leave insulation levels well short of current standards. Internal insulation - lining the walls with insulation board faced by plasterboard - is the best option where external appearances are valued but 100mm thickness of insulation would be needed and this would reduce internal space and require work to skirtings, power sockets and (sometimes) cornices. These houses, though, lend themselves to external insulation. Most are not particularly attractive as built and the projecting eaves means the roofs and gutters can remain as is. 100mm slabs of insulation could be fixed to the outer face of the walls and protected by render or cladding. There are many options for the external finish, each with its own visual style.

Cement render is a popular choice, while larch or cedar boarding are being used more and more. Other options are tile hanging, cement-based planks or slates, heat-treated timber rain-screen cladding,...



External insulation and cladding is ideally combined with replacement windows and doors. Unless these have already been upgraded to a good standard of thermal insulation and air-tightness they are best replaced with triple-glazed windows with good draught-proofing and thermal breaks.

Once insulation has been increased in the walls, roof and windows, the ground floor becomes a serious conduit for heat loss. The original construction had just 20mm or so of wood boards between the inside and a cold, well-ventilated undercroft. The best approach here is to lift and re-lay the boards after filling the spaces between the timber joists with insulation supported by a breather membrane draped over the joists. Another, air-tight membrane below the floor boards will reduce air leakage, and it is even possible to incorporate underfloor heating, as discussed below.

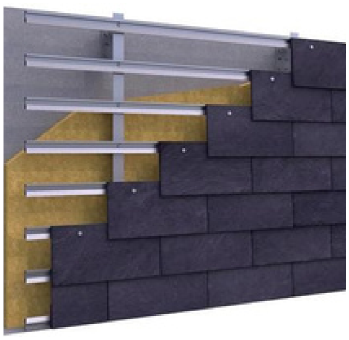


With good levels of insulation in the roof, walls and ground floor, plus triple-glazed windows one of these houses could match the low fabric heat loss of a new house built to today's standards.

Heating and ventilation

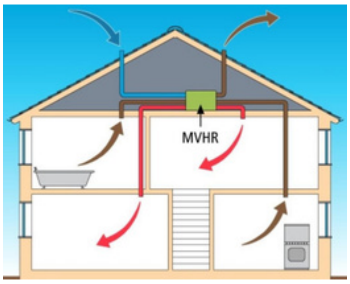
Once insulation has minimised fabric losses (heat flow through the roof, walls, floor and openings) ventilation losses become a much more significant cause of heat loss. The house heating warms up the air indoors but this warm air escapes through open windows, extract fans in kitchens and bathrooms, up chimneys, and through gaps around windows ad doors and anywhere building components meet. A well-insulated but leaky house will lose most of its heat this way.

Step one is to deal with leakage so that ventilation can be controlled (by opening windows and switching on fans) and draughts are eliminated. Many new homes, especially timber-framed ones, incorporate an airtight membrane lining the inside of walls and ceilings and sealed at joins and edges to minimise leakage, but this may not be necessary for existing homes. Plastered walls and ceilings are a good barrier to air leakage, but air can escape around edges - around windows, doors and roof hatches, behind skirting boards and architraves, and where floor joists are built into walls. If new doors and windows are installed they should have good draught-strips and be sealed around the edges, otherwise any doors, windows or ceiling hatches that are retained may need new draught-stripping and sealing.



Suspended timber floors are a major route for air leakage - between floor boards and around edges below skirting boards. The best solution is to lift the floor boards, lay a breather membrane across the joists to act as a support for insulation filling the space between the joists, and finish with an air-tight membrane sealed at joins and edges.

Building Regulations set limits on air leakage through the building envelope but also require mechanical ventilation of kitchens and bathrooms as well as natural ventilation by opening windows and trickle vents. Unintended air leakage is controlled but extract fans throw out large volumes of air together with the energy used in heating it. A much better solution is mechanical ventilation with heat recovery - MVHR. A simple device incorporating quiet-running fans, filters and a heat exchanger (usually located in a roofspace) runs 24/7 pulling moist and sometimes smelly air from kitchens and bathrooms, passing it through the heat exchanger and to the outside. At the same time fresh air is drawn from outside, passed through the heat exchanger and fed into living rooms and bedrooms. Instead of simply extracting warm air and all the energy it contains, to be replaced by cold air from outside, the heat exchanger recovers around 80% of the heat energy in the extracted air and transfers it to the fresh, filtered air being introduced. This enters rooms typically only one or two degrees cooler than the extracted air. Far more heat energy is recovered than is used by the fans, no extract fans or trickle ventilators are needed and windows can be kept closed in cold weather.



The MVHR unit and its ducts are easy to incorporate in a new build, and most existing properties have a roof space where the heat exchanger can be sited and ducts routed to the upper rooms. Most will also have redundant chimney flues which can serve to route ducts from the unit in the roof to ground-floor kitchens and living spaces.

Open fires of course draw enormous amounts of energy from homes straight up the chimney. Wood-burning stoves are more efficient but should have the combustion air fed by an under-floor duct from the exterior. Burning wood does not use fossil fuels but does still produce CO_2 which would be better left captive in the wood - trees being harvested for construction or making furniture rather than for firewood or bio-fuel heating and power generation.

The best current choice for domestic heating is indisputably the heat pump, and air-source heat pumps (ASHP) are relatively easy to install in most existing homes, replacing boilers. They are closely related to refrigerators and air conditioners, and similar in size and appearance to air-conditioning units. Standing outside a house, the ASHP has a fan, a compressor and a heat exchanger which shift heat from the outside air to the house's heating system. In the UK this usually means warming the water circulating through radiators or underfloor heating pipes. The magic of heat pumps is that they can use a modest amount of electrical energy to convert heat from cool outside air to useful heating temperatures indoors. They do this very effectively: one kilowatt of electrical power will typically produce around three kilowatts of usable heating. This ratio (known as CoP or coefficent of performance) is highest where the temperature of the heating medium - the water in the pipes - is warm rather than hot. This is why heat pumps are best paired with underfloor heating where a large surface area (the floor) is heated to a moderate temperature - unlike many radiator systems where radiators can be too hot to touch.

It is widely held that where boilers are replaced by heat pumps a house will need more or larger radiators fitted or, more radically, the whole heating system replaced by underfloor heating, but this does not necessarily follow. Suppose all the advice above has been followed - the house insulated and made airtight so that fabric and ventilation heat losses are drastically reduced - then existing radiators will be able to provide the reduced heating needs while running lower temperatures.

The home owner will have been used, with their powerful gas boiler, to the heating coming on for two or three hours in the morning, shutting off when everyone leaves for work or school, then running again in the evening until bedtime. But underfloor heating usually takes hours to get the floor up to temperature and start heating the house, so cannot heat the house quickly from cold. On the other hand, the floor holds the heat and the house stays warm longer when the heating shuts off. Underfloor heating is best controlled by programmable thermostats which can boost the temperature for the evening and let it drop a little overnight. Now this approach is needed for a system with a high thermal capacity but can be applied to a radiator system too. Running the radiators at moderate temperatures, under thermostatic control, without necessarily shutting the heating off completely - the same heat from lower temperatures for longer.

If the floor boards are lifted to insulate and leak-proof a suspended timber ground floor (see above) there is the opportunity to install underfloor heating which will work well with a heat pump and allow the downstairs radiators to be dispensed with, freeing up wall space. Heat rises and many of us prefer a cooler bedroom, so the original radiators should be fine upstairs.

Making an example

So you bought one of these old houses in Sheffield. Previous owners had installed roof and cavity-fill insulation along with small-bore central heating with a gas boiler but the house is draughty and there are one or two small damp patches where the cavity-fill had allowed water penetration. The original round-pin electrical sockets had been replaced with square pin but the original wiring remains. The boiler is getting old and gas bills are high and set to get much higher with fast-rising energy costs. You are rightly concerned about the climate crisis and very keen to do whatever you can. The house was reasonably priced, being in need of improvement, and your mortgage is not excessive, while the government has recognised that it can only stay in office if it reacts to the increasing public climate and cost-of-living worries and has introduced real, substantial and easily accessible grants and subsidies for energy-saving improvements*.

You double the thickness of roof insulation and fit a new insulated ceiling hatch with a loft ladder. Outside, you give the house a completely new look, adding 100mm of insulation protected by a waterproof breather membrane and larch cladding, fitting new triple-glazed doors and windows, wood on the inside and maintenance-free powder-coated aluminium on the outside with weatherstripping and sealed around perimeters. You have the house rewired and the plastering repaired. The kitchen needs refitting so after stripping out the old fittings you take up the ground floor, seal the walls between the joists with plaster and mastic around the joists, insulate and draught-proof it and lay underfloor heating pipes before replacing the floor boards, consigning the rusting old radiators to the skip, and assembling your new kitchen units.

The old boiler went out with the radiators and was replaced with an air-source heat pump against the back wall feeding the underfloor heating, the first-floor radiators, new heated towel rails and a big, insulated hot-water tank. An MVHR unit goes in the loft with ducts to vents in the bedrooms and bathroom, exhaust and fresh-air grilles at the eaves, and dropping in the disused chimney flues to vents in the kitchen-diner and living room. After a bit of experimentation over the first few weeks, you settle on the right settings for the room thermostats and the heating and ventilation just run themselves with barely any attention needed.
Your roof does not have a large south-facing slope but you have a flat-roofed garage at the back which you re-roof with a south-facing monopitch roof covered in photovoltaic solar panels wired to an inverter and a Li-ion 'solar' battery in the

garage. With the battery, electricity generated by the PV on sunny days when you're not using much energy yourself will be saved in the battery for use in the evening or to charge your new electric car.

You are now the proud and slightly smug owner of a 70/80-year-old house which you have brought right up to date and which can compare with a brand-new home built to Passivhaus standards. The house is the most comfortable one on your street, the most energy-efficient, least polluting, and the cheapest to run, while the estate agent's valuation suggests the improvements have already added more value than they cost. You're not the sort to brag about it but your neighbours are curious and have questions: what did you have done? how much did it cost? In a few years every house on the street, and many more on surrounding streets and throughout the country have done similar things, thousands of sound older buildings have been brought into the 21st century and given many more years of life, a generation of young men have learned new skills and technology, and Britain is a shining example of what can be done to tackle climate change.

* Remember, this is about what is possible, not necessarily what is probable.

first published March 2022

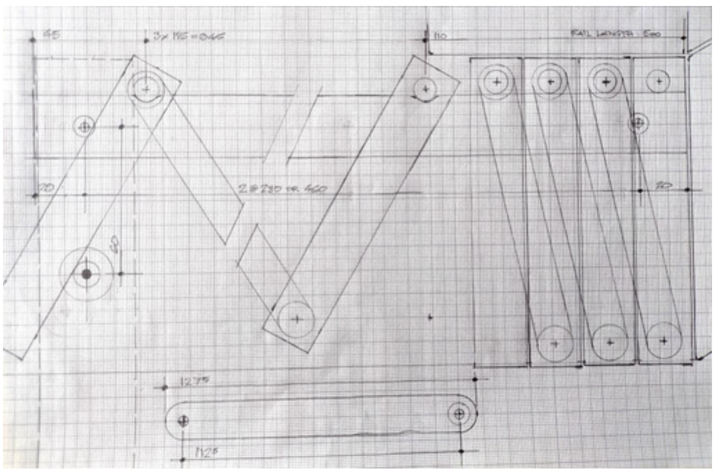
Brise-soleil

Bonjour. I'm not a big fan of French imports into the English language but sometimes (think croissant) there is no good proper Anglo-Saxon equivalent. Literally broken sun, the idea of the brise soleil is to act as a sunbreak, reducing the amount of sunlight entering a window (or glass door) to reduce glare and unwanted solar heating.

Our house has more glass than average and most of it faces south. This is quite deliberate, to maximise passive solar heating on the winter months. We do not, though, have air conditioning and so, like most homes this last summer, the house got a little warm at times. This was the first time I recall it being advisable to keep windows closed to keep the heat out. Most of the south-facing glazing is quite well shaded by a 60cm roof overhang and (deciduous) trees which give summer shade but lose their leaves to let the sun and light through in winter (while simultaneously capturing CO_2). However, our kitchen has a 5.4m run of glazing without shade and the kitchen was the warmest part of the house this summer: bring on the brise soleil!

Brise soleil normally takes the form of louvres and these can be arranged vertically in front of glazing or horizontally, projecting out above windows. In both cases the louvres should stop direct sunlight reaching the glass when the sun is high in the sky, while trying not to block the view or cause excessive loss of daylight. After considering the options I decided on a horizontal arrangement which could (and this is the clever bit) be retracted when not needed. The idea being that the overheating is only a problem during the summer months - June, July and August while in autumn, winter and spring we want all the light and sun we can get. In summer the sun is high in the sky - 60 degrees at midday in midsummer - and a horizontal projection will throw shade well down the window. In winter the sun is low in the sky and the projection does not stop it reaching the window.

The geometry suggested 50cm projection in addition to 20cm already provided by the eaves would shade the full height of the windows and most of the glass door height at midday in midsummer. Our house has larch cladding and so I used larch for the louvres. I wanted them to retract against the fascia below the gutter. The louvre blade width of 130mm was chosen to suit. After several iterations I refined the design as a full-scale sketch.



Four larch louvre blades are each supported by sliders at the top and three aluminium links join them together in such a way that when retracted they are packed together below the gutter (on the right of the sketch) but when deployed the links align them at 60 degrees (on the left).

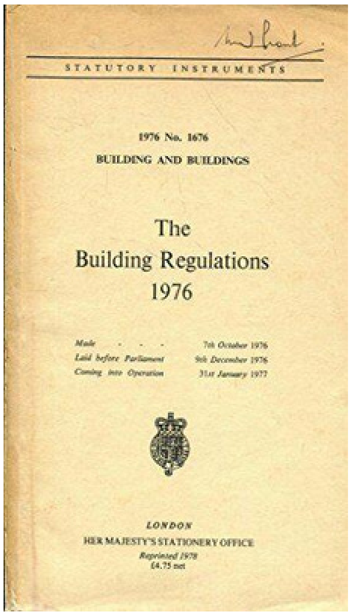
The sliders rest on aluminium rails at each end. The 6m width was too far for a single span so two sets of louvres are supported at centre span by rails fixed to an aluminium post aligned with the post between the window and sliding door. Two more rails are screwed through spacers into the roof eaves and gable.

Stainless steel wires (as used in balustrades) give lateral support to the post and support the outer louvre blade at 60 degrees. The rails have shallow notches along the upper edge to locate the sliders in the deployed configuration. When retracted the louvres sit neatly against the fascia below the gutter.

The larch was supplied by a local sawmill and the aluminium bar, black nylon washers and bobbins to use as sliders and spacers, and the stainless steel cable kits were all sourced online. I shaped, drilled and filed the aluminium components then took them to a local company to be powder coated black. Everything seems to work but it's now September and overheating is not a problem. I have probably messed up our chances of another hot, sunny summer next year though, so... apologies.

first published September 2022

Part O no!



When I began my career as an architect in 1971 the Building Regulations comprised a single small-format paperback volume about 10 or 12mm thick and gave pretty clear guidance on the rules and ways of complying. I am now retired and very pleased I no longer have to deal with the current regs. Over the years the scope of the regs has expanded to include topics such as energy conservation, electrical safety and, most recently, broadband provision and electric car chargers. The PDF file for the current regulations is more than 28MB and includes 18 volumes from Part A to Part S (that's the one about chargers). Not only are there far more rules than there were, covering many more factors, but their complexity has (in my opinion I must add) grown in proportion. Where there were once simple formulae for angles of light to windows or tables of limiting spans for floor joists there are now lists of other documents - British Standards and the like - which designers have to buy and wade through, and increasing dependence on computer software (more expense and expertise required) to comply with such issues as energy efficiency. The whole thing has grown to the point where it acts as a hindrance and disincentive to construction. Now for the real subject of this post, one of the more recent and (in my opinion again) misguided 'approved documents', Part O.

Part O deals, appropriately enough, with the problem of overheating. This in itself is perfectly reasonable. This last summer has seen a lot of overheating. My last post was about measures that we have taken to reduce the problem in our own home. So it is right that the regs should address the problem but has it been done the right way?

Part L deals with energy conservation and has evolved from a few U-values for walls, roofs and windows to very complex and comprehensive rules and provisions covering fabric losses, ventilation losses, solar gain, orientation, exposure, water heating, incidental heat, and more besides, and requiring computer software to demonstrate compliance. Part O is aimed at limiting overheating of buildings by summer sunshine. Part L already deals with solar gains and allows passive solar heating to play a part in reducing energy usage in winter. The document already has a section titled 'Limiting heat gains and losses' and includes guidance on comfort cooling and mechanical ventilation. Large buildings in Britain, with high volume /surface area ratios, glass curtain walls, hundreds of occupants each with a computer, and lights burning all day have required cooling as much as heating for thirty or forty years. Now, with global warming starting to seem very real rather than just a theory, summer overheating is becoming a problem in our homes as well as our office buildings. Air conditioning in homes is commonplace in places like the US and Japan and is starting to appear in home here too. AC controls overheating and consumes energy and it is quite right that comfort cooling and mechanical ventilation are covered in Part L. So why not deal with overheating there too?

We didn't need a Part O but we have it, so let's look at it. There's not an awful lot to look at, thankfully. It targets summer overheating by solar gain - trying to limit it and to deal with it if it occurs. There are two approaches. One is termed 'dynamic thermal modelling' and follows the methodology of CIBSE's TM59. I haven't dug down into this but I imagine more computer software, training and fees will be involved. The other approach is the 'simplified method' which sounds more attractive. This really is simple and aims to limit solar gain by limiting window size and removing any excess heat mainly by opening windows.

size matters

Two tables give limits on window size depending on location (basically inner London or everywhere else, though Manchester gets a special mention), orientation, whether there are opening windows on opposite walls (cross ventilation) and whether the room has more windows than other rooms in the house (??). The limits vary from 11% to 37% of the floor area. The 37% figure is for north or east-facing windows in cross-ventilated homes which is sensible. The reasoning behind some of the 11% limits is less transparent (in my opinion of course).

Now, Part L already has rules which tend to encourage house-builders to fit the small windows seen in most recently-built housing, as windows leak much more heat then well-insulated walls. I seem to remember the regs used to have rules designed to ensure good levels of daylighting in homes, but this highly desirable aim seems to have been abandoned and rooms in modern houses are often gloomier than those my generation grew up with.

Houses used to have bigger windows

As well as limiting window sizes, the simplified method requires windows in inner London to be glazed with low-g glass or shaded by shutters or, for south-facing windows, overhangs. Don't ask me why inner London windows require more protection from the sun - all I can suggest is that large numbers of air-conditioned office blocks and hotels are shifting heat from indoors out and causing the whole city to overheat.

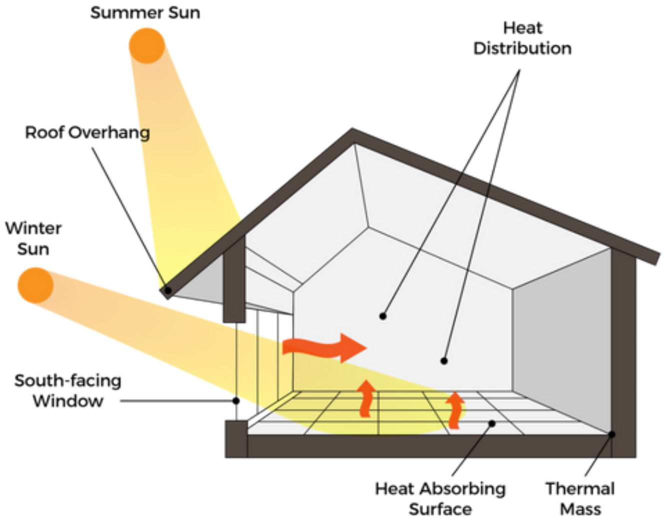
an open and shut casement

So, we have shaded our little windows to ensure the summer sunshine doesn't cause overheating, but if it does then two more tables set out minimum areas of opening windows. Again, location is a factor and cross-ventilation helps, but the minima range from a 4% to 13% of floor area or 55% to 95% of window area. Part O describes this approach as 'passive'. It is worth noting that a sliding sash window cannot even achieve 55% open area and even a hinged casement or top-hung window would struggle to give a free area of 95%.

Now, when Part O was introduced this might have made some sense, but this year, when temperatures were reaching 40 degrees C and exceed 30C for days on end, we were advised to keep our windows shut! If the outside is hotter than the air inside the house, opening windows is going to make things worse, not better. With the severe overheating we had a taste of this year and which is like to be worse in future, passive measures - simple ventilation - is not going to cut it. Part O says mechanical cooling should only be used where passive measures are not enough. I suggest that before many more years that will be more often than not. A further problem with relying on opening windows to deal with overheating is that this can create issues with noise, security, safety and pollution, Part O requires fall protection for windows above ground level (though this actually contradicts guidance in Part K which already deals with fall protection!) but noise, security and pollution may present insoluble problems.

sunny side up

Few house-builders pay attention to orientation. Look at a recent housing development and houses will usually be facing in all directions. Look at traditional homes - cottages, farmhouses and the like - and you will often find the principal rooms and most windows face south(ish). In winter the sun rises in the south-east, is still low in the sky in the south at midday, and sets in the south-west. Windows facing north, east or west will see little or no sun. In the middle of the day, the sun is strongest and, being low in the sky, penetrates to the backs of rooms, lighting and warming them. South-facing glazing gives useful passive solar gain when it is useful. In summer the sun rises in the north-east, rises high in the southern sky and sets in the north-west. It is low but quite strong in the east and west and strong and high in the south and overheating becomes a problem. designing homes so most glazing is on the south makes the most of passive gains in the heating season, saving energy. Windows facing other directions are not such a good idea, leaking heat in winter and risking overheating in summer.



Passive solar energy is free heating: The winter sun is low in the sky and warms homes through south-facing glazing.

In the height of summer roof overhangs, brise-soleil, deciduous trees or other forms of shade help prevent overheating from the high, hot summer sun.

give us a break

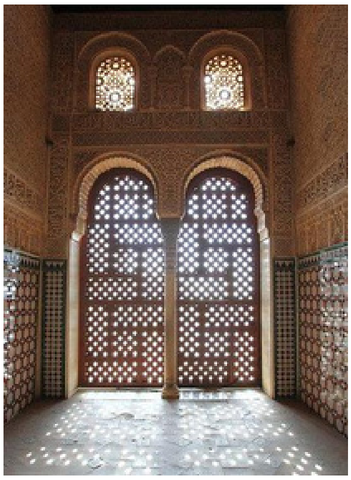
Part O makes no mention - none - of one of the most useful measures to avoid excessive solar gain: brise soleil - literally broken sun. This takes the form of slats or louvres arranged to shade glazing from the sun without causing too much loss of light. My last post described retractable brise soleil we have added to give shade to our south-facing kitchen windows in summer then fold out of the way to allow full daylighting in winter. The louvres extend around 60cm above the window giving full shade when the sun is at 60 degrees elevation at midday, midsummer, but, even if deployed would still allow the low winter sun to warm the space. We have other south-facing glazing but this is shaded by roof overhangs or trees. The most energy-efficient solution is to concentrate glazing on the south side to maximise passive heat gain in winter and to use brise soleil to minimise unwanted heat in summer, but Part O has nothing to say.

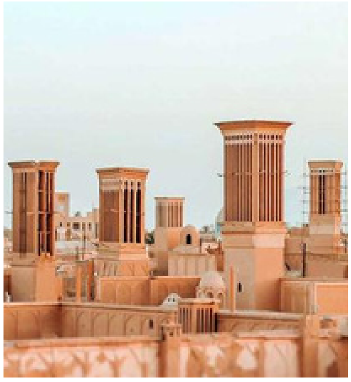
Given that we were advised to keep our windows shut and draw the curtains when things got bad, how do we cope when they get worse? Traditional middle eastern homes use features such as mashrabiya - screens to give privacy and shading and allow ventilation - wind-catching towers for through-ventilation, and shady courtyards with pools and fountains to cool the air. A few modern buildings incorporate ventilation 'chimneys' using natural convection - passive stack ventilation. These approaches have potential: using water for passive cooling is worth looking at. Beyond these we are faced with active cooling - air conditioning, basically.

mashrabiya to give privacy and shading and allow ventilation

wind-catching towers for through-ventilation

shady courtyards with pools and fountains to cool the air



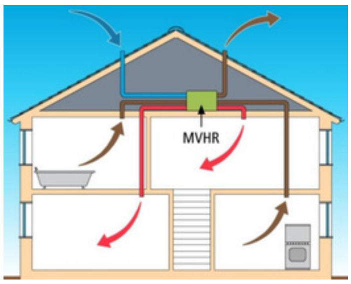


We are moving quickly away from gas boilers to using far more efficient and climate friendly heat pumps to heat our homes in winter. But a heat pump is basically an air conditioner in reverse. Air conditioners usually cool the air but will also heat it. Similarly, heat pumps can be effectively reversed to provide cooling. A single solution can provide complete climate control - less energy-efficient than passive methods but effective in occasional extreme need. The most energy-efficient homes - designed to PassivHaus and similar standards - use heat recovery ventilation (mechanical ventilation with heat recovery - MVHR) rather than relying on extract fans and opening windows. Quiet, draught-free and very economical on power, MVHR recycles the heat that would otherwise be thrown out by extract fans (or passive stack ventilation). These low-energy homes need very little extra heat in winter and this could be provided by a low-power heat pump extracting even more heat from exhaust air to warm the fresh air supply. Making this heat pump reversible would allow it to cool the incoming air in hot weather, dumping the heat to the outside, just like air-con. More energy-efficient still would be passive water-cooling of the supply air, possibly using cool water from an underground water-harvesting tank.

I think I have thrown in enough ideas to show that Part O is desperately limited and, although relatively new, already out of date. It should be scrapped and overheating and cooling strategies should be integrated with the energy conservation and heating rules and guidance in Part L. If simple tables, formulae and rules of thumb are inadequate, easy-to-use software should be made available for free, Some computer-aided design solutions already incorporate or link with environmental design software.

Summing up, the Building Regulations have evolved to the point where rather than enabling safe, healthy, energy-efficient, future-proofed buildings they complicate and hinder the design process. Part O in particular is unfit for purpose and a rethink is needed of all aspects of the regs that impact climate control and energy conservation in order to encourage, not hinder, the design of low-energy, comfortable, well-lit homes.

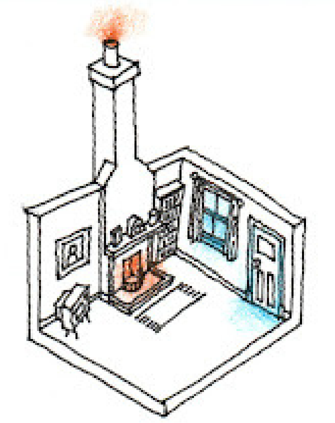
MVHR recovers heat from extracted air to warm fresh, filterd supply air



first published October 2022

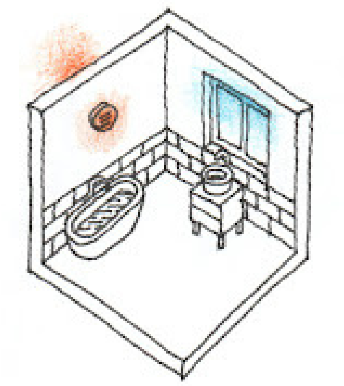
New lives for old chimneys

.(or ideas for heat recovery in older houses)



In olden days...

Right through the first half of the twentieth century the typical house had a fireplace in each of its principal rooms. A pair of semis or terrace houses might share a chimney stack with eight chimney pots, one for the front room, dining room and front and back bedrooms in each house. These fireplaces were open to the rooms and even without a fire thermal convection caused volumes of warm air from indoors to escape up the chimney to the outside, replaced by cold air from outside drawn in through air bricks or as draughts under doors and around leaky windows. With a fire lit to really drive convection, this loss of heat was multiplied.

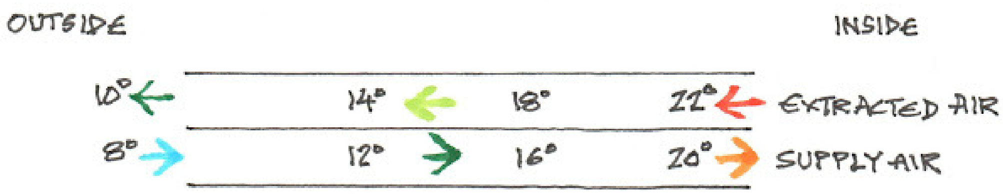


When I was a boy...

Since the sixties central heating grew to be almost universal and houses were built with fewer chimneys and most new homes now have none. Older houses were retrofitted with boilers and radiators and fireplaces were blocked up. Building regulations have required increasing levels of insulation and air tightness, reducing fabric heat losses (through walls, roof, doors and windows and floors, but necessitating extract fans and trickle vents to give adequate ventilation. With more insulation fabric losses have reduced but extract fans pump warm air straight out of the home pulling cold air in to replace it, so ventilation heat loss becomes a major factor.

These new-fangled ideas...

A tiny (but increasing) number of new homes are built to the Passivhaus standard or close to it. They incorporate very high levels of insulation and air-tightness to minimise the need for heating. They still need ventilation though, but rather than throw heat away via extract fans they have mechanical ventilation with heat recovery (MVHR). A central unit, often sited in the roof space, has fans to extract moist or smelly air from the kitchen and bathroom and pull in fresh air from outside and filter it to supply to the living spaces and bedrooms. That's the MV bit. The HR bit is the clever part and is amazingly simple: a heat exchanger with a double labrynth of air channels bringing the warm extract air into close contact with the cooler fresh air supply without letting them mix.



Imagine the heat exchanger channels as two ducts sharing a thermally conductive wall. The temperatures in this explanation are based on actual measurements I took on our own MVHR system. The house is heated to 21-22C while the outside temperature is around 8C. The fans run quietly but continuously passing outgoing and incoming air in opposite directions. The extract air from the kitchen and bathrooms enters the heat exchanger at 22C while clean, fresh air arrives in the house at 20C. Outside, the supply air is drawn in at the ambient temperature of 8C while the expelled air is a little warmer at 10C. All the way through the heat exchanger the extract air is a couple of degrees warmer than the supply air but is giving up it's heat to warm the incoming air - heat recovery. Instead of throwing out 11-12C of heat just around 2C is lost and around 85% is retained. Ventilation heat loss is slashed.

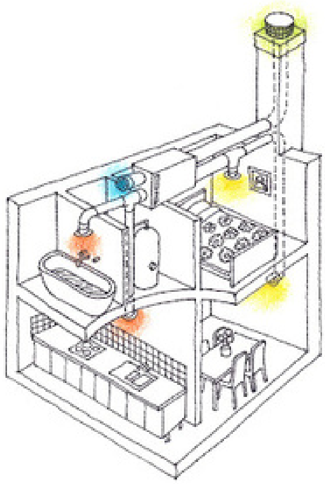
Distributing air to and from all the rooms in a house from a central MVHR unit can involve quite a lot of ducting. If it is designed into a new house this need not cause any problems. Even in many existing homes - especially bungalows - it may still be easy by using the roof space. In a two or three storey house, though, routing ducts from several rooms on lower floors to a central point and then arranging main supply and exhaust ducts to the outside can be awkward. Which is where I want to come back to the chimney.

Retrofit for purpose

With a very high proportion of Britain's carbon footprint being due to domestic heating, it is essential to make homes more energy efficient. Standards are very slowly improving for new build but we build relatively few new houses and most of the nation's homes are old and leaky. Repair is less wasteful than replace so even if we could demolish and rebuild like they did in the sixties, improving the existing housing stock is a better solution - retrofit. Going beyond the usual cavity-wall and loft insulation and solar panels to wide-ranging improvements to wall, floor, door and window insulation, air-tightness and low-carbon heating is even more effective - deep retrofit.

Once insulation has been radically increased and fabric heat losses minimised, ventilation heat loss becomes more significant and throwing warm air out of extract fans seems an even dafter idea. The answer, we have established, is heat recovery, but retrofitting a whole-house ventilation system, like insulating walls and floors, can be difficult and disruptive. But what if our house has a chimney? Around 53% of homes were built before 1965 and were invariably built with chimneys. Disused and sealed off since the central heating went in, the chimney provides an air channel connecting both floors of the house to the outside via the roof space. In many homes it would be possible to make use of it to route ventilation ducts.

Illustrated is an example where the MVHR heat exchanger and fan unit is sited in the roof space extracting air (orange) through the bathroom ceiling and via a duct from the kitchen, routed through the airing cupboard, and out to the upper part of the chimney where it is exhausted (green) to the outside having given over its heat to warm up fresh air (blue) taken from the well-ventilated roof space and fed (yellow) into the bedrooms though the ceilings and to the ground-floor living spaces via the lower part of the chimney stack. Using the the roof space, a redundant chimney and a first-floor cupboard minimises clutter in the rooms themselves an old house might be brought up to near Passivhaus standard.



first published April 2023