# Retrofit: is Fabric First Really the Best Strategy?

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*Heat pumps drastically reduce carbon emissions and can decrease energy bills. Delaying heat pump adoption by insisting on a 'fabric first' approach increases initial costs and carbon emissions, and extends our dependency on fossil-fuels, without providing any significant upside.*

There is a common misconception that heat pumps are only effective in well-insulated homes. This largely stems from the industry's insistence on a 'fabric first' approach to retrofits, prioritising improvements to insulation and windows, i.e., the fabric of the building, before replacing gas boilers with heat pumps.

Historically, a 'fabric first' approach made sense in the UK, and it is still appropriate for new builds. However, this is no longer the case for retrofits due to several key developments that have changed the economics and the carbon impact of heat pumps, and increased the urgency of getting off gas:

- **Gas prices** have risen faster than electricity prices. Not long-ago electricity cost 6 times more per unit than gas, whereas now it only costs 3.3 times more. This changes the economics significantly. Previously without fabric upgrades, energy bills would increase for all but the very best heat pump installations; now even an average heat pump installation won't increase your bills. The cost ratio may change, but forecasts suggest it will stay in a range where good heat pump installations will reduce bills.
- **Heat pump performance** has improved in the UK due to a combination of better products and a growing community of heat pump engineers who focus on getting excellent performance from their installations.
- **Carbon intensity** of electricity production in the UK has declined by about 65% since 2012, so replacing a gas boiler with a heat pump today would more than halve a home's annual carbon emissions, making it by far the most impactful measure you can take in a home to reduce emissions.
- **Global temperatures** have risen by 1.09°C from 1850-1900 to 2011–2020. We've already begun to see the awful and costly impacts from even this relatively modest amount of warming. Delaying good action in search of perfect action is indefensible.
- **Energy security** has become a priority due to Putin's fossil-fuel funded invasion of Ukraine.

Combined, these factors now mean that heat pumps can reduce bills, more than halve a home's carbon emissions and improve energy security, without resorting to deep fabric upgrades. Delaying heat pump installations by insisting on deep fabric retrofits is therefore delaying achieving net-zero goals with very little justification. Many in the industry are realising it is time for a fresh approach – and we agree.[1]

## But wait, do heat pumps actually work in poorly insulated homes?

Yes! Heat pumps are used all over the world to heat enormous buildings which need far more heat than any home. All that is needed for a heat pump to keep a home warm is for it to be able to provide heat at the same rate the home loses it. A poorly insulated home might need 20kW of heating power on a cold winter day. There are

heat pumps that can produce 1000's of kW of heat. There is absolutely no problem finding heat pumps with adequate power to heat your home. So where does this myth come from? It's mostly about radiators.

## It's all about the radiators (and flow temperature)

Your radiators must be able to distribute the heat generated by the heating system as fast as it's produced. Historically we achieved this by running very hot water through small radiators. We did this because producing cooler water in a gas boiler made a corrosive condensate that we did not have the technology to deal with. We cracked this problem in the 1980's and since 2005 all new gas boilers fitted in the UK are condensing. Condensing gas boilers are up to 10% more efficient when run at lower flow temperatures, but despite this they are often set up to run at very high temperatures.

Radiators with very hot water in them output heat at a tremendous rate. That means we've become used to turning the heating on for brief periods, which warm up our homes very quickly. That feels economical, because you don't have the heating on for long, but you're really just asking your heating system to produce huge amounts of heat at a low efficiency. (For more on turning down your boiler temperature to save money right now see Nesta's money saving challenge).

This is especially important for heat pumps as their efficiency relates even more strongly to flow temperature. Domestic heat pumps can produce very hot water (up to 70°C+) but this reduces their efficiency. The lower the flow temperature, the more efficient the heat pump, lowering both energy bills and carbon emissions. So, running heat pumps at as low a flow temperature as possible is key to maximising the benefits a heat pump can bring.

If you turn the flow temperature down from 70°C to 45°C you more than half the radiator output. You can offset that reduction by:

1. Increasing how long the heating is on for, so the radiators emit heat at the same low power, but for longer.
2. Increasing the radiator area (e.g., replacing single with double panel radiators) so the radiators emit heat at a higher power despite the low flow temperature.
3. Improving the home's insulation so the reduced heat output from the radiators is adequate to balance the home's heat loss.

The cheapest solution will normally be some combination of points 1 and 2. It may also be sensible to upgrade the insulation, but the decision should be taken with a clear understanding of each alternative, rather than based on dogma.

## Don't heat pumps increase energy bills and fuel poverty?

Simply put, no. A good heat pump installation should decrease your energy bills. Let's look at how this is possible. The cost of a unit of heat is dependent on the cost of the energy source, combined with the efficiency of the heating system itself. As heat pumps are powered by electricity, which is more expensive than gas, they need to achieve a greater efficiency to offset this cost difference. Exactly how much greater that efficiency needs to be is dictated by the ratio of the cost of electricity compared to the cost of gas.

In October 2021 electricity cost 5.1 times as much as gas per kWh. A heat pump would need an efficiency 5.1 times better than a gas boiler[1] to reduce bills at those running costs (slightly lower if the home also disconnected from the gas grid). Only the very best heat pump installations achieve that. In that context, the 'fabric first' approach provided a solution in that, if you carried out insulation measures at the same time as your heat pump install, your bills could go down. Your bills would of

course have gone down even more if you had just done the insulation and kept the gas boiler – but the insulation helped disguise the fact that the heat pump alone would have increased bills.

However, with gas prices now soaring due to the war in Ukraine and renewables limiting the impact of gas prices on electricity prices to at least some extent[4], plus with 'green levies' removed from electricity bills under the energy price guarantee, that ratio has come down to 3.3. That means a heat pump needs to be 3.3 times more efficient than a gas boiler to reduce bills, which for a typical gas boiler with an efficiency of 85% means the heat pump needs an efficiency of 2.8 (or 2.6 if you disconnect from the gas grid completely, negating the standing charges). There is obviously a great deal of uncertainty about where wholesale costs and government support will go. Current forecasts suggest that while the ratio may increase, it will stay in a range where good heat pump installations will reduce bills.

For houses on direct electric heating – disproportionately lower-income households – the case is much more straightforward[5]. Heat pumps use the same energy source but are more than 3 times more efficient, meaning that heat pumps will slash bills in these homes. Despite this we  hear concerns that installing heat pumps in houses with electric heating will exacerbate fuel poverty: actually it helps to reduce it.

Finally, heat pump technology continues to improve[6], whilst increasing installer familiarity with heat pumps has resulted in improved installed performance. Engaged installers and an active monitoring community are showing just how good heat pump performance can be. Greater policy focus on installation quality and performance monitoring would be a far more productive than pushing for a 'fabric first' approach.

[1] A typical gas boiler has an efficiency of 85% so the heat pump would need an efficiency of 5.1 * 0.85 = 4.3

## Can the grid cope and produce enough renewable energy to electrify everything?

Perhaps the most valid argument in favour of a maintaining a 'fabric first' approach is that it helps to limit the extent that we will need to upgrade grid infrastructure and build out renewables. This is certainly a valid concern. We must double or triple the capacity of our existing electricity systems to enable the electrification of transport, industry and heating to be able to achieve net-zero goals. This will certainly require country-scale renewables alongside significant upgrades to the transmission system. Building out transmission infrastructure is challenging, so it's always worth thinking about whether there are cost effective ways to reduce the scale of those upgrades. Whilst we must certainly keep this in mind, it is also important to factor in the following:

- Modelling of the UK suggests that the 'cost optimal' balance from the system perspective is to reduce heat demand by about 10%[78]. This amounts to a pretty 'light' fabric retrofit, such as cavity wall insulation, loft insulation and some window upgrades. This differs from other countries because of the UK's large wind resource, which coincides well with seasonal heat demand.
- People don't change their heating system very often, which sets a pretty slow pace for heat pump adoption. Fears about what the grid would look like at 100% heat pump adoption shouldn't stop us getting from 0.01% to 5% adoption.
- Technology evolves. Battery costs will keep falling and we'll get better at demand flexibility. Insisting on deep fabric upgrades now to manage peak demand closes the door on those options solving the problem later.
- There is little to no ordering impact here. If we accelerate heat pump adoption now and decide in 5 years that external wall insulation really is the cost-optimal way to reduce the strain on the grid, then we can just insulate those homes then!

## Surely it's sub-optimal to install heat pumps now and insulate homes later?

Yes, it is indeed sub-optimal – but not by very much. If you install a heat pump and later improve your insulation, your heat pump will be larger than you need. That just isn't that bad!

On the cost side, you will have spent slightly more on a bigger heat pump, but the cost of heat pumps doesn't vary all that much with their capacity[9]. You may also have spent more on radiator upgrades than if you had done the insulation first, but those bigger radiators will still improve your heat pump's efficiency even after the insulation improvements.

Your bigger heat pump will cycle (turn on and off) more than a smaller one would have done. Whilst that isn't ideal for efficiency or heat pump lifetime, you can mitigate this risk by installing a model with a good turn down ability (i.e., it can run at a fraction of its max output power).

With the lower upfront costs involved, the small added cost of installing a heat pump now and insulating later is still a better solution than delaying the decarbonisation of your home until you have the cash and time to do everything all at once.

## Are you saying never do insulation?

No! Insulation is wonderful. It makes your home more comfortable, it reduces your bills, and it makes your home more resilient to heat waves and power cuts. But a deep retrofit will cost about £40,000 whereas a heat pump install will cost about £15,000 (see our companion piece on Retrofit Pathways to Decarbonisation for detailed modelling). If you have the capital and time to do so, a deep retrofit of your home will make it a much better place to live. You do have to be careful about material selection and ventilation to ensure a more air-tight home doesn't result in poor air quality or structural issues but this is surmountable with careful design. The approach we are suggesting here is based on the fact that most people cannot afford to do everything all at once and that the benefits of heat pump installations shouldn't be delayed by someone not having the money and time for complex wall and floor insulation.

## So what is the right approach?

We recommend a more pragmatic approach to retrofitting, prioritising bill savings and carbon reductions at a reasonable initial cost. We suggest focusing initially on installing solar, a heat pump, and carrying out any easy insulation measures that haven't already been done. If budgets and the condition of the home allows, the remaining steps can be done over a longer time frame.

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| **Within 5 years** | 1. Easy insulation options. Where they haven't yet been done, such as loft insulation top-ups and cavity wall insulation where safe to do so |
| | 2. Increasing radiator area. Swap out existing radiators for thicker versions, and/or add more radiators. |
| | 3. Behavioural shifts. Run heating systems at a lower flow temperature for longer. This also saves energy with existing gas condensing boilers. |
| | 4. High-quality heat pump installations, running at as low a flow temperature as possible with weather compensation. |
| | 5. Solar panels, to reduce the cost of electricity. |
| | 6. Window upgrades. Install high quality, well fitted double-glazed windows when the existing windows need replacing. If the existing windows are of a low quality (single or pre-1998 poorly sealed double glazing) then it makes sense to replace them sooner rather than later for cost, carbon, comfort and air-quality reasons. |
| **Longer term** | 7. Suspended floor insulation, when access allows. |
| | 8. External wall insulation, when the capital is available and where the exposed wall area is a significant proportion of the external area (often not the case in terraces). Due attention should be paid to moisture management. |
| | 9. Internal wall insulation, with extreme care, given the very real moisture management risks that it brings. |
| | 10. Solid floor insulation, if you are smashing up the floor slab for some other purpose (like you want the delights of underfloor heating). |

## Does this also apply to new builds?

No! Retrofitting insulation is expensive and complex. Designing and building a new home properly from the beginning isn't. Add to that the fact that new homes, properly maintained, will stand for about a hundred years and you see the picture is very different. Investment in better fabric for new build is cheaper, and has a longer lifetime to return the investment, than retrofitting insulation in existing homes. Of course, new builds should also have heat pumps and solar installed from the beginning, rather than wasting money on soon-to-be-obsolete gas infrastructure and gas boilers that will only need to be ripped out to meet our climate goals. So, for new builds it really is a 'do everything, all at once' situation.

Hopefully we've made a strong case for a more pragmatic approach to retrofits, that prioritises cost effective measures to not only decrease your homes carbon emissions but also decrease your energy bills.

For a detailed look at how this approach compares to other strategies, please see Retrofit Pathways to Decarbonisation produced using our proprietary energy model 'Hedgehog'.

***Author: Steph Willis is one of Sero's dedicated data scientists and our resident heat pump expert, with a wealth of experience in maximising the potential of this innovative technology.***

**Endnotes:**

1. Insulate Britain? Yes, but by how much?, Richard Erskine
2. How the energy crisis affects the case for heat pumps, Nesta
3. Good COP/Bad COP: Balancing fabric efficiency, flow temperatures and heat pumps,Richard Lowes, RAP
4. The structure of the wholesale market means that the marginal unit sets the price so only renewables on long term contracts for difference have brought electricity prices down.
5. In modern, well insulated flats direct electric options can make more sense than a centralised heat pump because the losses and reduced control associated with a centralised system become significant when heating load is low.
6. See chart 7 in Nesta's How to reduce the cost of heat pumps February 2022 report.
7. The CCC's balanced pathway in their 6th assessment report assumes that *'energy efficiency and behavioural measures in our Balanced Pathway deliver a 12% reduction in heat demand to 2050'*
8. Elizabeth Zeyen et al's Mitigating heat demand peaks in buildings in a highly renewable European energy system
9. See chart 8 in Nesta's How to reduce the cost of heat pumps February 2022 report