BELLONA
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IS HYDROGEN IN HOME HEATING HOT AIR?

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GAZING INTO THE FUTURE THROUGH A DATA LENSE

Human beings spend more than 70% of their lives in buildings. The pandemic has increased this even further. It is safe to assume that Europeans have spent more than 90% of their lives inside their homes over the past year.

Thus, the transition to a carbon-neutral future needs buildings at the centre of the discourse.

People are asking themselves more and more:

HOW WILL OUR HOMES BE 30 YEARS FROM NOW?

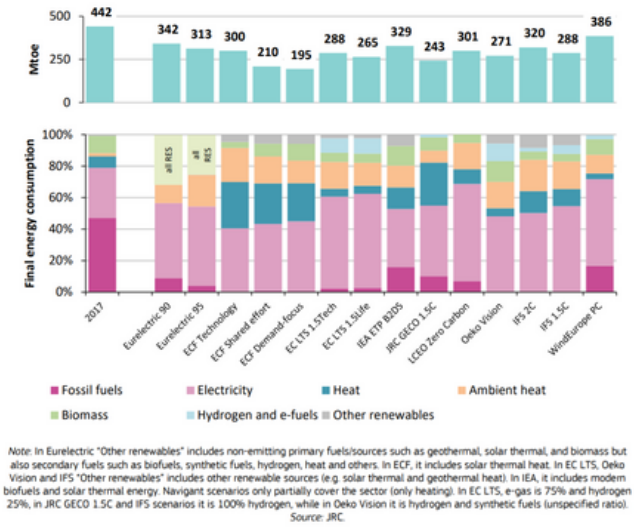
People tend to ponder about this when thinking about sophisticated smart gadgets, technological innovations, or home robots. However, this question permeates the world of sustainability as well. Materials often take the centre of the scene, with innovative circular alternatives alongside more efficient construction techniques able to lower the impact of cement on the environment.

In this briefing, we delve into what will heat our buildings and what role the different energy carriers have to play in keeping our homes warm 30 years from now.

PROJECTIONS SHOW A LOT OF ELECTRICITY AND AMBIENT HEAT, MUCH LESS HYDROGEN

If one looks at the projections for 2050, some clear messages can be derived. Fossil fuels, which today cover almost 50% of the buildings' demand, will shrink substantially as a residual fuel in most cases. Electrification will increase a lot. Today just above 30% of the final energy consumption in buildings is covered by electricity, which is forecasted to rise to over 60%. Ambient heat from heat pumps will increase by up to 7 times more than what we have today, and district heating is seen as increasing in most models. Biomass and hydrogen are expected to cover the remainder of the demand. Scenario-based predictions of future market penetration of hydrogen in energy mix of heat for buildings are mixed. But some scenarios show little or no hydrogen in this market by 2050.

FIGURE 1: FINAL ENERGY CONSUMPTION IN THE EU28 BUILDING SECTOR IN SCENARIOS THAT REACH AT LEAST 90% EMISSION REDUCTION IN 2050



Source: European Commission (2020) "JRC Technical Report: Towards net-zero emissions in the EU energy system by 2050"

HYDROGEN COMES WITH A LOT OF CHALLENGES, AND YET IS AT THE CENTRE OF THE POLITICAL DISCOURSE

Despite the future scenarios indicating a minimal role for hydrogen in the buildings sector, today's political discourse is too focused on hydrogen's big promises. It overlooks its challenges and false expectations that hydrogen will play a central role in heating and cooling in the upcoming decades. Countless discussions gravitate around the need of getting the gas distribution network 'hydrogen-ready' and that hydrogen is already getting blended with natural gas in some demonstration projects using existing pipelines.

The long-term idea is that progressively increasing the amount of hydrogen and biogases will reduce the carbon footprint of the fuels used to heat our buildings. This will require a substantial retrofitting of existing gas networks, given the much smaller size of the hydrogen molecules than methane. Existing pipes are generally not suitable to transport gas mixtures containing a significant fraction of hydrogen.

Home boiler manufacturers are also investing heavily in the development of hydrogen boilers. These boilers will be very similar to those running on natural gas today, and their entire value chain, from production to installation, won't require a massive shift. Given the similarities to the current systems, substantial reskilling of workers won't be needed, and only marginal changes in the production chains will be required. Moreover, such boilers' upfront cost won't be very different from the ones on the market today. Nevertheless, this solution will need consumers to pay for the fuels, whose cost is forecasted to be much greater than natural gas.

HEAT PUMPS ARE A VALUABLE ALTERNATIVE, THAT CAN COME WITH THE ADDITIONAL BENEFIT OF COOLING

An alternative to hydrogen boilers exists and seems to be preferred by most of the models described above: heat pumps. Heat pumps are already a mainstream option in new constructions. For instance, in Ireland, building regulations since 2008 have encouraged the installation of heat pumps.[1]

They are powered by electricity, and instead of producing heat by burning a fuel, they transfer it from outside buildings into their interiors. This makes them up to eight times more efficient than gas boilers.

Moreover, heat pumps tend to be much more versatile, as reversible heat pumps can be used for cooling and heating. With climate change, heatwaves and cooling degrees are becoming more frequent across Europe,[2] making cooling an increasingly more attractive service for consumers, which boilers cannot offer. Finally, heat pumps are best situated to be integrated into a smart grid system, allowing for fast demand response when needed.

Heat pumps can transfer heat from water, ground or air to either water or air, depending on the local conditions and the heating system's necessities. Nevertheless, heat pumps are often disregarded by consumers as they require very high upfront investments.

Moreover, the industry today is mainly focusing on boilers. Therefore a massive shift towards heat pumps would require a complete transformation of the value chain and a thorough reskilling of the workforce.

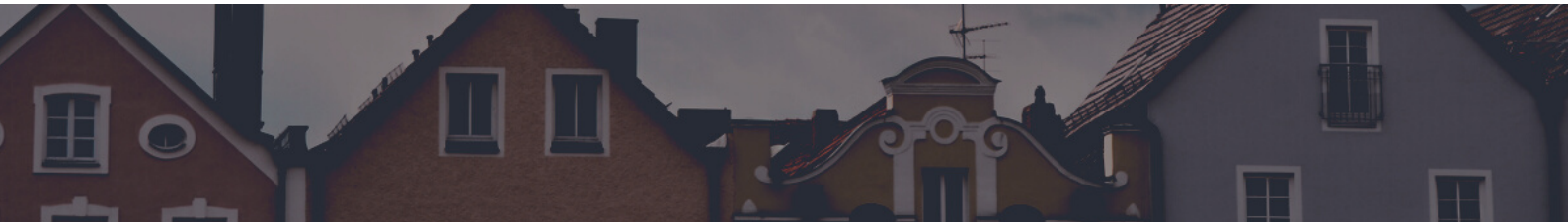
Furthermore, they are last efficient in cold weather, when heat is needed most. Finally, as heat pumps work at a much lower temperature than traditional boilers, insulation plays a big role in their effective functioning and the radiators' dimension.

Given that a significant proportion of European building stock is old and poorly insulated, a large-scale uptake of heat pumps will first require substantial investment in building retrofitting. This cannot be done overnight.

Thus, to reach a vast deployment of heat pumps in 30 years, actions need to be taken in the upcoming decade. The Renovation Wave is looking to shift the European renovation rate from one to three per cent. Ensuring that these renovation activities take a holistic perspective on heating is crucial for this policy's long-term impact.

DISTRICT HEATING SYSTEM ARE THERE TO STAY, AND EXPAND

District heating can also play a crucial role in densely populated urban areas or where excess heat can be recovered. District heating tends to be very efficient and often transform a byproduct (heat in factories) into a valuable good. Moreover, well-designed heating system networks can rely on a central heat storage system that can be used to balance intermittent renewables.



Finally, synergies exist between heat pumps and district heating, as the former can support a shift from current fossil fuels-based systems to renewable electricity-based ones. This will be the case, for instance, in Helsinki, where a seawater heat pump system will be used to convert renewable electricity into heat when this is widely available. This will then be stored as heat and distributed through the district heating system. [3]

Therefore, wherever a district heating system is already in place, it should be maintained and enhanced, and new opportunities sought wherever possible. Wherever not possible, individual heat pumps and, to a lesser degree, hydrogen boilers will come into play. As we have seen, both solutions have upsides and downsides.

However, it's essential to compare them on a level playing field to understand what it is sensible to invest to prepare our buildings for 2050. Three crucial metrics to compare these two technologies are cost, availability of the energy carrier and employment repercussions.

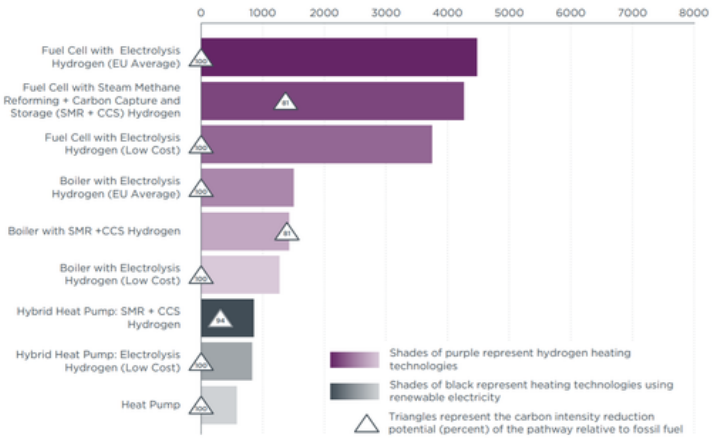
BOTH HAVE HIGHER CONSUMER COSTS: UPFRONT FOR HEAT PUMPS, OPERATIONAL FOR BOILERS

Installing a heat pump bears a much higher upfront cost than installing a boiler, especially when an insulation upgrade is needed. Heat pumps systems can cost up to several times more than their counterparts. However, their operational cost is much lower. The cost of hydrogen in the future is yet to be determined.

However, estimations show that the median production cost in Europe in 2050 will hardly be lower than 5-10 USD/KgH2[4] depending on location and connection to electricity production; to this, distribution cost will need to be added. Conversely, heat pumps are very efficient, thus consume much less energy than boilers. Moreover, the amount of electricity to operate a heat pump will be significantly lower than the electricity required for electrolysis to produce an equivalent amount of heat delivered by hydrogen.

Overall, the ICCT estimated that in 2050 the annuitized capital expenses, operating expenses, and fuel costs to run a heat pump powered directly with renewable electricity from the grid would be 50% lower cost than using a boiler with low-cost electrolysis hydrogen.[5]

FIGURE 2: ANNUAL HOUSEHOLD HEATING COST (EUROS/YEAR)



ES1. Cost comparison and greenhouse gas intensity reduction potential of different technology options for heating a household for one year in the EU in 2050.

Source: ICCT (2021) "Hydrogen for heating? Decarbonization options for households in the European Union in 2050"

Another important cost to be considered is the one to retrofit the distribution network. Electricity grids would need to be upgraded if all the buildings were to be heated by heat pumps. Nevertheless, the irreversible shift to electric mobility will require a similar uptake of power to heat pumps. Therefore a retrofit of the electricity grid will be needed regardless. On the contrary, retrofitting the gas grid to make it hydrogen ready will be useful for hydrogen boilers. Therefore, this cost will have to be entirely borne for one specific use. If hydrogen uptake were limited to particular sectors, such as steelmaking, where few other solutions exist, this would require a much more limited retrofitting exercise than getting the entire gas grid fit for hydrogen.

HYDROGEN WILL BE A SCARCE FUEL; ELECTRICITY WILL BE INTERMITTENT BUT ABUNDANT

Concerning the energy carrier, hydrogen will most likely be a scarce resource. Deploying hydrogen production entails deploying either large-scale renewable generation (green hydrogen) or large-scale carbon capture technologies (blue hydrogen). This is due to the high energy intensity to operate electrolysers, whose conversion efficiency is in the range of 50 to 70%.[6]

On the contrary, heat pumps are powered by electricity. Therefore, they would require renewables' deployment, but not to the same extent that producing green hydrogen would, given the conversion losses.

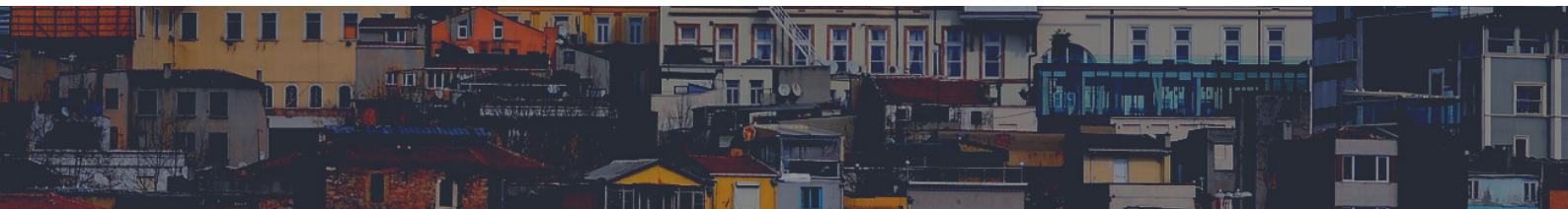
However, hydrogen has the advantage that it can be more easily stored than electricity, thus less impacted by the intermittency of production. To cope with that, heat pumps would need to be integrated with a smart system and benefit from improved thermal storage, which is only possible in well-insulated buildings.

JOBS WON'T BE LOST, JUST TRANSFORMED AND SOME MORE WILL BE CREATED ALONG THE WAY

Finally, the risk of job losses in the boilers production and gas sector is often put forward as a reason to opt for this solution. However, a switch to heat pumps would create a lot more jobs in both the direct production and installation industry and building renovation, given the high need for insulation.

One can't deny that in the industry transformation, some jobs will be lost. However, they will be substituted by others. Reskilling the workforce would allow for a smooth transition and potentially create new employment in the construction sector.

Neither of these solutions will likely take up 100% of the market in 2050. Deployment of heat pumps will be dependent on local conditions and renovation rates. Nevertheless, given the analysed comparative advantages and the projections to 2050, it is most likely that heat pumps will play a major role in the decarbonisation of building heating, covering a significant proportion of the final demand.



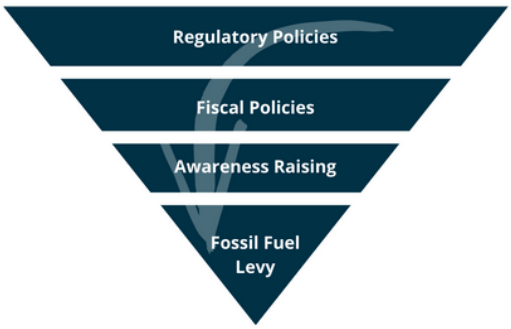
2050 IS IN THE MAKING NOW, THE POLICY CHOICES WE MAKE TODAY SET THE COURSE FOR THE FUTURE

Policies today have a great role to play in determining which energy systems will keep our home warm in 2050. If we consider heat pumps as the most cost-efficient solution that will largely prevail in 2050, a resilient system needs to be built starting from today. As we say in Bellona, net-zero by 2050 will have to be set in motion by 2025 already, and indeed, this very much applies to the heating sector.

Therefore, a potent policy mix needs to be put in place to support heat pumps uptake, and it should include:

- Strict and precise regulatory policies, self-improving standards to show a clear pathway;
- Financial incentives to help consumers overcome market barriers;
- Awareness-raising campaigns to inform consumers and industries about the benefits of this transition;
- A fossil fuel levy to amplify and fast forward the synergic effect of the other policies. This should come after the above, in a supporting role, instead of being in the driving seat for the transition.

HOW TO GET TO A FULLY DECARBONISED BUILDING HEATING SECTOR BY 2050?



Regulatory policies must be central as they set the stage for the way forward. By setting increasingly stricter building codes, governments can make sure that new buildings are equipped with the most efficient heating solutions. Similarly, targeting any building on sale or rent prompts renovation of the existing building stock.

To face the high upfront investment of renovations, as well as the split incentives between tenants and building owners, governments can set up obligation schemes for the utilities (also known as white certificates) to shift some of the burdens away from final consumers and placing on companies with high access to capital.

Shifting support incentives from fossil fuels powered heating systems to heat pumps are probably the most pressing policy. Today, gas boilers and heat pumps are considered two different technologies under energy efficiency regulations. Thus, they can both receive incentives. However, even the most efficient boilers cannot compete in efficiency with heat pumps. Therefore, only the latter should be part of subsidies schemes.
Moreover, despite their high-efficiency boilers today run almost exclusively on natural gas, thus incentivising them to provide subsidies for additional GHG emissions.

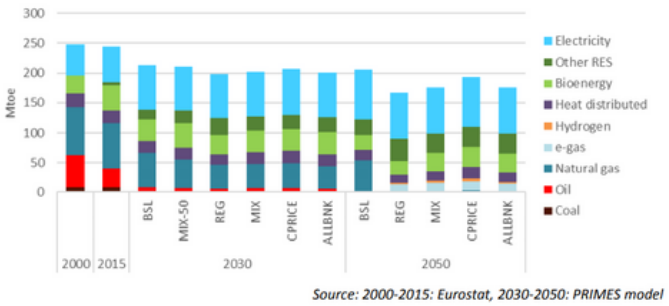
Raising awareness is another important part of the puzzle. As RAP shows in Northern European countries, where the shift to heat pumps is already largely happening, creating a broad awareness across both consumers and industry is a necessary measure.[7]

This implies setting cross-sector heat pump associations, including industry, government and more comprehensive expertise, and using these bodies to provide and lead quality assurance programmes for households and installers. Moreover, this must be complemented with measures targeting the wider public to support consumer confidence.

Finally, countries can impose a fossil fuel levy on natural gas used in homes, putting it on a level playing field with electricity, as the European ETS covers power generation. Nevertheless, it is essential to remember that consumers are not always profit maximisers, thus applying levies alone won't drive the entire transition.

As shown in the graph below, the European Commission's impact assessment has determined that a regulatory scenario (REG) will drive energy consumption down more than a carbon price (CPRICE) one, especially in the longer term.

FIGURE 3: ENERGY DEMAND IN RESIDENTIAL BUILDINGS



Source: European Commission (2020) "Impact assessment accompanying the document: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Stepping up Europe's 2030 climate ambition"

Moreover, the CPRICE scenario is the only one forecasting a residual use of natural gas in 2050. Therefore, regulatory policies and targeted incentives schemes are needed to overcome market barriers and ensure a full transition. Obligation schemes (also known as white certificates) shift the upfront investment burden on utilities and can be useful in convincing those consumers with low access to capital. Moreover, imposed minimum energy performance standards of buildings purchase and rentals can foster the outdated building stock renovation, making it easier to install heat pumps later on.

WE MUST NOT FORGET FUEL POVERTY

Whichever the policy mix, it's crucial to keep energy poverty at the centre of the discourse. As we have seen, installing heat pumps requires a high upfront investment because of the system itself and the renovation requirements.

Whichever the policy mix, it's crucial to keep energy poverty at the centre of the discourse. As we have seen, installing heat pumps requires a high upfront investment because of the system itself and the renovation requirements. Therefore, it is crucial to reinvest at least some of the funds collected through such a carbon pricing scheme to support low-income households. Together with the energy savings, this would bring many other additional benefits, such as improved living conditions and health.

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