



A QUARTERLY JOURNAL FOR DEBATING ENERGY ISSUES AND POLICIES

## Decarbonizing heat in the European buildings sector: options, progress and challenges

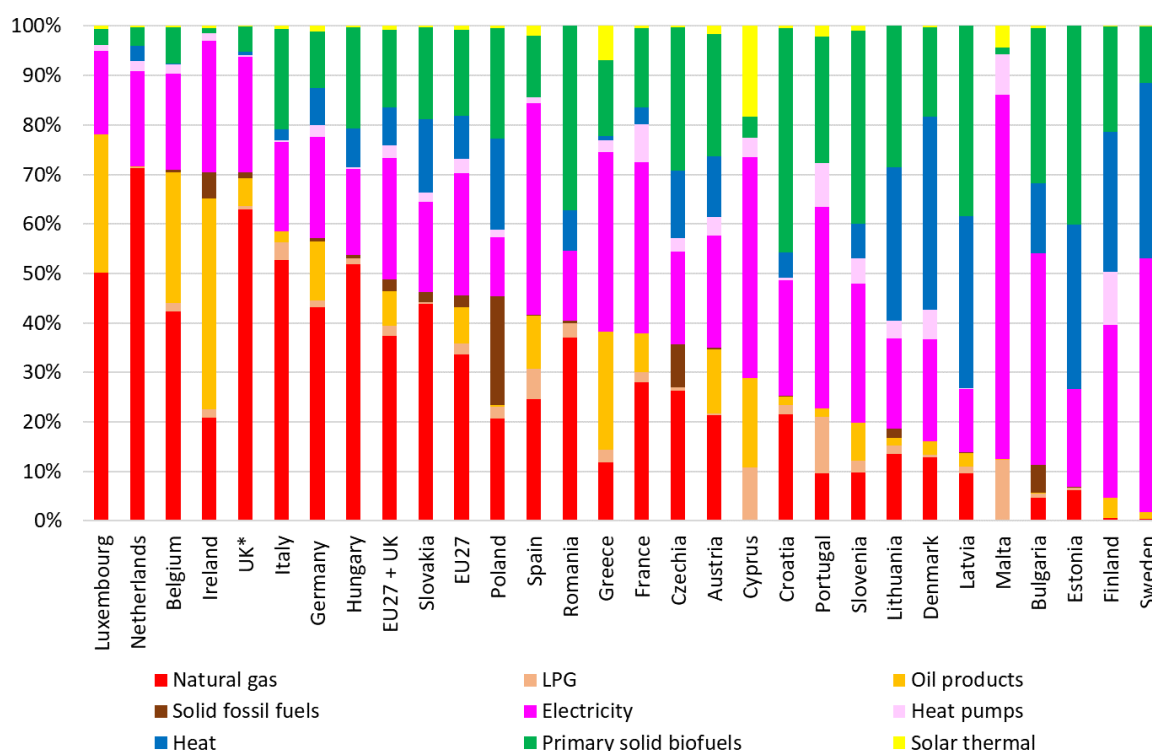
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## INTRODUCTION

This edition of the *Oxford Energy Forum* is dedicated to the challenges posed by the decarbonization of heat in the European buildings sector. Decarbonization of energy systems has become a key topic as both the EU and individual countries, including the UK, attempt to achieve carbon neutrality by 2050. So far, the electricity sector has been the main focus of low-carbon policies, but if the region is to meet its long-term environmental target, efforts will need to expand to other sectors, including the heating sector, which is the region's largest single energy user, covering about 50 per cent of its final energy demand.

Most (nearly two thirds) of the energy consumed for heating is used in buildings, essentially for space heating, though some is also used for water heating and cooking. And although the heating sector is moving towards low-carbon energy, almost half of the energy used in the residential sector still comes from the direct combustion of fossil fuels (natural gas, oil, and even some coal), as seen in the figure below. In 2021, more than 35 per cent came from natural gas alone. Record high gas prices over the past 18 months have increased the focus on how we heat our homes, adding affordability and energy security concerns to the environmental benefits of decarbonizing the housing fleet.

**Figure 1: Final energy consumption in households by type of fuel in 2021**



Source: Data from [Eurostat](https://ec.europa.eu/eurostat). Graph by the author.

\* Note: data for the UK is for 2019.

The energy transition in the European buildings sector relies on two main pillars: lowering the energy demand and decarbonizing the energy supply.<sup>1</sup> Reducing the energy needed to keep buildings warm can be done by improving the insulation and energy performance of existing buildings, supported by behavioural changes by consumers to increase energy conservation. Given the complexity of scaling up deep energy-efficiency retrofits and the significant proportion of old buildings in Europe, it is imperative to look for solutions to decarbonize the heat supply. Alternatives to fossil fuel sources for heating buildings are available (heat pumps, district heating, or even decarbonized gases), but there is no silver bullet. Cities and regions have a key role to play in driving the decarbonization of buildings, as options need to be adapted to local needs and circumstances.

<sup>1</sup> Arguably, a full decarbonization of the buildings sector would require a drastic reduction of the embodied emissions of construction and materials, but this angle is not covered in this issue.



One of the key conclusions of this issue is that the decarbonization of buildings will need to have a central role in the transition to a zero-carbon future, but the task is enormous and lacks implementation speed. Much needs to be done, and some of it will take time. The 15 articles in this edition of the *Oxford Energy Forum* discuss some of the key aspects of the puzzle: the existing building stock, the pace and extent of renovation, and the existing low-carbon options with a focus on heat pumps and district heating, highlighting their main benefits but also the key challenges facing their deployment, the policies implemented and their shortcomings, the problems linked to inadequate taxation, the importance of local diversities, and the issue of energy poverty. Specific cases are used to illustrate these various questions.

The edition opens with an article by *Takeshi Miyamori* and *Ji Soo Yoon* on the decarbonization of buildings in cities and regions. The authors point out that energy sources for space heating and heating methods in residential buildings vary greatly across the EU and may also differ significantly across cities and regions within the same country. Buildings are local infrastructure by definition and reflect different ways in which the population takes shelter from local weather conditions. Building stock also differs across places in terms of age, size, tenure, usage, and energy performance. The authors therefore argue that national governments cannot tap into the full potential for decarbonizing buildings without subnational policy actions and targeted support to cities and regions. They conclude that the energy and climate battle will be won or lost in cities and that only a coordinated effort across national and local governments can get us closer to energy security and a net-zero future.

In the next article, *Mariangiola Fabbri* points out that the diversification of the EU's energy supply and investment in renewables should not be considered the only priorities to decarbonize heating. A new study from the Buildings Performance Institute Europe shows that improved insulation of all existing residential buildings in the EU would alone result in a 44 per cent reduction of energy demand for heating in buildings: 46 per cent in gas savings, 44 per cent in heating oil savings, and 48 per cent in coal savings, with most of it happening in Germany, France, Italy, and Poland. Not only would this contribute significantly to securing the bloc's energy independence, it would also help achieve climate neutrality by 2050. Buildings are a vital infrastructure and should be treated as a priority to reduce energy consumption and achieve decarbonization, through both new construction and renovation. However, surprisingly, they are not yet treated as such. The author concludes that to reach its 2050 net-zero targets and improve its energy security, the EU needs to accelerate building decarbonization with a clear and coherent strategy to jointly reduce energy demand in addition to switching to renewables.

The following articles focus on the development of heat pumps in Europe. We begin with *Alix Chambris* offering her thoughts on whether the current crisis could unleash a *green swan* (unpredicted event that positively transforms the economy) for buildings. The author notes that 30 to 40 per cent of Russian gas imported into the EU in 2021 was used to heat buildings. Overnight, the replacement of gas for space heating became a top priority for energy security, next to climate goals. It presented Europe with a unique opportunity. Changing consumer preferences, the investment readiness of the private sector, and the new policy framework could constitute a critical mass for exponential change: the green swan of buildings decarbonization, which could very well take the shape of a heat pump. The speed and scale of the transformation is difficult to anticipate as the market has been relatively stable over the past decades, but change theory indicates that technological change usually starts slowly then accelerates exponentially. A green swan in buildings would unleash an exponential ramp-up of heat pumps by 2030, a renovation wave, and millions of prosumers (people both consuming and producing energy) benefiting from self-consumption and selling flexibility to the grid. Should the RePowerEU strategy have been called ReHeatEU?

*Thomas Nowak* continues the discussion and agrees that heat pumps need to be one of the main contributors of change, and that this must happen soon. While heat pump sales have soared in recent years, bringing the total number of installed heat pumps to 17 million in 2021, the author argues that we are still way off from where we need to be. The main reason for this shortcoming was, until recently, the low price of fossil-based heating, although investment costs in renewables heating are also still often higher. The author mentions the well-known high up-front investment costs, but also, more surprisingly, the operating costs due to differences in taxation levels (as well as fossil subsidies). The author advocates for policymakers to select the most efficient technology and then implement all necessary measures to deploy it at speed. He reckons that in the long term, renewable energy and heat pumps are the best solution not only for the environment but also for the economy and should be made the imperative of the energy transition. The author concludes that much still needs to be done, and some of it will take time, but action is crucial because we are not acting for the next winter, but for all the winters to come.

Picking up a similar theme, *Michael Taylor* points out that for new buildings in Europe, heat pump technologies are typically the most economical solution to decarbonization, and depending on expectations regarding fossil gas, could also be economic in their own right. However, the same often does not hold true for the renovation segment, although recent technology developments mean some heat pumps are now suitable as one-for-one replacements for existing boilers, even in many poorly insulated buildings. The author also reviews some data on costs and performance of heat pumps from primary sources. Despite the difficulty of making comparisons between countries due to data boundaries, terminology, and availability by technology and market segment, some common themes can be drawn, including the decline of installed costs per kW thermal over time, the presence of economies of scale, and an apparent increase of system efficiency—measured as the coefficient of performance—through time.

*Marek Miara* expands on the application of heat pumps in existing buildings and considers the question whether a house has to be renovated first in order to install a heat pump. Clearly, the less energy needed to create a comfortable indoor climate, the better. That's why renovation measures to reduce heating energy demand always make sense. This applies to all heating systems, not just heat pumps. And based on the monitoring of about 300 heat pumps in the field over the past 20 years, the author argues that houses do not have to be extensively renovated to allow for an installation of a heat pump. Of course, the lower the heat losses, the more efficiently a heat pump can operate, but the research results show that heat pumps as heating sources function reliably also in existing buildings, if installed correctly, and are ecologically advantageous, even if this realization has not yet gained sufficient acceptance. The author mentions another barrier to rapid deployment: the price of electricity for operating heat pumps, which is almost four times higher than the price of heating oil and natural gas in Germany, although this will gradually change with the CO<sub>2</sub> pricing that has been in effect since January 2021.

*Matthias Janssen*, and *Christoph Riechmann* then take the debate in a different direction and advocate for a portfolio of technologies to reduce emissions rather than betting on a single technology. The authors draw attention to a key feature of the buildings sector, which is that heating demand is highly seasonal. Demand in winter months is at least four times higher than in summer, as measured by the seasonality of gas usage, and if such demand were to be met solely by electric heat pumps, the current peak electricity demand would more than double, despite the generally high efficiency of heat pumps. The authors argue that it is hard to conceive practical ways of avoiding at least some use of low-carbon gas either as an energy carrier or for long-term (inter-seasonal) storage of electricity in any national energy system. Without a contribution from low-carbon gas, either the electricity generation system would have to be massively overbuilt or significant seasonal electricity storage would need to be developed. Because of the presence of externalities and the maturity of some of the technologies, policymakers will need to support low-carbon heating options, will benefit from adopting a portfolio of heating technologies, should be as technology-neutral as possible, and should just ensure coordination where needed.

The next three articles provide some important context for district heating solutions. We begin with an article by *Aksana Krasatsenka*, *Michael Wiggin*, and *Andrej Jentsch*. The authors note that district heating represents about 12 per cent of the heating market in Europe and is by far the most common heating solution in the cold-winter countries in northern and eastern Europe. But while district heating has been a gateway to deploying more renewable heat in buildings, natural gas still represents almost half of its fuel mix. They discuss the potential for district heating to supply 20 per cent of heat in buildings by 2030 (with 50 per cent of it supplied by renewables and waste heat) and almost half of Europe's heat demand by 2050. They emphasize that strategies are easier to implement within new networks, but existing networks, 10,000 in total in Europe, also have a large potential to progressively shift to cleaner approaches. The main conclusions are that district heating can leverage economies of scale and might reduce the requirements for building and electricity grid retrofits, and in many cases, it can come with significantly lower societal costs than individual solutions.

We then turn to *Nazar Kholod* and *Meredydd Evans*, who provide further thoughts on this theme, focusing on the deployment of individual heat substations (IHSs) in European countries. Efficient IHSs with thermostatic controls and automated weather regulation can significantly improve district heating efficiency and lower costs. IHSs also make it possible for homeowners to control their heat consumption. The authors explain that the IHS became standard equipment in Western Europe in the 1980s and in Central and Eastern Europe in the 1990s as part of comprehensive district heating reforms. Some countries, like Ukraine, were slow in introducing the IHS. The authors postulate that this could change soon due to Russia's invasion of Ukraine, which has led to a large-scale destruction of buildings and district heating systems. The government of Ukraine is developing a comprehensive building retrofit strategy to renovate all residential and public buildings after the war and reduce energy consumption for heat in residential and commercial buildings by three times between 2020 and 2050. Buildings should be rebuilt or renovated with IHSs added, which would play an important role in decarbonizing buildings and would also provide district heating companies and customers with means to manage heat supply.

The following article by *Kristina Lygnerud* focuses on the potential of urban waste heat. According to the author, this resource could meet approximately 10 per cent of the European heat demand for buildings, but despite strong environmental features (no combustion and locally available), it is not widely used. Important findings from the ReUseHeat project show that technology is not what is hindering urban waste heat recovery implementation, but rather the lack of fitters and installers with the necessary capabilities and the absence of standardization, which leads to contractual discussions having to be undertaken from scratch every time, which is both time consuming and costly. The author concludes that the current context of climate urgency in combination with a war that has forced Europe to shift away from gas has led to a situation where we need to make the best possible use of available resources, and urban waste heat should be one. The technology and the resource are already there.

Moving on to the policy discussion, *Colm Britchfield* provides his perspective on the changing political and policy landscape in the UK for decarbonizing buildings. The UK's housing stock is inefficient, relatively old, and heavily dependent on gas. Tentative attempts to address this over the last decade have mostly ended in failure. The author thinks that the 2022 energy crisis may have marked a turning point in the political treatment of the built environment. However, he also warns that political attention is no guarantee of policy success. Although the UK government is increasingly recognizing that demand-side measures like energy efficiency must play a role in energy and climate security, the energy efficiency market is fragmented and relatively weak, and current policy support is insufficient. To make real progress on efficiency and electrification, new regulation and stable public investment are essential. Industry needs consistent and growing demand, and consumers need more attractive options. Politicians are understandably wary about regulations that bring near-term costs to their voters, but the author argues that the government needs to commit to heat electrification or risk delaying vital private investment. The energy crisis may well have created new political momentum for decarbonizing homes and buildings, and policymakers must not let this opportunity pass them by.

In the following article, *Katja Kruit* focuses on the Dutch market, where over 90 per cent of residential and commercial buildings use natural gas for heating and cooking. The Dutch Climate Agreement aims to phase out natural gas for heating, which means transitioning 150,000 existing buildings per year from natural gas heating to alternative energy carriers and infrastructure. Depending on building and neighbourhood characteristics, electric heat pumps, district heating, or carbon-free gas may be the best options to decarbonize heating. Cost and feasibility studies indicate that in most scenarios, a combination of systems will have the lowest overall costs. The author reviews some of the policy instruments used in the Dutch heat transition and concludes that decarbonization of the national building stock has largely depended on 'soft' policy measures (subsidies and energy tax), but due to the current technical and financial feasibility of decarbonization measures, the conditions are now right to move to a comprehensive package with stronger, regulatory instruments to ensure long-term impact. According to the author, two areas stand out in which there is obvious room for policy strengthening: performance standards for privately owned homes and the introduction of a carbon cap for heating fuel.

*Jacob Janssen* and *Annelies Huygen* continue the discussion about the decarbonization of the Dutch heating sector but provide a different perspective by focusing on the option of district heating. Heating networks are thought to be an attractive alternative for many urban neighbourhoods, but they will need to be built from scratch in the Netherlands. The Dutch municipalities will therefore face two new major challenges in their path to decarbonize their buildings sector: the development of brand-new district-heating systems, and the sourcing of their own energy supply, because the gas supply is organized at the national level. Looking at the example of Denmark, where district heating is popular among consumers and supplies energy to about two-thirds of the population, the article provides some insights into what the Netherlands could learn from the Danish approach to district heating: transparency, instruments (for instance accounting rules), standardized socio-economic and cost-benefit analyses, heat sourcing tools, and a technology catalogue. Cost-based tariffs also help to keep costs low with a local oversight. All these measures help decision-makers and stakeholders make better-informed decisions.

The next article, by *Jakub Sokołowski* and *Maciej Sokołowski*, looks at the specificities of the Polish market. The authors examine the evolution of the residential heating sector during the decarbonization process from the 1990s to 2022. Thirty years ago, energy transformation began with the transition from a centrally planned to a market-based economy, focusing on achieving energy security and the utilization of domestic coal. With the accession to the EU in the early 2000s, policymakers started to focus on energy-related environmental targets, but a series of inadequate policies did not foster a rapid transition in the residential sector. In contrast with the rest of Europe, coal still represents about 30 per cent of the energy used by households, and Poland alone accounts for about 90 per cent of all the coal used by this sector in Europe. The authors argue that the energy crisis that started in 2021 shifted the focus of climate policy goals in Poland to mitigating energy price hikes for residential consumers. Transitioning to low-carbon options will help reach both objectives, and the authors argue that public institutions will need to actively guide end-users through the energy transition.

The final article brings us back to the UK and emphasizes the importance of local specificities. Taking the example of the residential sector in Northern Ireland (NI), *Ryan Madden* explains the challenges of an energy transition in a market where 68 per cent of homes are still fuelled by oil and where 72 per cent also use fires as secondary heating (with coal and peat as common fuel sources). The author identifies a variety of reasons why NI is so dependent on carbon-intensive heating sources, including a shortage of gas network infrastructure, a lack of political will, and the region's lower level of income compared to the rest of the UK and the Republic of Ireland. Lower incomes also mean that many householders in NI feel unable to pay the upfront capital costs for efficient gas boilers or other low-carbon heating sources (such as heat pumps or solar panels), and therefore continue to purchase small quantities of oil at inflated prices. The relative inefficiency of buildings, 50 per cent of which were built prior to minimum building thermal performance standards in 1973, is also highlighted as a key problem. The author argues that there is no 'silver bullet' approach and that a diversified strategy that focuses on renovation, low-income households, pilot testing, heat pumps, and collaboration with the Republic of Ireland would be most effective in ensuring a deep decarbonization of the residential heating sector.

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## DECARBONIZING BUILDINGS IN CITIES AND REGIONS

*Takeshi Miyamori and Ji Soo Yoon*

Buildings are central to the transition to a zero-carbon future. [Almost 40 per cent of global energy-related CO2 emissions come from buildings and construction](#). The ongoing global energy crisis, triggered by Russia's war of aggression against Ukraine, has reinforced the pressing need to improve energy efficiency and energy security in buildings while making sure that buildings help mitigate the impact of climate change. In this context, cities and regions have a key role to play in driving the decarbonization of buildings.

This article first provides a brief overview of building decarbonization across Europe and how it differs from one place to another. Next, it discusses what co-benefits the decarbonization of buildings can have. Finally, it provides concrete examples of how cities can lead the way to decarbonize buildings in co-operation with national governments.

Why does the decarbonization of buildings need to be locally differentiated in Europe?

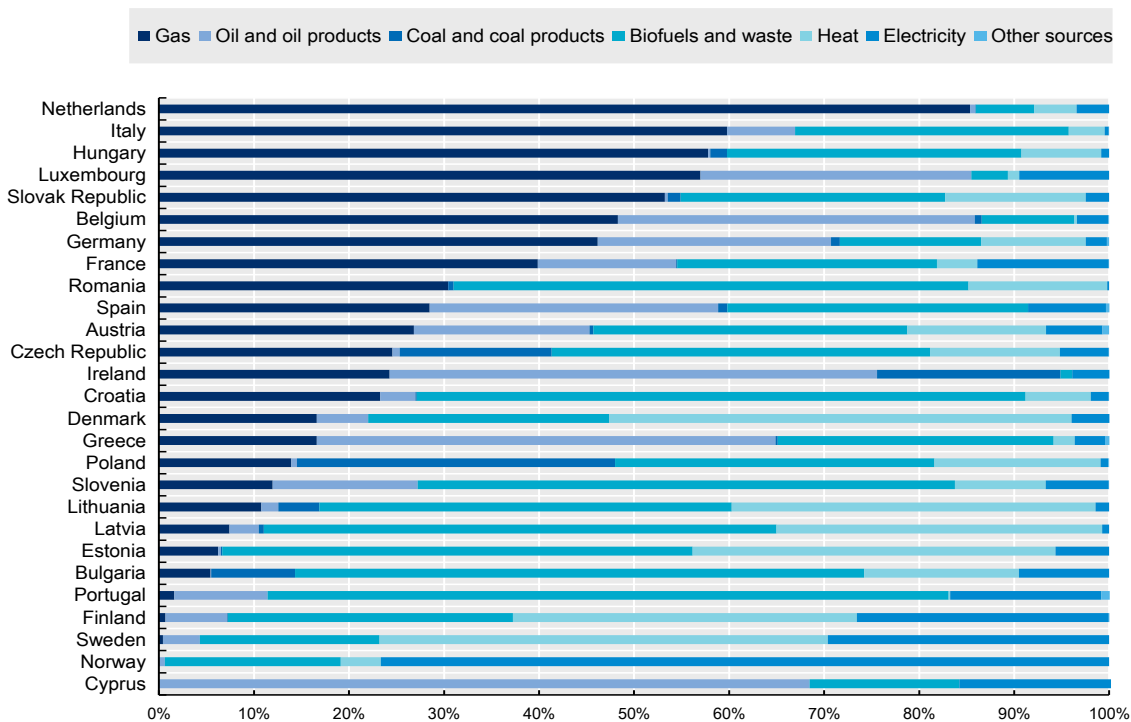
It is estimated that in [Europe, 85–95 per cent of the buildings that exist today will still be standing in 2050](#). Despite large variations across countries, [new housing represents less than 3 per cent of total housing stock in OECD countries](#). Therefore, the energy transition of existing buildings is the backbone of decarbonizing buildings in Europe.

The energy transition in the built environment can be approached from two angles: energy demand and energy supply. Regarding energy demand, it is critical to reduce energy use, and particularly to minimize the amount of energy required for heating buildings. In 2020, space heating accounted for almost two-thirds (62.8 per cent) of the total energy consumption of households in the EU. Taken together, space heating and water heating account for [about 78 per cent of the final energy consumption of households in the EU](#). Reducing energy demand in buildings could be done through residents' behavioural changes on energy conservation and improvements in buildings' insulation and energy performance.

Regarding energy supply, it is imperative to find alternatives to fossil fuel sources for heating buildings. Energy sources for space heating in residential buildings vary greatly across the European Union. The Netherlands is the most dependent on natural gas, whereas Norway is fully independent from natural gas.

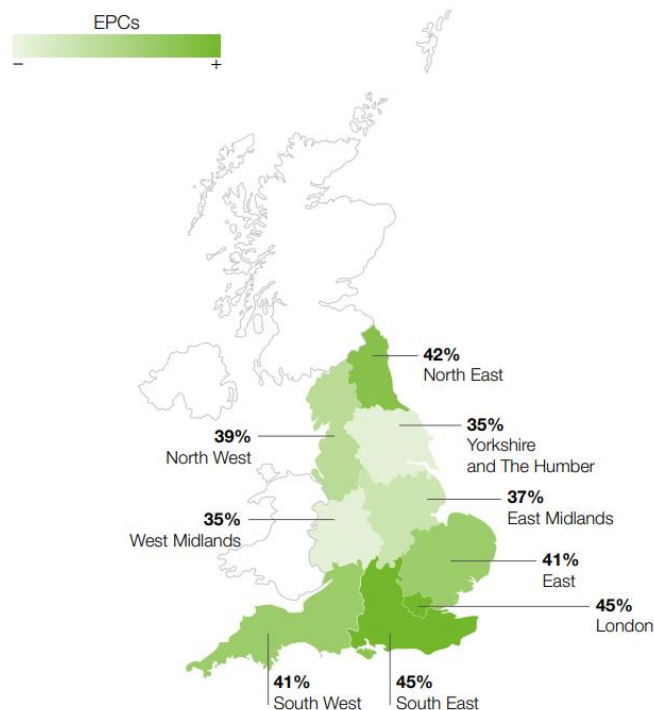
Energy sources for heating and heating methods may also differ significantly across cities and regions within the same country. Buildings are local infrastructure by definition and reflect different ways in which the population takes shelter from local weather conditions. For example, houses in colder regions generally have better-insulated walls, while those in hotter areas have features such as long eaves to minimize exposure to heat. Building stock also differs across places in terms of age, size, tenure, usage, and energy performance. For instance, in the Netherlands, [around 60 per cent of total dwellings in the municipality of Almere have an energy rating of A to A++, whereas this share is only 23 per cent in the municipality of Rotterdam](#). Similarly, regions in England face different energy needs due to the difference in the energy efficiency of building stock. Among nine regions, the three middle regions (Yorkshire, West Midlands, and East Midlands) have more inefficient homes (below the Energy Performance Certificate rating of C) than the northern and southern regions. Therefore, national governments cannot tap into the full potential for decarbonizing buildings without subnational policy actions, and they should provide targeted support to cities and regions.

Figure 1: Energy use for space heating in residential buildings by source (EU27, 2019)



Source: IEA, [Energy Efficiency Indicators](#), and authors' calculation.

Figure 2: Share of homes in England that have an Energy Performance Certificate (EPC) rating of C or above



Source: [HM Government, Heat and Buildings Strategy, 2021](#).

Note: Energy Performance Certificates show the energy condition of the property and consist of an energy label and energy plan. Buildings are rated from A to G, with A indicating the most energy-efficient buildings ([IEA, Energy Labeling Scheme for Buildings, 2021](#)).



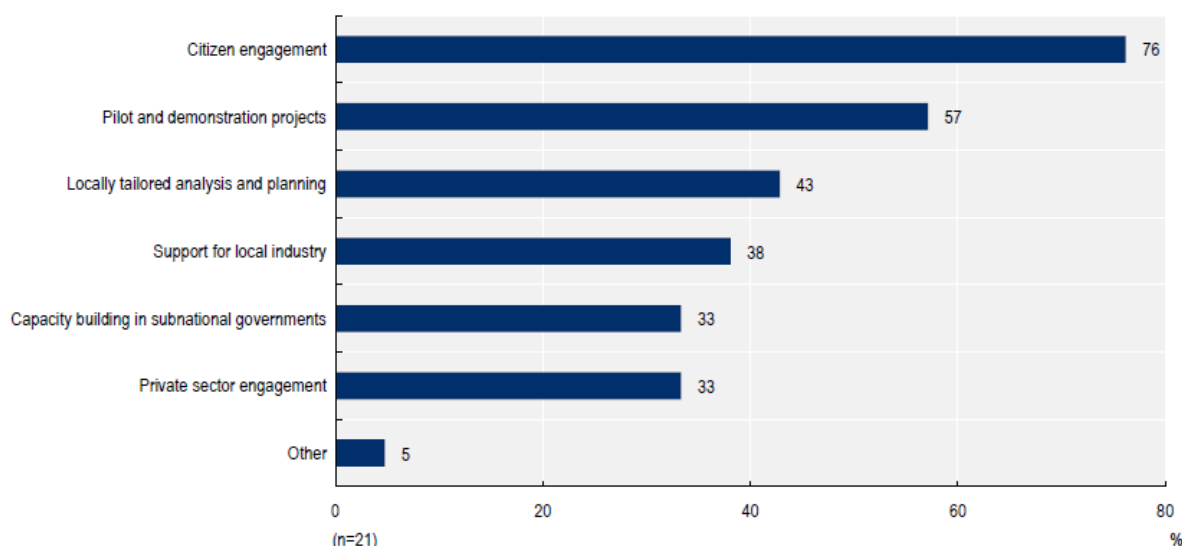
### What co-benefits can cities and regions get from the decarbonization of buildings?

In addition to environmental benefits, the decarbonization of buildings can also help create jobs and improve health. According to estimates from the [International Energy Agency](#), every US\$1 million spent on energy efficiency measures in buildings has the potential to create between 9 and 30 jobs. Measures to improve insulation, heating, and ventilation can also help enhance both physical and mental health, [by reducing respiratory and cardiovascular conditions as well as reducing chronic stress and depression](#). Lastly, decarbonizing buildings can also help achieve social policy goals. According to the OECD survey on [Decarbonising Buildings in Cities and Regions](#), in which 21 cities and regions participated, 89 per cent of cities reported that a primary benefit of energy efficiency in buildings is to help reduce energy bills for low-income households.

### What can cities and regions do to decarbonize buildings?

Cities and regions are deploying a wide range of policy instruments to decarbonize buildings. According to the OECD survey on Decarbonising Buildings in Cities and Regions, the most commonly used measures by cities and regions are citizen engagement (76 per cent of responses) and pilot and demonstration projects (57 per cent). In addition, about 30–40 per cent of cities work on locally tailored analysis and planning, support to local industry, private sector engagement, and capacity building in subnational governments.

**Figure 3: Measures taken by cities and regions to decarbonize buildings ('n' refers to the number of respondent cities and regions and % is the share of the 21 respondents)**



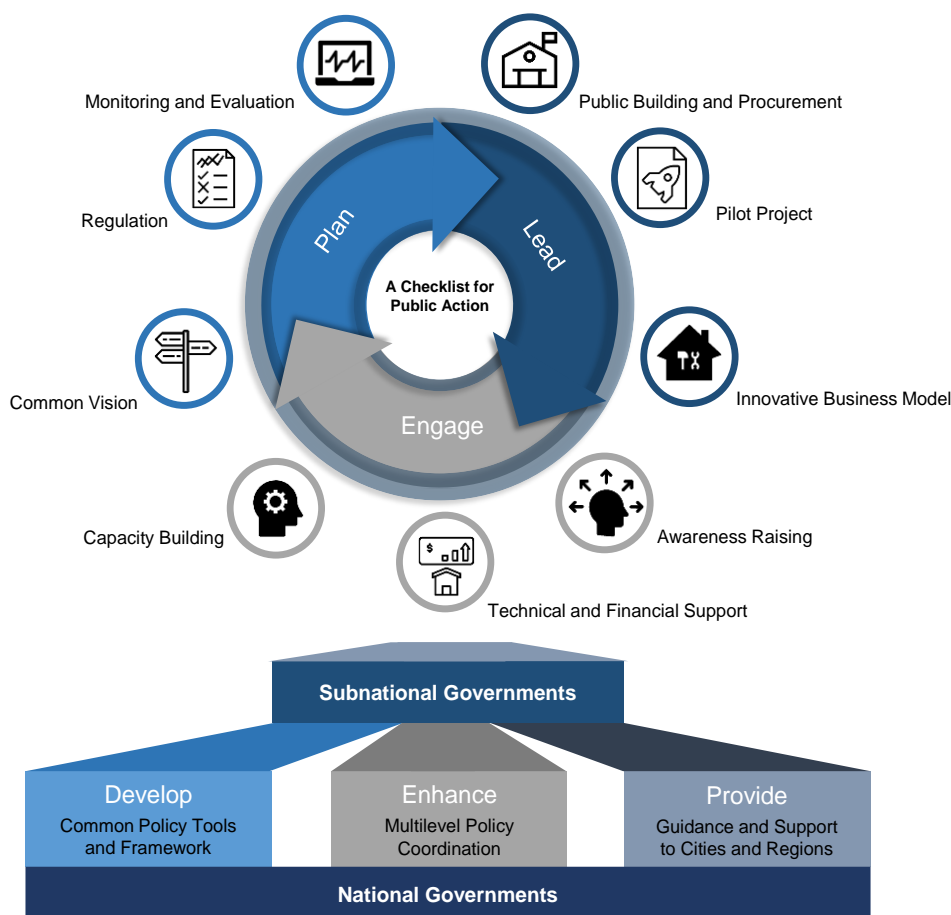
Source: OECD (2022), *Decarbonising Buildings in Cities and Regions*.

Note: 21 cities and regions participated in OECD Survey on Decarbonising Buildings in Cities and Regions (2022). The cities and regions are from different parts of world including Europe, North America, East Asia, etc.

However, according to the OECD survey, 74 per cent of cities and regions reported that they need further support from their national government, for example to scale up pilot projects and raise awareness among the public. Both national and subnational actions are needed to achieve the intended goals and to exploit synergies in a whole-of-government and multi-level governance approach. This is the reason the OECD Checklist for Public Action was created to support policymakers at all levels of government in decarbonizing buildings, through three main types of actions: planning, leadership, and engagement. The following section will highlight examples of cities and regions for each type of action.



Figure 4: OECD Checklist for Public Action to Decarbonise Buildings in Cities and Regions



Source: OECD, *Decarbonising Buildings in Cities and Regions*, 2022

Planning: Geneva spearheads the energy transition through its 2020–2030 Energy Master Plan

As in many other European cities, half of the primary energy consumed in Geneva is used for heating and domestic hot water, 90 per cent of which comes from fossil fuels. The annual renovation rate remains below 1 per cent. To accelerate the energy renovation of the building stock in Geneva, the Energy Master Plan 2020–2030 sets out the cantonal vision to increase the annual renovation rate to 2.5 per cent by 2030 and to 4 per cent by 2050. The plan also includes a [renovation strategy based on studies of the Geneva building stock, and monitoring indicators as well as financial support for homeowners](#). The [Energy Master Plan 2020–2030](#) includes 28 action plans within five themes (Sobriety, Efficiency, Resources, Storage and Management, and Energy Infrastructures), which have been drawn up with all the parties concerned. By including long-term goals and targets, roles, and the responsibilities of key stakeholders, the Energy Master Plan serves as a roadmap towards building decarbonization.

#### **Leadership: Dutch municipalities lead by example to scale up building decarbonization by promoting neighbourhood pilot projects through the Natural-Gas-Free Neighbourhood programme**

In 2018, the Netherlands launched pilot projects under the “Natural gas-free neighbourhood programme” (in Dutch: Programma Aardgasvrije Wijken - PAW). This programme aims to examine what bottlenecks municipalities encounter and which solutions are effective, by testing and starting measures in a pilot neighbourhood. This allows for the development of in-house knowledge by planning the process step-by-step. Also, the energy transition in the built environment comes with a range of technical, social, regulatory, and financial challenges that are difficult to foresee. For the unexpected challenges, Dutch municipalities can provide solutions chance-by-chance while adjusting the new lesson to the next step of the process.

Once the neighbourhoods have been selected for pilot projects, each neighbourhood receives [4 million to €5 million on average](#), depending on investment needs and business cases. Municipalities then implement sustainable measures in the neighbourhood, factoring in local conditions such as the availability of local heating sources and the level of energy efficiency of local building stock. The learning experience from these pilot neighbourhoods is shared across participating municipalities, and the national government aims to scale up the measures to the national level.

#### **Engagement: The Berlin Heating Exchange Programme engages a broad array of stakeholders, citizens, and local businesses to take action in building decarbonization by providing financial support**

In Germany, around half of residential buildings rely on natural gas for heating, and another 24 per cent on oil heaters. To change this pattern, Berlin launched the Berlin Heating Exchange (Heizung tauschen Berlin) programme to channel its renovation funding towards new heating systems such as heat pumps. This programme offers step-by-step guidelines to citizens on how to implement sustainable measures in their homes and what kinds of funding are available to them. Moreover, the programme provides a [one-stop shop of information](#) on heat pump manufacturers and energy consulting services to connect citizens with local businesses.

As part of the Berlin Heating Exchange programme, the city started a [subsidy scheme called Efficient Buildings PLUS](#) in 2022, which helps replace old heating systems. This subsidy scheme exploits synergies with the existing national government's subsidy scheme. For instance, it costs around €20,000 to install a geothermal heat pump in a single-family house in Berlin. [The household can receive up to 35 per cent of this cost from the Federal Office of Economics and Export Control and another 25 per cent from the city of Berlin under the Efficient Buildings PLUS scheme.](#)

#### **Conclusion**

Home to almost half of the global population, cities consume two-thirds of global energy and generate [more than 70 per cent of annual global carbon emissions](#). The energy and climate battle will be won or lost in cities. As illustrated in the examples above, cities and regions are already taking key actions to decarbonize buildings through locally tailored strategies and to overcome bottlenecks in effective and efficient ways. But only a co-ordinated effort across national and local governments can get us closer to energy security and a net-zero future.

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## **ENERGY PERFORMANCE OF BUILDINGS: BEST PRACTICES FOR NEW BUILDS AND RENOVATION**

*Mariangiola Fabbri*

To achieve its climate and energy targets, the EU must decarbonize the building sector, which is responsible for 36 per cent of EU greenhouse gas emissions and 40 per cent of its energy consumption.

The full decarbonization of the EU building stock relies on three pillars: reducing the energy needed to keep buildings warm and functional (operational energy), switching supply from fossil fuels to renewable energy, and decreasing the embodied emissions of construction and materials.

The European Commission committed to tackle buildings decarbonization at the beginning of its mandate by launching the EU Green Deal (December 2019), the Renovation Wave Strategy (October 2020), and the Fit for 55 policy package (July 2021) to double the annual renovation rate in the EU (from 1 to 2 per cent), to foster deep renovation, and to reduce greenhouse gas emissions in the buildings sector by 60 per cent by 2030. In its proposal for a recast of the Energy Performance of Buildings Directive, the European Commission included measures to deliver those objectives more concretely and specified that the building stock should reach Zero-Emission Building level by 2050.

The invasion of Ukraine by Russia in 2022 made these objectives more pressing and driven by energy security concerns. Faced with increasing energy prices and the need to reduce its dependency on gas imports, the EU decided to phase out imports of Russian fossil fuels well before 2030. Rather than reducing energy demand through long-lasting structural measures, this strategy largely focuses on switching energy suppliers and boosting the deployment of renewables and renewable heat technologies.



While these solutions have their merits, diversifying the EU's energy supply and investing in renewables should not be considered the only priority to decarbonize heating. The acceleration of building decarbonization objectives and the recent push for some renewable heating technologies, like heat pumps, makes it necessary to have a clear and coherent strategy to both reduce energy demand and switch to renewables. The push for renewable heating supply should go hand in hand with energy demand reduction (by improving the building envelope, resizing heating equipment, and phasing out fossil-based heating systems), which is a precondition for heat decarbonization, as it allows a faster growth of the renewable energy share in the energy mix.

In recent years, the deployment of renewable heating technologies has grown significantly. Heat pumps are the dominant technology on the market: they have seen annual double-digit growth rates in the past 10 years and are forecast to continue or accelerate this rate in the future. If coupled with a steady decrease in heating energy demand, renewable heating technologies not only would support the decarbonization of heating and cooling in buildings but would also significantly contribute to reducing electricity peak consumption and enabling the growth of renewable heat. In a moment when decision-makers are compelled to find solutions to guarantee energy supply and lower energy prices, it is necessary to consider all solutions, but it is imperative to advance those aligned with the EU Green Deal and the climate agenda. Aligning efficiency measures with the deployment of renewable heating technologies enables optimal solutions in terms of cost-effectiveness, improved comfort for building occupants, reduced CO<sub>2</sub> emissions, low environmental impacts, and energy security.

The time for incremental change is over: policies prioritizing long-term demand reduction and an acceleration of building renovation should go hand in hand with a push for renewable heating.

The EU aims at installing 30 million additional heat pumps by 2030 compared to 2022,<sup>2</sup> which means doubling the current installation rate. At the national level, several member states are supporting heat pump deployment through targets, regulations, and incentives. In Germany, for example, there is an objective to annually install 500,000 heat pumps by 2024, reaching a stock of 6 million installed heat pumps in 2030. In France, under the subsidy scheme related to building renovation, Ma Prime Rénov, gas boilers have not been eligible since 1 April 2022 and heat pumps get a bonus. According to the International Energy Agency, heat pump sales growth in the EU in 2021 was around +35 per cent compared to 2020, twice as much as in the previous decade. In several member states, sales growth has been even stronger (+60 per cent in Italy and Poland, and +40 per cent in France), and a tripling of the number of heat pumps is expected in the EU between 2021 and 2030.<sup>3</sup>

With this in mind, it is clear that buildings are a vital infrastructure and should be treated as a priority to reduce energy consumption and achieve decarbonization, through both new construction and renovation. Surprisingly, they are not yet treated as such.

The Buildings Performance Institute Europe (BPIE) developed the [EU Buildings Climate Tracker](#), which is an index composed of a set of indicators, as a response to the challenges of collecting and using data to monitor and assess decarbonization progress in the EU building stock. The Tracker serves as a benchmark and assessment tool for the status of decarbonization progress in the European buildings sector and its progress towards climate neutrality by 2050. It aggregates six indicators:

- CO<sub>2</sub> emissions from energy use in buildings by households and services
- final energy consumption in households and the service sector
- improvement in EPC (energy performance certificate) ratings
- share of energy from renewable sources (for heating and cooling, and in gross electricity consumption)
- cumulative investment in renovation in real terms
- annual domestic expenditure per household in real terms.

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<sup>2</sup> European Commission (2022), *REPowerEU Plan*, Brussels.

<sup>3</sup> International Energy Agency (2022), *The Future of Heat Pumps*, Paris.

Figure 1: Path to climate neutrality 2050 with milestones, EU Tracker

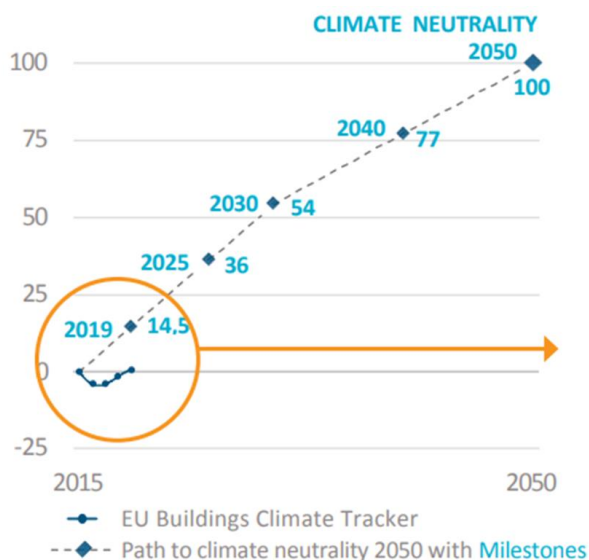
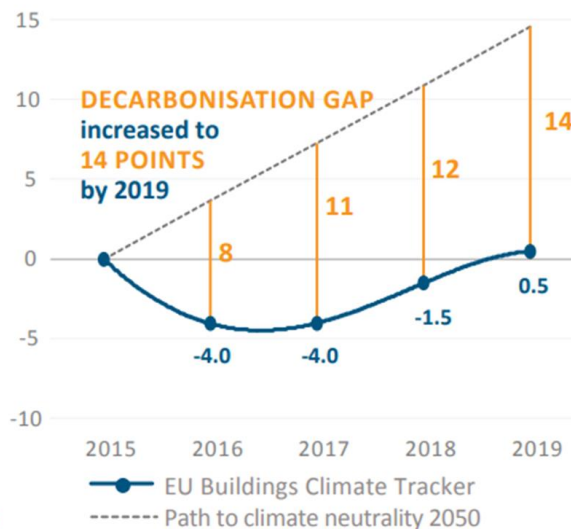


Figure 2: EU Buildings Climate Tracker with growing distances to the path to climate neutrality 2050



<sup>16</sup> The dashed line is the path from the starting point "0" in 2015 to climate neutrality "100" in 2050.

Source: BPIE (2022), *EU Buildings Climate Tracker - Methodology and Introduction of Building Decarbonisation Indicators and their Results*.

The tracker assumes the target of a highly energy-efficient and fully decarbonized building stock by 2050. In the figure above, the dashed line represents the direct 35-year reference path from the starting point of 0 in 2015 (the reference year when the monitoring of building sector decarbonization started, based on the adoption of the Paris Agreement) to the target point of 100 in 2050. The Tracker sets intermediate milestones in 2025, 2030, and 2040. It assumes that the path to the goal is linear; while reality may differ, this assumption makes the benchmarking of progress clearer.

Comparing the evolution of the Tracker (dark blue line) with the reference path, it is evident that decarbonization of the building stock in the EU is far from on track and well below the desired levels. This lack of progress led to almost a doubling of the decarbonization gap (i.e., the distance between the dark blue line and the dashed grey line) between 2016 and 2019, from 8 to 14 points.

On a positive note, it can be observed that since 2017 and up to the latest observed values (2019), the decarbonization index is moving in the right direction.

A [BPIE analysis of data](#) covering 66 per cent of the total European residential floor showed that over 97 per cent of the residential building stock has an energy performance certificate below class A and must be updated to achieve the 2050 decarbonization vision.

The energy performance of buildings is highly dependent on the quality of the building envelope. The lower the thermal losses through walls, roofs, floors, and windows, the less energy is needed to keep a building's indoor temperature at a comfortable and stable level. Last year [BPIE modelled](#) the improvement of the building envelope with a change in U-values for walls and roofs in eight countries. The U-value expresses the rate of transfer of heat through a building structure. The lower the U-value, the better insulated a structure is. The change in U-values of walls and roofs from higher to lower values is therefore an expression of improved insulation. Results showed that if all goal U-values were achieved across all countries, 45 per cent of final energy could be saved.

A [new study extended to the EU 27](#) confirmed that improved insulation of all existing residential buildings in the EU alone would significantly contribute to securing the bloc's energy independence and achieving climate neutrality by 2050. The table below shows the potential final energy savings for all member states in space heating by energy carrier.

Figure 3: Potential energy savings in residential heating

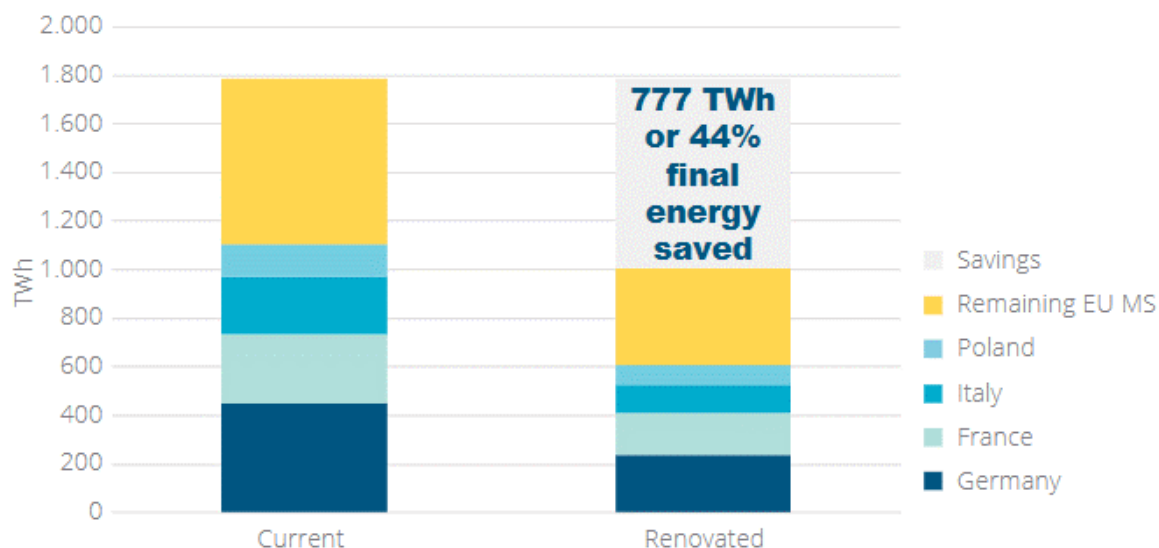
Country	Final energy consumption <sup>20</sup> 2020 (TWh)	Potential savings in final energy for residential space heating (TWh)						
		Coal	Natural gas	Oil	Renewables and biofuels	Electricity	Heat	Total potential savings
Germany	452.6	1.7	93.8	60.0	36.0	3.5	19.2	214.3
France	283.1	0.1	34.8	18.3	38.4	16.1	4.9	112.6
Italy	233.3	-	68.8	7.9	33.2	0.5	4.4	114.8
Poland	135.3	26.6	7.7	0.4	11.0	0.3	6.4	52.4
Spain	68.3	0.2	9.1	10.4	10.9	2.6	-	33.2
Belgium	67.0	0.1	7.1	6.7	1.7	0.5	-	16.1
Netherlands	65.9	-	31.5	0.2	3.5	1.1	1.2	37.5
Romania	57.8	0.2	10.4	-	17.2	0.1	4.7	32.5
Czechia	57.5	4.0	7.5	0.2	11.8	1.3	3.4	28.2
Austria	54.3	0.1	7.4	5.0	9.8	1.3	4.0	27.8
Sweden	46.5	-	-	0.3	1.4	2.1	3.4	7.2
Finland	39.1	-	-	0.4	3.2	2.0	2.3	7.9
Hungary	34.8	0.3	15.1	-	-	0.4	2.1	17.9
Denmark	29.3	-	1.1	0.2	2.4	0.2	2.3	6.2
Greece	28.3	-	2.2	6.1	3.8	0.7	0.3	13.1
Slovakia	23.3	0.2	5.7	-	3.2	0.7	1.6	11.4
Ireland	22.1	1.5	1.9	4.7	0.2	0.3	-	8.7
Croatia	18.0	-	1.8	0.3	4.7	0.1	0.5	7.4
Bulgaria	15.1	0.6	0.5	-	5.3	0.7	1.4	8.5
Lithuania	11.5	0.1	0.4	0.1	1.6	0.1	1.2	3.4
Portugal	10.7	-	0.1	0.3	4.5	0.3	-	5.2
Latvia	8.3	-	0.1	0.1	0.8	-	0.6	1.6
Estonia	7.9	-	0.1	-	1.2	0.1	0.9	2.4
Slovenia	7.7	-	0.1	0.6	1.9	0.4	0.5	3.4
Luxembourg	4.7	-	1.6	0.9	0.1	0.2	-	2.8
Cyprus	1.6	-	-	0.5	0.2	0.1	-	0.9
Malta	0.2	-	-	-	0.1	-	-	0.1
<b>TOTAL</b>	<b>1784.4</b>	<b>36</b>	<b>309</b>	<b>124</b>	<b>208</b>	<b>36</b>	<b>65</b>	<b>777</b>

Note: Empty cells imply that the energy carrier is either not used or used in insignificant quantities. Due to rounding of decimals, the numbers provided in the column 'Total potential savings' can slightly differ from the sums of the individual values.

Source: BPiE (2023), *How to Stay Warm and Save Energy—Insulation Opportunities in European Homes*.

The full renovation of EU residential buildings would result in a 44 per cent reduction of energy demand for heating in buildings, leading to gas savings of 46 per cent, heating oil savings of 44 per cent, and coal savings of 48 per cent. Most of the final energy savings would happen in Germany, France, Italy, and Poland, as shown in the figure below. Higher energy savings could be achieved in the residential sector if other renovation measures beside improved insulation were added, such as window replacement or heating system replacement or improvement.

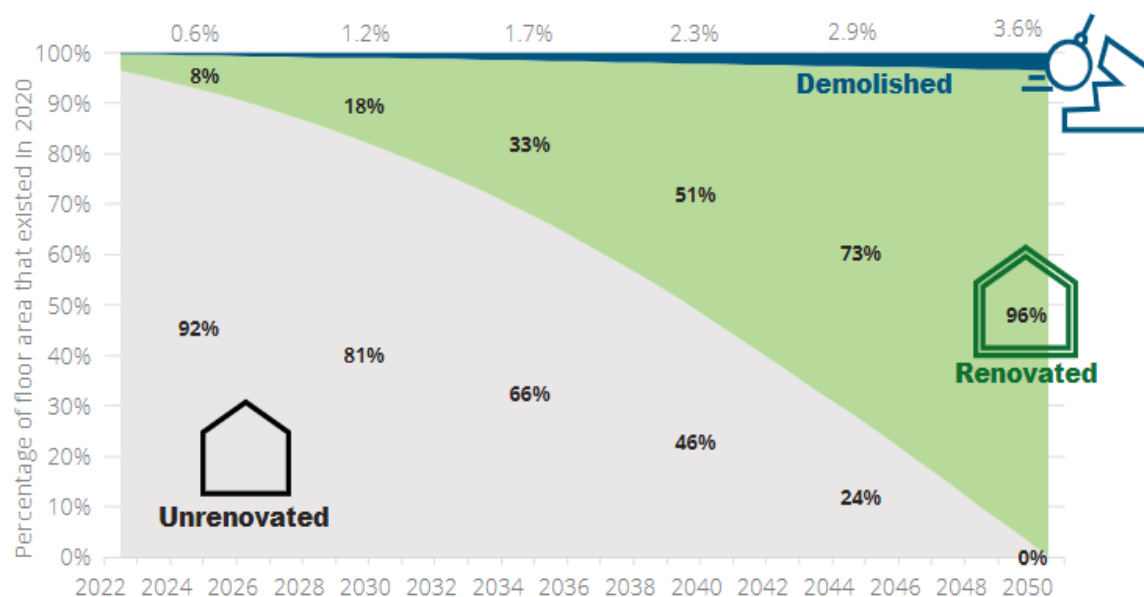
**Figure 4: Final energy consumption for residential space heating in current and renovated buildings and final energy saved in EU 27**



Source: BPIE (2023), *How to Stay Warm and Save Energy—Insulation Opportunities in European Homes*.

The analysis applied two renovation scenarios—one following the renovation rate goal set by the European Commission in the Renovation Wave (achieving a 2 per cent renovation rate by 2030), and one assuming improved insulation of all existing residential buildings by 2050 (a full-renovation scenario, with annual renovation rates going from 1 per cent in 2020 to 2 per cent in 2030 and up to 4 per cent by 2050). It showed that achieving and maintaining a 2 per cent renovation rate is insufficient to achieve climate goals or significantly contribute to energy independence. Under this scenario, over one-third of residential buildings will be left untouched by mid-century and 235 TWh of potential final energy savings will be wasted. This is more than the savings potential for Germany alone, or the potential for Italy and France combined. The figure below illustrates the full renovation scenario.

**Figure 5: Projected renovation and demolition of buildings existing in 2020 in the full renovation scenario, 2022–2050**



Source: BPIE, *How to Stay Warm and Save Energy*.

Improving the energy performance of the building envelope in existing residential buildings would substantially lower fossil fuels consumption, increase energy security, and enable the effective growth of renewable heat. To streamline these savings and achieve all these benefits, renovation programmes should prioritize projects achieving deep renovations and provide financial assistance and advisory services to support building owners. Minimum Energy Performance Standards for existing buildings, designed on a differentiated basis according to ownership structure and focusing on worst-performing buildings across all segments, together with public funds and subsidy schemes aiming to phase out fossil fuels and enable deep renovations, would trigger higher savings and support heating decarbonization.

## Conclusions

Since the beginning of the war in Ukraine, the EU's attempts to show leadership in addressing climate change and to guide the clean energy transition have been increasingly challenged. Torn between the need to meet the short-term challenges brought by the energy crisis and to continue the transition towards climate neutrality, the EU and its member states are called to make bold choices to secure a prosperous and sustainable future. This article shows that increasing the energy performance of the building envelope in residential buildings contributes to both objectives and that there are some clear choices ahead of us to achieve energy and climate security.

To fully tap into the energy savings and fossil fuel savings potentials, renovation activity in the residential sector must accelerate and increase in the next decade.

- If the current average annual renovation rate is doubled by 2030 as stated in the Renovation Wave strategy, and the rate then stagnates until 2050, the full potential energy savings outlined in this study will not be tapped.
- To fully benefit from the savings potential, the entire building stock must be renovated by 2050, and the renovation rate must at least double by 2030 and then further increase to reach 3 per cent by 2035 and 4 per cent by 2050.
- Building policies must align short-term actions with long-term needs and ambitions. Building renovation must be delivered at a high pace to reduce energy consumption in the long term and to enable a quick and successful phase-out of fossil fuels in residential buildings.

Without an acceleration in renovation now, more than two-thirds of the building stock will remain to be renovated between 2030 and 2050. A bolder approach in the next 10 years, matching increasing rate and depth of renovation and a push towards serial renovations, would better address the need to get rid of fossil fuel imports and rapidly reduce energy demand in buildings.

The fossil fuel phase-out efforts across the EU raise the question of affordable and efficient technology for replacing gas boilers and other fossil fuel equipment. As suggested by recent research, heat pumps may be one of the most affordable and efficient solutions for decarbonizing heating systems in buildings.

There is a strong debate on whether heat pumps can heat inefficient buildings and how this may significantly affect the potential for their market uptake. If properly designed, sized, installed, and connected to adequate heat emitters (for example, properly sized radiators), heat pumps may be used in any building. However, if installed in an inefficient building, at high electricity prices, their operational costs could threaten the economic feasibility of the investment. The benefits deriving from properly insulated buildings (like increased comfort) would also be potentially lost. BPIE's research shows how improving insulation of residential buildings can reduce energy demand and drastically cut oil and gas used for heating. Reducing demand to allow a steady increase of renewable energy supply as an alternative to fossil fuel imports is the solution the EU and all countries should pursue to achieve their climate goals and secure energy supply at reasonable costs.

Lowering energy demand is a prerequisite to make lasting reductions to energy consumption, achieve heating decarbonization, and allow a steady increase of renewable energy supply. Recent events have revealed weaknesses in the energy sector and have disrupted debates and decisions across Europe. They are also an opportunity to fix these wrongs and finally adopt farsighted policies leading to the decarbonization of buildings and a just and clean energy transition.





## REHEATEU: A ONCE-IN-A-LIFETIME OPPORTUNITY FOR ENERGY SECURITY AND CLIMATE PROTECTION

**Alix Chambris**

The war in Ukraine has increased the focus on the way we heat our buildings. Overnight, the EU's dependency on Russian energy threatened the economy at an unprecedented scale. It became urgent to decouple the EU economy from Russian energy supply. Of the Russian gas imported into the EU in 2021, 30 to 40 per cent was used to heat buildings. Equally worrying, 30 per cent of greenhouse gas emissions come from buildings. Today, this makes the replacement of fossil fuels in buildings by renewable solutions a top priority for energy security as well as for climate goals.

Could the current crisis unleash a *green swan* that will exponentially transform the building sector in this decade? A green swan is an unpredicted event that positively transforms the economy. 'This extraordinary bird symbolises the potential for change and, in particular, for transformation.'<sup>4</sup>

### The opportunity

**Renewable solutions:** The sales ratio of oil and gas boilers to hydronic heat pumps was 5:1 in 2021, but there has been a significant increase in the sales of heat pumps since then.<sup>5</sup> New heat pumps working with natural refrigerants can provide a higher output temperature which makes them suitable for the existing building stock—gone are the days when heat pumps were only suitable for new buildings. In fact, the green swan may very well be a heat pump. One goal at the EU level is to reach a share of 49 per cent renewables in buildings by 2030 compared to 24 per cent in 2020, including by installing 10 million new hydronic heat pumps by 2027 and 300 GW of photovoltaics (PV) on rooftops by 2030. The achievement of EU 2030 targets would lead to total annual heat pump sales of 7 million units (both hydronic and air-to-air solutions) and a savings of 21 bcm of gas by 2030—which is 'equivalent to almost 15 per cent of EU pipeline imports from Russia in 2021'.<sup>6</sup>

**A strong European manufacturing base:** With less than 10 per cent imports of heating appliances from third countries, the EU manufacturing base is strong. However, past years showed a worrying sign: the trade balance in heating deteriorated from 2015 to 2021. The EU–China trade balance went from a surplus of €249 million to a deficit of €390 million within five years.<sup>7</sup> Current disruptions of global supply chains and policies like the American Inflation Reduction Act are now putting additional pressure on EU manufacturers. This is where a strengthened industrial policy could really make a difference. It could alleviate the temporary threats and even strengthen the European manufacturing base.

**Social acceptance and affordability:** Already before the war in Ukraine, 35 million Europeans lived in energy poverty.<sup>8</sup> While the rising energy prices hurt people and the economy, they are a clear additional reason to speed up the energy renovation of buildings. Recent data show a tangible shift of consumer preferences towards renewable solutions, especially heat pumps, PV, and self-consumption models. The speed and scale of the shift depend on two issues: the upfront cost of heating systems, which is still three to four times higher for a hydronic heat pump than for a gas boiler, and their operating costs. A ratio of gas to electricity price between 1:2.5 and 1:3 per kilowatt-hour would ensure that the electricity bill remains acceptable compared to a conventional gas solution (see current price ratios on [energypriceindex.com](https://energypriceindex.com)).

**Speed and scale:** The speed and scale of the market transformation on the supply side correlates with (1) manufacturing capacity and the availability of (2) supplies (material and components) and (3) installers. The achievement of EU targets requires a threefold increase of the existing heat pump manufacturing capacity and a parallel decrease of conventional combustion solutions. This is possible with a massive pan-European upskilling programme and job creation: Half of the 1.5 million installers need training and 750,000 more should be recruited.<sup>9</sup>

<sup>4</sup> John Elkington (2020), *Green Swans, the Coming Boom in Regenerative Capitalism*.

<sup>5</sup> EHI (2021), *Heating Market Report*.

<sup>6</sup> IEA (2022), *The Future of Heat Pumps*.

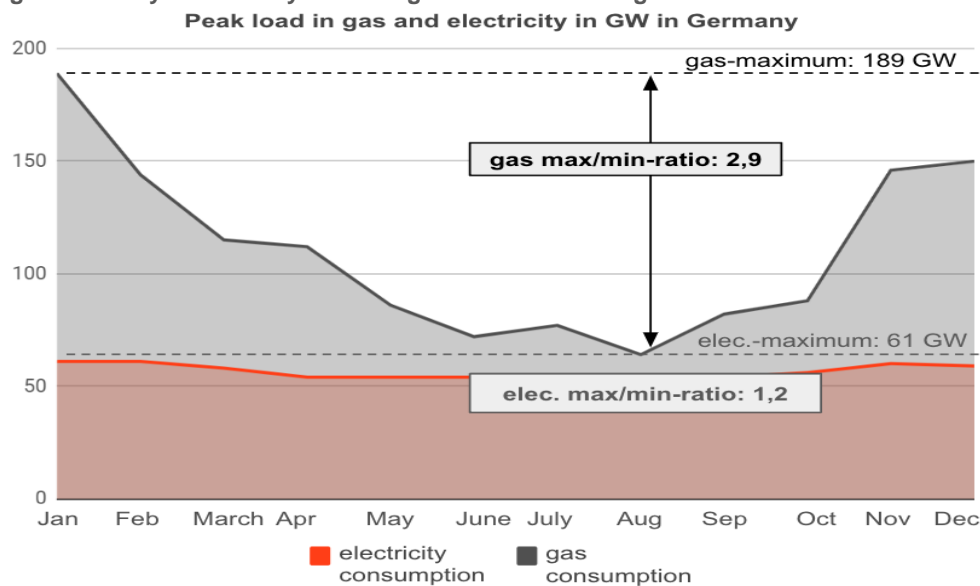
<sup>7</sup> Euractiv (May 2022), *Battle for Dominance in Heat Pump Markets*; Joint Research Center (2022), *Heat Pumps in the European Union*.

<sup>8</sup> Data from Eurostat.

<sup>9</sup> EHI (June 2022), *Heating Systems Installers*.

**A heterogeneous building stock with high peak demand in winter:** Buildings are heterogeneous, meaning that a diversified mix of heating solutions is necessary to meet all heat profiles, including district energy. The European heating demand is on average three times higher during the winter than in the summer. The gas infrastructure is built in such a way as to meet this higher winter demand, but the electricity infrastructure is not yet equipped to meet it, as shown in the figure below. Gas properties make it a convenient energy carrier for storage over longer periods of time. Hybrid gas–heat pump solutions, including the hybridization of existing, already installed, gas boilers with heat pumps, can utilise this potential and address seasonality at lower system costs.

**Figure 1: Challenges raised by seasonality of heating demand in buildings**



Source: Frontier Economics (2021), *Die Rolle von Wasserstoff im Wärmemarkt*.

### The green swan

Changing consumer preferences, the investment readiness of the private sector, and the policy framework could constitute a critical mass for exponential change: the green swan of buildings decarbonization.

**Consumers:** Energy security concerns triggered by the war in Ukraine and the increasing salience of climate change is leading to a true awareness shock among consumers. Climate change is not a theoretical threat made by distant scientists anymore; its effects are tangible, salient, and immediate. In 2022 alone, over 15,000 people died in heat waves in Europe.<sup>10</sup> Movements such as Fridays for Future have been another eye opener for many. This awareness shock combined with rising energy prices is already translating into what could be the premise of the biggest market shift in decades. According to preliminary figures from the Association of the European Heating Industry (EHI), the sales of gas condensing boilers decreased overall by 8 per cent in 2022 vs 2021, and the sales of air-to-water heat pumps increased by 40 per cent, with big differences across member states.<sup>11</sup>

**Private sector:** This awareness shock is equally tangible in the private sector. Heat pump targets at EU and national levels and possible bans of oil and gas boilers have given a strong market signal for investors. This has led to investment pledges amounting to €4 billion in the heat pump ramp-up in Europe.<sup>12</sup>

**Policies:** It is likely that this shift will be maintained and accelerated by the implementation of the new EU energy and climate framework: REPowerEU and the Fit for 55 package—'fit' for a 55 per cent greenhouse gas reduction by 2030 compared to 1990 levels. The table below provides an overview of the potential transformative effect of the upcoming policy framework.

<sup>10</sup> WHO (November 2022), *Statement – Climate change is already killing us, but strong action now can prevent more deaths*.

<sup>11</sup> EHI (November 2022), year-end forecast in 12 European countries. This report is not publicly available yet.

<sup>12</sup> IEA (2022), *The Future of Heat Pumps*, table 3.4; see overview of national heat pump targets in table 1.1 of the same report.

Table 1: Potential effects of policies on heating in buildings

Market push via legal requirements	Market pull via subsidies, taxation, and transparency
<b>Ban of, or restrictions on, new stand-alone oil and gas boilers in existing buildings</b> EU: by 2029 via ecodesign DE: 2024 via the 65% renewable rule UK: 2035 NL: 2026 DK: 2028 AT: 2040	<b>Subsidy schemes for buildings and individual heating systems</b> DE: recovery plan led to +10% growth of heating market in 2021, +13% in 2020 IT: Superbonus scheme led to +20% market growth EU: large amount of funding (via EU recovery plan, EU budget, and revenues generated by strengthened emission trading scheme), and end date for subsidies targeting fossil-fuel heating systems by 2024/2025 via the Energy Performance of Buildings Directive (EPBD)
<b>Phase-out of fossil fuels in heating</b> , equivalent to a mandatory retrofit of existing installations by a sunset date EU: by 2040 via EPBD DE: gradual decrease of allowed use-phase via Gebäudeenergiegesetz DK: by 2035	<b>Reduced VAT for green solutions</b> EU level: reduction of VAT anywhere down to 0% allowed at national level for green products DE: 0% VAT for PV instead of 19%
<b>Renovation requirements for least performing buildings</b> EU: ca. 15% of existing buildings by 2033 via EPBD* NL, FR: similar incentives * Proposal of European Commission: non-residential—class F in 2027 and at least class E after 2030; residential—class F in 2030 and at least class E after 2033.	<b>Transparency, mandatory energy labels</b> for end-users and reporting requirements for companies—via Energy Labelling Directive and Corporate Sustainability Reporting Directive
<b>Renovation requirements for public buildings and social housing</b> EU: 3% of public buildings >250 m <sup>2</sup> per annum (potentially including social housing)	<b>Extra subsidies for more environmentally friendly solutions</b> DE: +5% on-top for heat pumps using natural refrigerants starting in January 2023; in future: extra subsidies for products with lowest environmental life-cycle footprints
<b>PV (or renewable) requirements for new and existing buildings</b> EU: PV deployment on all existing and new non-residential buildings by 2027, by 2029 on all new residential buildings	<b>Energy prices</b> (including energy taxation, extension of EU Emission Trading Scheme to buildings and price caps) <b>and Electricity Market Design</b> : impacting relative total cost of ownership of products, profitability of self-consumption models, and demand-side response

Source: Author's own compilation of existing legislations and ongoing revisions. Note: most policies listed in this table are still under discussion, either at the drafting or the negotiation stage, so changes are still very likely.

This table clearly shows the magnitude of the transformation that could be driven by policies. We should pay close attention to the EU, the UK, and those member states that are at the forefront of these policies (such as Germany, Netherlands, France, and Denmark), as they could become mainstream in the foreseeable future.



The speed and scale of the transformation is difficult to anticipate as the market has been relatively stable over the past decades. Change theory indicates, however, that technological change usually starts slowly then accelerates exponentially.<sup>13</sup>

### Industrial policy

A green swan that keeps value creation, jobs, and sustainable growth in Europe will need a strong industrial policy. We are witnessing a paradigm shift in the design of industrial policy at EU and national levels, with proposals on the table that were unthinkable even two years ago, such as a European Sovereignty Fund or extra subsidies for clean technologies ‘made in Europe’. Here is a list of six success factors for an effective industrial policy in heating.

- **Ramp-up of EU manufacturing capacity** via public support in R&D, capex (direct funding and accelerated depreciation), skills, and guarantees. It is possible to leverage existing instruments such as the EU Innovation Fund and the Temporary Crisis Framework for State Aid.
- **Speed.** Support measures, especially financial instruments, must kick in immediately, with faster lead-times. The approval duration of Important Projects of Common European Interests, for example, is inappropriate for the heat pump opportunity. Forced import of renewable solutions can be avoided by giving sufficient lead time to the European industry for the ramp-up of manufacturing capacities.
- **Skills.** Leverage the European Social Fund and other instruments such as the EU Pact for Skills to attract and train installers (see above).
- **Regulatory certainty.** The Fit for 55 package combined with national initiatives will be a strong driver for investments. A priority is to steer those investments and leapfrog into environmentally friendly, circular, and resource-efficient solutions. Most European heating manufacturers consider that there is no conflict between increasing production capacities to reach the 10 million heat pump target by 2027, and higher environmental goals, for example via the F-gas and REACH regulation.<sup>14</sup>
- **Subsidies targeting end-users.** A priority is to secure demand for low-carbon solutions until economies of scale and innovation further reduce their production costs. Behavioural economics shows that upfront costs have a greater impact on final consumer decisions than total cost of ownership; this has to be factored into the design of national subsidy schemes. Extra subsidies for products ‘made in EU’ would also be a strong pull for European-based manufacturing.
- **Supply chains.** Evaluate and support the European production and diversification of the supply of key components such as compressors, semiconductors, and power electronics—for example, with an extension of the framework set out in the European Chip Act to other critical clean technologies.

### The long-term perspective

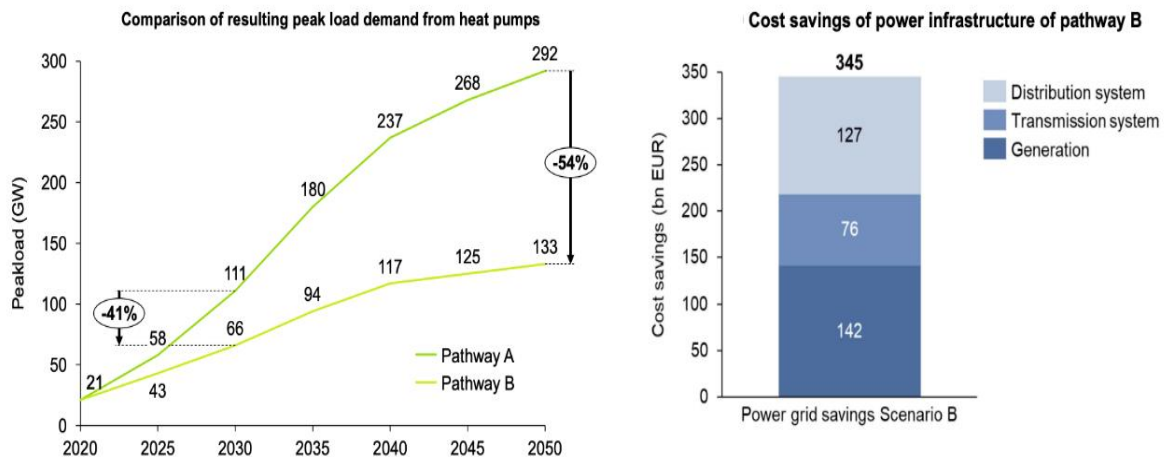
A green swan in buildings would unleash an exponential ramp-up of heat pumps by 2030, a giant renovation wave, and millions of prosumers (actors both consuming and producing energy) benefiting from self-consumption and selling flexibility to the grid. A question that remains open is the role of green gases in buildings.

A study was commissioned by EHI to compare a full-electric scenario (Pathway A) with a balanced-mix scenario (Pathway B) where the heating stock is fully carbon neutral by 2050. Its findings projected that, in the latter scenario, gas demand goes down to 460 TWh in 2050 vs 1280 TWh in 2020. Meanwhile, the peak load demand from heat pumps is 50 per cent lower, leading to €345 billion of accumulated savings until 2050.

<sup>13</sup> See for example: Ray Kurzweil (1999), *The Age of Spiritual Machines*.

<sup>14</sup> EHI (2022), position papers shared with EU policy makers.

**Figure 2: Cost savings resulting from lower peak load demand in a green gas scenario for a decarbonized building stock**



Source: Guidehouse (2022), *Decarbonisation Pathways for the EU Building Sector*.

The availability of green gases for other hard-to-abate sectors is critical. Yet, the amount of green gases that will be available in 2050 and their costs are uncertain. Some evaluations send a positive signal, for example:

- Biomethane production potential in the EU has been estimated at 1,350 TWh.<sup>15</sup>
- Hydrogen production potential in the EU has been estimated at 1,710 TWh.<sup>16</sup>

Assuming that half of the 460 TWh gas demand for buildings is met by hydrogen, and the other half by biomethane, that would mean, in this estimation, that only 13 per cent of the available hydrogen supply would go to buildings.

Heating appliances are ready for green gases. Additional evaluations of the cost-efficiency of security of energy supply and resource adequacy are still needed to meet the seasonality of heating demand at the lowest costs possible.

## Conclusion

The decarbonization of the building stock is a unique opportunity to enhance both energy security and climate protection. Policies, evolving consumer preferences, and the private sector's willingness to invest indicate that we could see a green swan in buildings in this decade. That green swan could very well take the shape of a heat pump. In the words of Professor Martin Viessmann, 'This is a once in a lifetime opportunity to write climate history' for each and every one of us<sup>17</sup>. Maybe the EU energy security strategy adopted in the wake of the war in Ukraine should have been called REHeatEU instead of REPowerEU.

<sup>15</sup> IEA (2020), *Outlook for Biogas and Biomethane*.

<sup>16</sup> Guidehouse (2019), *Gas for Climate Study*.

<sup>17</sup> Viessmann (2022), speech delivered during the visit of Chancellor Olaf Scholz in the factories of the Viessmann Group on 9 August.



## DECARBONIZING HEAT DEMAND IN EUROPE NEEDS AN ALL-HANDS-ON-DECK APPROACH

**Thomas Nowak**

Nearly half of global energy demand is for heating, and this is met mainly by fossil fuels. This is true for most areas, including Europe.<sup>18</sup> As a result, the heating sector is a big emitter of carbon, and this must radically change if we are to stand a chance of decarbonizing and upholding our climate goals.

With buildings responsible for 40 per cent of final energy demand, [their decarbonization is a must to master this challenge](#). In the EU, [the share of renewables in heating exceeded 23 per cent in 2021](#). However, annual growth has been below 1 per cent for most of the last decade—too slow to achieve the needed change in time.

Deploying more renewable energy from biomass, bioliquids, biogas, and heat pumps as well as from solar thermal, geothermal, and waste heat will be needed, and it will have to happen faster than in the past to bring down our dependency on fossil energy and reduce emissions.

[Heat pumps need to contribute the main share of the needed growth, and they must do so soon](#). Cooling, while covered by EU legislation on renewables, has only now been officially defined and added to the energy statistics. For simplicity, cooling is not addressed separately in this article.

### Heat pump sector breaking records

[In 2021, total sales of heat-pump-based heating and hot water solutions grew to 2.2 million units](#) (+34 per cent)—taking a market share of over 20 per cent. This breaks down into sales of about 960,000 air-to-water, 806,000 air-to-air, 130,000 ground-coupled, and 250,000 sanitary-hot-water heat pumps. Around 20,000 commercial and industrial heat pumps were sold, but a precise number is not available. These annual sales brought nearly 20 TWh of renewable energy to the mix, replacing 25 TWh of fossil energy (due to the inherent higher efficiency of heat pumps compared to fossil boilers), and avoiding 5 Mt of CO<sub>2</sub>—roughly equivalent to the annual emissions of [Cyprus](#). This brings the total number of installed heat pumps to around 17 million in Europe, covering over 10 per cent of heaters in buildings.

While it is fantastic to see such unprecedented growth in the heat pump market, we are far from where we need to be. To reduce demand for fossil energy and remove heating-related emissions, we need a complete overhaul of the market and legislative conditions to accelerate the deployment of heat pumps.

### All about laws and legislation

It has taken quite some time to move the policy discourse beyond decarbonization of electricity and to shift the attention of policymakers to the importance of decarbonizing heating and cooling. In Europe, heating and cooling were covered in legislation on renewables, energy efficiency, and energy performance of buildings. It took until 2016 for the European Commission to publish a heating and cooling strategy, which set out actions and tools to ensure that the heating and cooling sector contributed to the EU objective of climate neutrality by 2050. In 2020, the EU strategy for energy system integration connected the electricity and thermal energy sectors and acknowledged the importance of heat pumps for sector coupling. Most recently—and as a reaction to the war in Ukraine—the European Commission presented its REPowerEU communication, followed by a package of legislative measures to reduce Europe's dependency on Russian gas.

The REPowerEU package suggests doubling the annual sales of hydronic heat pumps by 2026 and proposes a target of an additional 30 million to be installed by 2030. Air-to-air heat pumps are not covered in this package. As they have a share of about 45 per cent in total heat pump sales, they are also relevant for the reduction of fossil energy demand. It seems plausible and necessary that this technology segment will grow at the same speed as hydronic heat pumps. Applying a similar growth rate as needed to achieve the REPowerEU targets to all heat pump categories would lead to 20 million additional heat pumps by 2026 and nearly 59 million by 2030. The table below presents one possible scenario.

<sup>18</sup> IEA (2022), *The Future of Heat Pumps*, Paris, p. 21.

**Table 1: REPowerEU scenario for hydronic (air-water) heat pumps and European Heat Pump Association (EHPA) extrapolation to all heat pump categories<sup>19</sup>**

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Air–air	823,434	1,053,995	1,264,794	1,492,457	1,716,326	2,076,754	2,554,407	3,193,009	3,991,261	4,829,426
Air–water	984,527	1,260,194	1,512,233	1,784,435	2,052,100	2,483,041	3,054,141	3,817,676	4,772,095	5,774,235
Brine–water	128,218	164,119	196,943	232,393	267,252	323,375	397,751	497,189	621,486	751,998
Sanitary hot water	245,775	314,591	377,510	445,462	512,281	619,860	762,427	953,034	1,191,293	1,441,464
Other	977	1,251	1,501	1,772	2,037	2,465	3,032	3,790	4,738	5,732
Total	2,182,931	2,794,151	3,352,981	3,956,518	4,549,996	5,505,495	6,771,759	8,464,698	10,580,873	12,802,856
Indicative growth rate	34%	28%	20%	18%	15%	21%	23%	25%	25%	21%

The growth of all heat pump technologies paves the way for the much-needed energy transition in the heating sector. According to a European Heat Pump Association forecast, the application of exponential growth rates to all heat pump solutions would result in more than 50 per cent of all buildings being covered by heat pump solutions in 2030. Comparing this to today's market share, installed numbers need about to quadruple.

Next to its contribution to the energy and climate targets, decarbonizing heating and cooling will also lead to improved air quality and have positive effects on human respiratory health, since a heat pump does not emit particulate matter and nitrogen oxide. Also, in the context of the ongoing war in Ukraine, the importance of local renewable energy sources for the security of supply cannot be stressed enough.

While the fundamental need to move away from fossil energy, including in heating, has been known for decades, it has only slowly found its way into policy. The first versions of the Energy Performance of Buildings Directive stressed the need for more renewables in heating as well as for insulating the building envelope, but both measures lacked implementation speed. The annual renovation rate of buildings has remained at about 1 per cent, far below the [EU's target of 3 per cent](#). Likewise, the use of renewable energy in heating met the EU's targeted annual increase of 1.1 per cent (1.3 per cent if waste heat and cold are included) only once. The table below shows its increase over the years being at around 0.6 percentage points on average.

**Table 2: Evolution of renewables-based heating for EU-28**

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual increase	0.42	1.17	0.46	0.89	0.38	0.09	0.42	0.78	0.83	0.66
Share of renewables	17.42%	18.58%	19.05%	19.93%	20.31%	20.40%	20.82%	21.60%	22.43%	23.09%

Source: Data from Eurostat

The latest European Parliament position on the revision of the EU's renewable energy legislation sets a new target of at least 40 per cent renewable energy in final energy demand and includes a sub-sector target for their use in the building stock (49 per cent). An indicative increase rate is set at 2.3 percentage points and even 2.8 percentage points if waste heat and cold are included.<sup>20</sup> Negotiations on this legislation are ongoing and expected to conclude in early 2023. Without a significant increase in implementation action, both the overall and annual targets will be difficult to reach.

<sup>19</sup> Figures for all years beginning 2022 are estimates.

<sup>20</sup> European Parliament (2022), *Renewable Energy Directive*, adopted amendments P9 TA(2022)0317DRAFT RES Directive.



### Levelling the playing field

The main reason for this shortcoming until recently was the low price of fossil-based heating. Despite the negative external effects of using fossil energy, pollution costs rarely found their way into the cost calculations of end users, commercial actors, and policymakers. Hence, they were influencing neither price nor behaviour. It was more tempting to use seemingly cheap fossil energy than to invest in 'costly' renewable energy sources, both for electricity generation and for heating and cooling.

Today renewable energy has become the cheapest of all alternatives for electricity generation. According to the International Energy Agency, [70 per cent of all investment in new power generation capacity is spent on renewables-based technologies](#).

However, renewables in heating face a different situation. Investment costs are often still higher than those of fossil-based heating systems. Even today, the investment cost of a new heat-pump-based heating system is often two or three times that of a fossil-fuel-based solution. If in addition the building needs renovations, the difference in price will be higher still. Apart from the up-front investment cost, the operating costs are also often higher because of differences in taxation levels as well as fossil fuel subsidies. In many countries, energy taxation levels put a heavier burden on electricity than on fossil energy. This makes it difficult to recover higher investment cost over the lifetime of an installation.

The process of convincing individual users on the benefit of changing their heating system (not only good for the environment, but also for the individual) is slow. It is often hampered by a lack of transparency and impartial information on available and suitable solutions as well as on the renovation measures that need to be taken. Uncertainty includes the selection of technology, the need to trust in a new solution, and the check of installation quality and performance.

Even if a more collective perspective on renewable heating is taken, for example with district heating fed by renewable energy, the execution would not be simple. Buildings might still require renovation, and the difficulty to convince decision-makers would shift to the communal level. The right technology is not easy to select, planning horizons are long, and city councils would need to be convinced, permits to be obtained, and end users to be involved. [Mass roll-out of heat pumps is feasible with today's technologies, but innovation is still needed, and society must be taken on board](#).

### Looking ahead

In the long term, however, renewable energy and heat pumps are the best solution not only for the environment but also for the economy. Numerous [studies](#) by scientific bodies and international agencies show that a renewables-based energy system is an investment in the short term, saving energy cost in the long term.

Hence it is the short-term investment horizon that needs to be reshaped and the operational costs reduced relative to fossil-based solutions to allow the higher initial investments to be recovered. The war in Ukraine has influenced both the perception of fossil heating and the operating cost of different solutions. The price of fossil energy has tripled in some parts of Europe, gas is no longer seen as a bridging fuel, and Russia is not perceived as a trustworthy partner to deliver energy. Shifting dependency on gas from Russia to other rather less democratic states has not re-established trust in fossil fuels.

Today, heat pumps are recognized as the best solution for decarbonizing heating and cooling, and demand is skyrocketing—not least as the technology is acknowledged as being of local origin. Europe has a strong research and development as well as manufacturing base and is market leader in many of the technology's segments. Heat pumps are installed by local experts and facilitate the use of local energy sources. Integrating heat pumps into the electric grids provides flexibility and helps to increase the utilization factor of renewable energy, in particular from photovoltaic and wind generation.

### Concerted action leading to accelerated deployment

What remains is the need for ambitious and concerted action to really make the EU's 'energy efficiency first' principle the guiding star of the energy transition on all levels. Policymakers must not shy away from selecting the most efficient technology and then implementing all necessary measures to deploy it at speed. Heat pumps should be made the imperative of the energy transition. This will require joint effort on all levels, what the European heat pumps sector calls a heat pump accelerator, to ensure the shift from the dominating use of fossil energy to the use of renewables, mostly heat pumps.

Such a strategy should aim at and promote a decarbonized heating sector by 2050. It should take the whole value chain into consideration and support its conversion, from education and training to research and development, from supporting the extension of production capacity, including for small and medium-size companies, to establishing financing and advice vehicles for end consumers.



And finally, it should continuously review the regulations governing the sector as well as take stock of market progress. Ideally such reviews would happen regularly and include stakeholders to evaluate progress made and decide on any need for a change of speed or focus. It should evaluate the current market and legislative framework regarding simplicity of choice and installation as well as affordability and financing options for heat-pump-based solutions. Administrative procedures must be shortened, and one-stop-shops—bodies which bring together all the different steps a consumer must take to buy and connect a heat pump—need to be established to support customers and create trust in the technology. Financing vehicles need to be set up for all uses of heat pumps, in particular for industrial applications and in district heating. Energy taxation likewise needs a review to overcome the disadvantages given to electricity. EU governments will be required to establish zero per cent VAT for renewables and put financial support packages in place with a focus on renovation and low-income households.

Much needs to be done, and some of it will take time. Achieving a carbon-neutral heating and cooling sector based on energy efficiency, heat pumps, and renewables requires everyone to pitch in—an ‘all hands on deck’ attitude.

This is crucial, because we are not acting for the next winter but for all the winters to come. Properly executed, a heat pump accelerator addressing all the points raised here will help the industry to increase the capacity of the value chain and deliver, not only on the REPowerEU targets, but on the final target of a decarbonized heating and cooling sector.

## HEAT PUMP TECHNOLOGIES IN THE EUROPEAN BUILDINGS SECTOR: APPLICATIONS, MARKETS, AND COSTS

**Michael Taylor**

### Heat pumps as a means of decarbonizing the buildings sector

Sooner rather than later, countries need to accelerate the decarbonization of end-use sectors if they are to meet their Paris Agreement goals and avoid dangerous and expensive climate change. Globally, the buildings sector accounts for around 3 gigatonnes (Gt) of direct carbon dioxide (CO<sub>2</sub>) emissions per year, with electricity use and associated fossil fuel combustion for district heating raising that figure to 10 Gt of CO<sub>2</sub> per year.<sup>21</sup>

In buildings, both residential and commercial, the direct use of fossil fuels is dominated by space and water heating and cooking. In countries with material heating seasons, especially those with cold climates, space heating accounts for the largest share of total building energy consumption and also direct fossil fuel use. Options are available to address these emissions—such as energy efficiency efforts including retrofits that reduce heat loss (through additional insulation, improved air tightness, and superior window solutions). However, given the urgency of decarbonizing the buildings sector and the difficulty of scaling up deep energy efficiency retrofits of the existing building stock—a crucial issue in Europe with its significant proportions of old buildings—it is important to decarbonize the heat supply.

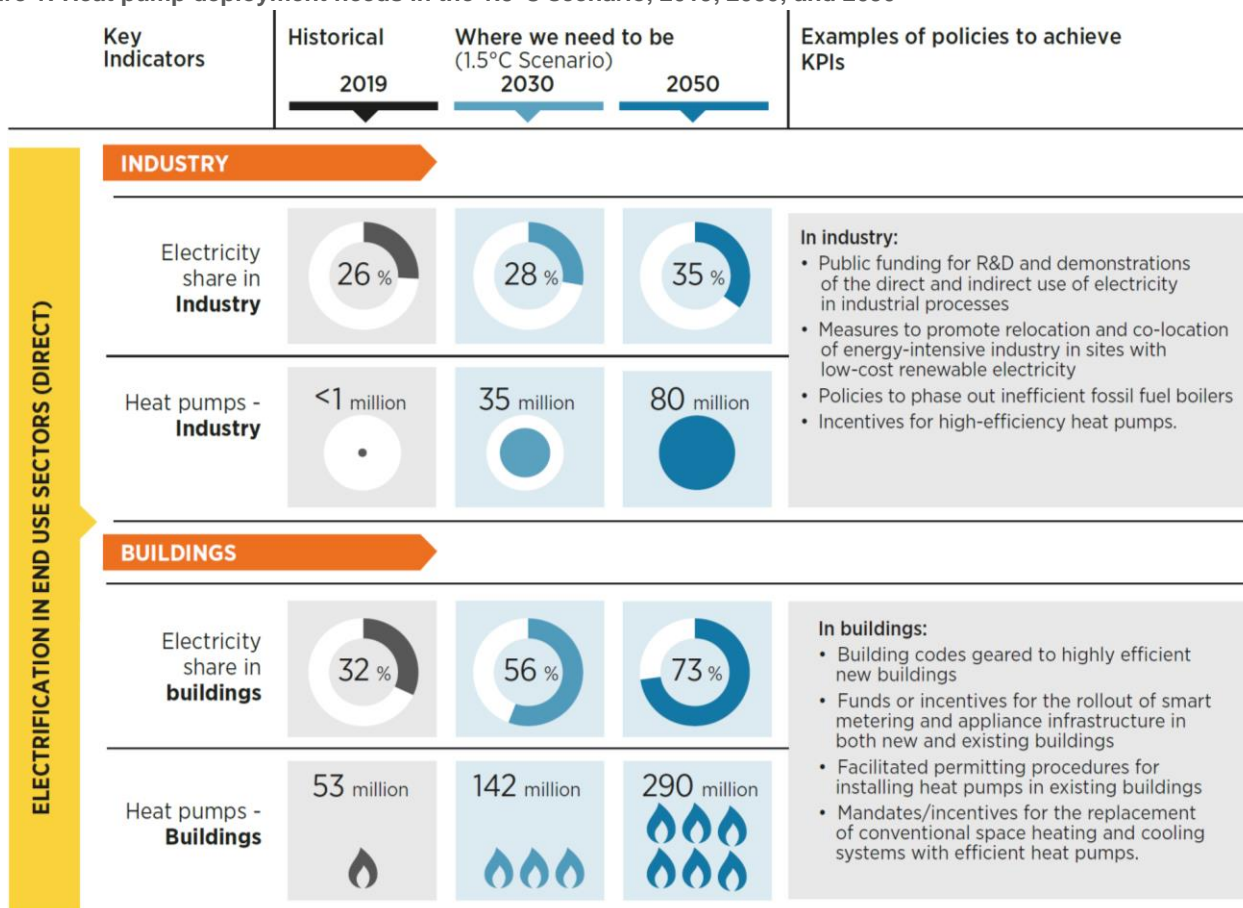
With the fall in renewable power generation costs, Europe and the wider world have a solution at hand. A decarbonized electricity sector makes the electrification of end-use sectors an avenue to rapidly reduce buildings emissions. Heat pumps in buildings and industry represent a highly efficient solution for decarbonizing sanitary hot water, space heating, and low-temperature-process heat needs. Heat pump technologies are a mature, reliable, and established solution for space and water heating. However, despite growing market deployment in recent years, their use in countries with substantial space heating demands (with the exception of the Nordic countries) remains low. This needs to change rapidly if the world is to keep the Paris Agreement goals in play.

The International Renewable Energy Agency's (IRENA's) 2022 *World Energy Transitions Outlook* outlines a pathway for the world to achieve the Paris Agreement goals and avoid the worst impacts of dangerous climate change by transforming the global energy landscape. In the buildings sector, heat pumps play a vital role in decarbonizing energy use. The total number of heat pumps providing space and water heating in cold-climate countries would rise close to ninefold, exceeding 142 million by

<sup>21</sup> IRENA (2021), *World Energy Transitions Outlook*, Abu Dhabi.

2030 and reaching 290 million by 2050 compared to the approximately 53 million installed in 2018. Investments in heat pumps would need to rise from an estimated US\$12 billion per year in the period 2017–2019 to an average of US\$144 billion per year between 2021 and 2030, before easing back to US\$77 billion per year in the period 2031–2050.

**Figure 1: Heat pump deployment needs in the 1.5°C scenario, 2019, 2030, and 2050**



Source: IRENA (2022), *World Energy Transitions Outlook*, Abu Dhabi.

The *World Energy Transitions Outlook* pathway is ambitious, but industry and policymakers have not stood still, heat pump technologies have improved, and, with targeted policy support, there has been growth in European markets. The fossil fuel price crisis of 2022, combined with greater policy ambition, has seen heat pump installations grow significantly in a number of existing and new markets. Scandinavian countries have long set the benchmark—heat pumps have been the top choice for new heating systems for years—but other, newer markets are now seeing rapid growth, from Belgium to Poland.

Crucially, the narrative changed in 2022. The fossil fuel price crisis has stirred increased demand for heat pumps by consumers and policymakers, with record new additions likely in 2022 in many European markets. Perhaps more importantly for the longer term, it has highlighted the vulnerability inherent in Europe's dependence on fossil gas imports. Consumers and policymakers have had a sharp reminder that energy security is not an abstract concept and that import disruptions have direct negative economic consequences for consumers and can have wider macroeconomic cost impacts that need to be factored into policy evaluations.

### Heat pump technologies and applications

Although heat pumps have modest to low shares of the stock of space and water heating equipment in most countries—with the exception of those in Scandinavia—the technology is, in fact, almost ubiquitous in buildings in member countries of the Organisation for Economic Co-operation and Development. Heat pumps are, literally, everywhere—small units provide refrigerators and freezers the cold required for them to function, while the air conditioning (space cooling) systems of cars rely

on heat pumps, as do the cooling and refrigeration systems in the cold chains for food and medicine. In the buildings sector, the largest number of heat pumps are deployed for space cooling purposes, but many are so-called reversible systems which can also provide heating. Heat pumps are also increasingly meeting sanitary hot water and space heating needs, either as forced air (in North America) or via hydronic radiators and underfloor heating (in Europe). Residential heat pumps typically provide hot water up to 70°C, but dedicated hot water heat pumps using CO<sub>2</sub> as the refrigerant can provide water up to 90°C.

Compared to the combustion of fossil fuels for the provision of heat, they are remarkably efficient, capable of converting one unit of electrical energy into 2.5 to 5.5 units of heat (an efficiency range of 250 per cent to 550 per cent), depending on the heat pump technology, climate, and end-use needs. In comparison, the average for currently installed fossil fuel boilers might be in the 80–85 per cent range, with new condensing boilers up to 95 per cent efficient.

The efficiency of the heat pump system is dependent not only on the technology, but also on the design of the installation and whether it is optimized to perform as efficiently as possible. One implication of this is that the rapid growth of the sector will be reliant on concurrent efforts to recruit and train installers, scale -up quality assurance systems, and maintain consumer confidence in the real-world performance of systems. Poorly designed or installed systems will not reach their potential.

Two key factors affect heat pump efficiency:

- The main determinant of efficiency for a given technology is the temperature ‘delta’ or ‘uplift’ for space heating and ‘downshift’ for cooling—the difference between the temperature of the energy source (air or water) and the desired output temperature.
- As a general rule, the lower the temperature delta (in absolute terms), the higher the efficiency. For instance, a temperature uplift of 30°C would result in a theoretical coefficient of performance (COP) of 5 (i.e. 500 per cent efficiency), while if it was 70°C the COP would fall to 2.5.<sup>22</sup>

The implications of this are:

- The higher the temperature of the renewable energy source, the greater the efficiency.
- The lower the set-point temperature of the heating system, the greater the efficiency.

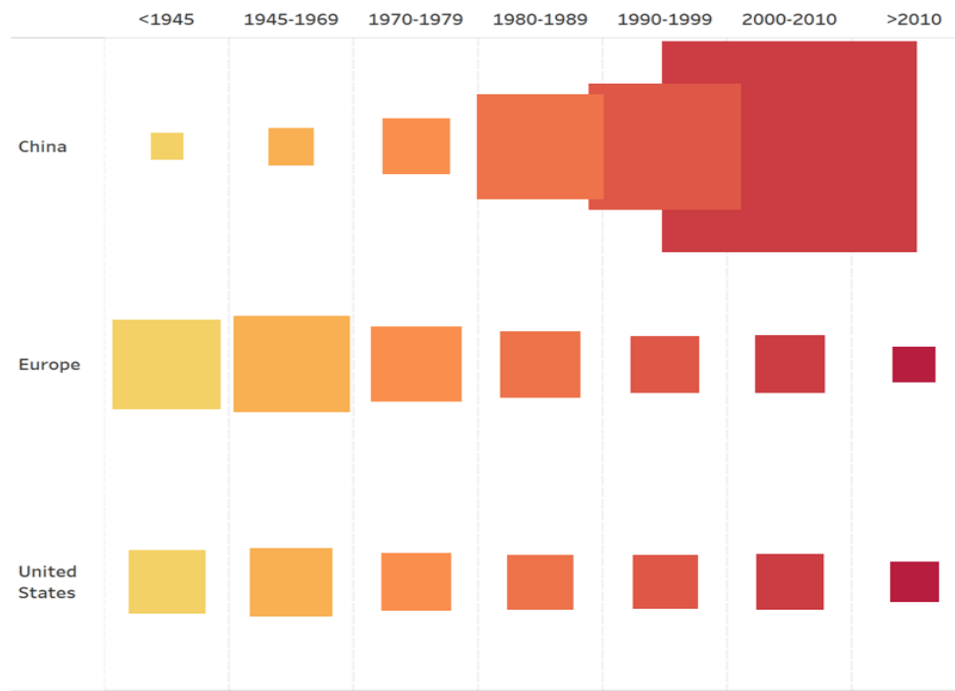
In the current stock of buildings, building age and pre-existing heating systems have an impact on optimal heat pump systems’ design and efficiency. Older buildings often rely on higher outlet temperatures in their radiators to compensate for the leaky nature of the building envelope, raising the temperature uplift for heat pumps and requiring larger peak capacities to cope with the greater demand from poorly insulated homes. Increasing the surface area of the heat distribution system can allow lower temperatures and greater efficiencies, but requires replacing existing radiators or, ideally, installing underfloor heating, which can help reduce the required outlet temperatures and improve efficiency.

This has important implications for the economics of heat pumps, as the higher temperature lift required with older leaky buildings that require high radiator temperatures significantly lowers the system’s efficiency. In Europe, one-fifth of the residential building stock was built prior to 1945 and two-fifths before the first oil crisis of the 1970s. Most of these buildings require significant energy to heat, given their leaky nature and the relatively modest penetration of deep energy retrofits. For instance, the average useful energy demand for buildings built before 1970 in Germany and Belgium exceeds 200 kWh/m<sup>2</sup>/year, compared to around 60–80 kWh/m<sup>2</sup>/year for buildings built after 2010.

<sup>22</sup> EHPA and European Copper Institute (2018), *Heat Pumps: Integrating technologies to decarbonize heating and cooling*, EHPA, Brussels.



Figure 2: Residential building stock age distribution in China, Europe, and the United States



Source: IRENA (2022), *Renewable Solutions in End-Uses: Heat Pump Costs and Markets*, Abu Dhabi.

For new buildings, in Europe heat pump technologies are typically the most economical solution to decarbonization and, depending on fossil gas expectations for the future, economic in their own right. However, the same often does not hold true for the renovation segment. Moderate to deep energy efficiency renovations greatly enhance the economics of heat pumps by reducing required operating temperature (boosting efficiency) and reducing the size of the heat pump required. However, recent technology developments mean heat pumps that are suitable as a one-for-one replacement for existing boilers are now available and can provide the 70°C flow temperatures needed in many poorly insulated buildings. That said, in recent years, policymakers have shifted focus to address this issue more holistically with a more flexible approach, where a key consideration is whether a building or renovation package meets a ‘low temperature comfort standard’—that is to say, is capable of achieving adequate comfort with a maximum heating system flow temperature of 55°C. This will help ensure higher efficiency and lower costs for the occupants of residential buildings.

However, these are not simple trade-offs. Deep or moderate efficiency refurbishments—focusing on increasing insulation of the building envelope, improving air tightness, and reducing/eliminating thermal bridges—reduce heat loss and allow a smaller heat pump and lower temperature lift. However, the benefits of higher efficiency and lower heat pump system costs have to be optimized relative to the cost of the refurbishment. In practice, this means a building simulation and economic analysis are required. Making this process as accurate as possible and presenting the information in a clear manner to the customer is therefore crucial.

Residential heat pump costs

IRENA’s mandate recognizes the importance of data, on the cost and performance of renewable energy technologies and those that facilitate the energy transition, to policymakers and other stakeholders. IRENA has recently extended its data collection efforts to include heat pumps, so that policymakers and other stakeholders have the most reliable, up-to-date data in order to make robust, well-informed decisions.

However, given the large number of stakeholders, relatively modest economies of scale in manufacturing and even less in installation, and multitude of distribution channels, the collection of cost and performance data for end-use technologies in buildings remains a perpetual challenge. This is as true for heat pumps as for other end-use technologies.

Based on its previous experience with cost data collection for renewable power generation technologies, IRENA prioritized the collection of installed project costs, where available, from different sources (e.g. government support schemes and industry surveys), accepting that in many cases this would not be available and secondary data sources would be needed to expand the country coverage.

In the 2022 report *Renewable Solutions in End-Uses: Heat Pump Costs and Markets*, IRENA presented the results of an ongoing data collection effort. The report detailed insights from primary sources on heat pump costs, and sometimes performance, for residential buildings in France, Germany, Ireland, Italy, Sweden, and the United Kingdom. In some instances, data for heat pump installations in commercial buildings were also available. Data for a further 29 markets came from secondary sources, where the accuracy of the data was less obvious.

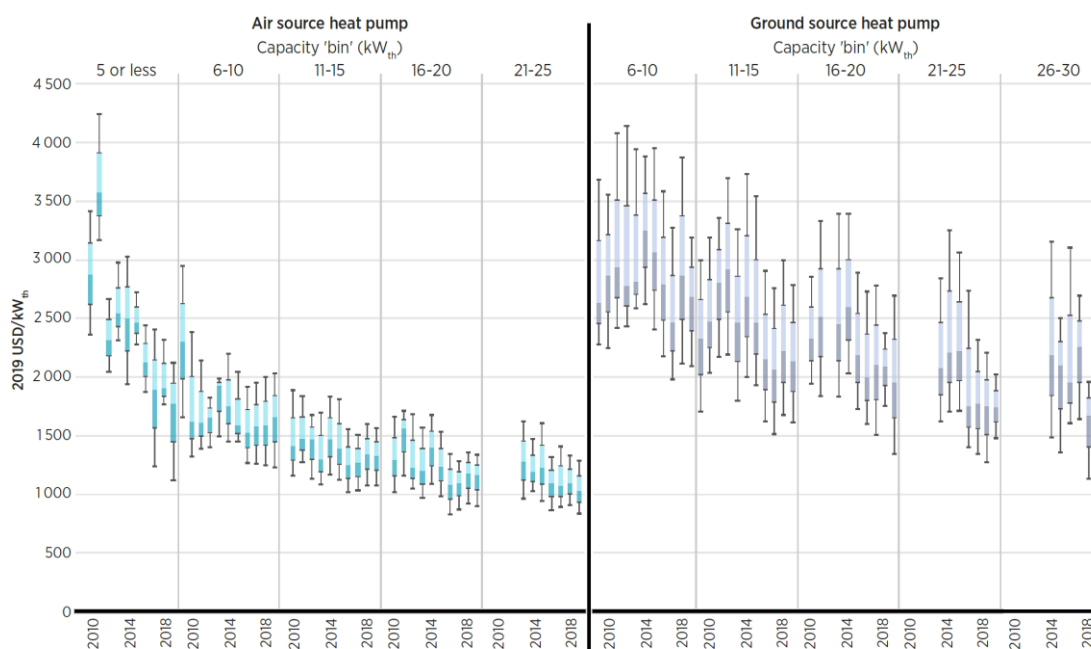
Differences in data boundaries, terminology, and availability by technology and market segment were the norm, complicating comparisons between countries. As a result, the insights from the data were primarily constrained to within a given market, although some common themes did emerge, including the following:

- The installed costs per kilowatt thermal ( $\text{kW}_{\text{th}}$ ) generally declined over the period of data availability, although often not smoothly. Total installed costs by project varied significantly for similar-sized systems of a specific technology, similar to the experience with renewable power generation technologies.
- Economies of scale were evident when detailed data were available.
- System efficiency, measured as the COP, generally increased over time, but data on this are less widely available.

It is worth highlighting these key points with some of the data from the report.

The figure below presents the specific total system cost for residential heat pump systems in the United Kingdom. For air-source heat pumps (ASHPs), the largest cost reductions occurred for the smallest category—5  $\text{kW}_{\text{th}}$  or less—but all size groups saw significant declines. The experience for ground-source heat pumps (GSHPs) was somewhat different, with the smallest category to see significant deployment (6–10  $\text{kW}_{\text{th}}$ ) experiencing a volatile cost path, which left it little changed between 2009 and 2019. However, by 2019 all categories above 16  $\text{kW}_{\text{th}}$  had median costs below US\$2,000/ $\text{kW}_{\text{th}}$ , with GSHPs in the 26–30  $\text{kW}_{\text{th}}$  category falling to US\$1,560/ $\text{kW}_{\text{th}}$  by 2019. The figure also highlights the economies of scale of larger systems. This is an important consideration in the overall economics of a heat pump system. Smaller systems, in well insulated homes which require lower peak heating capacities, will have lower total installed costs than larger systems, but not proportionately lower.

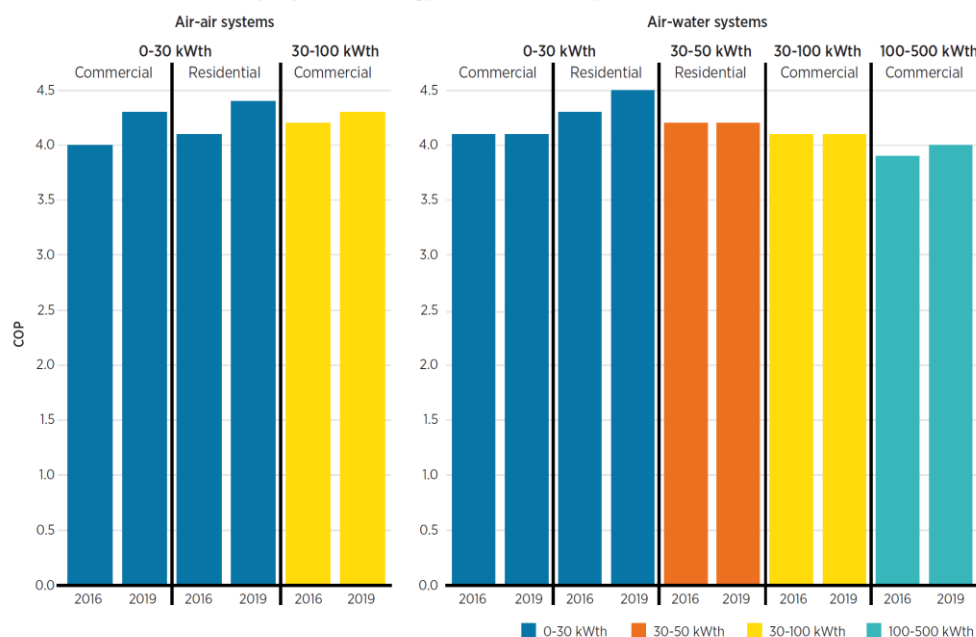
**Figure 3: Residential ASHP and GSHP total installed costs by capacity, 2010–2019**



Source: In IRENA (2022), *Renewable Solutions in End-Uses: Heat Pump Costs and Markets*, Abu Dhabi (p.38).

The next figure highlights the increase, albeit modest, of the median COP of systems supported by the Italian government. The median COP of the systems supported increased over time for residential systems, with the exception of the larger 30–50 kW systems, where the COP remained unchanged in 2019 compared to 2016 at 4.2, albeit with systems installed in 2018 seeing a value of 4.5. Commercial systems reported lower median COPs across the board compared to the same technology and size in residential systems. For air-to-water ASHPs, this is possibly due to the higher share of sanitary hot water use in commercial applications. However, this does not explain the lower COP in air-to-air systems.

**Figure 4: Heat pump COP trends in Italy by technology, sector and system size, 2016-2019**



Source: In IRENA (2022), *Renewable Solutions in End-Uses: Heat Pump Costs and Markets*, Abu Dhabi (p.35).

This data collection effort represents a modest first step in trying to improve the availability of cost and performance data for heat pumps in the buildings sector, and IRENA hopes to continue to expand its data collection efforts in the future.

## APPLICATION OF HEAT PUMPS IN EXISTING BUILDINGS

**Marek Miara**

Existing buildings are crucial to achieve climate neutrality. Around 75 percent of residential space is still heated with fossil fuels today. In the next two to three decades, these homes will have to have completely CO<sub>2</sub>-free heating. Alongside CO<sub>2</sub>-free district heating, the heat pump is the key technology to achieve this.

The more studies, scenarios, and forecasts ascribe an important, even decisive, role to heat pumps in decarbonizing the building sector, the more often these questions arise: How can heat pumps be used in existing buildings at all? Do all existing buildings need to be extensively retrofitted first? Are heat pumps able to guarantee the high flow temperatures required? Can heat pumps in existing buildings achieve reasonable efficiency values?

The goal of this article is to provide well-founded answers to these questions, to counter prejudices, and to create a good basis for future decision-making. The article is based on the knowledge and experience gained from almost 20 years of heat pump research at the Fraunhofer Institute for Solar Energy Systems ISE (Fraunhofer ISE). During this time, Fraunhofer ISE has, among other things, monitored and analysed roughly 300 heat pump systems in the field.



Certainly, the challenge of finding a suitable technical solution and implementing it successfully is greater in some cases. However, these few cases should not call into question the general usefulness of heat pumps in existing buildings. Equally undoubtedly, heat pump installation should become faster and easier, and operation even more efficient and economical. The heat pump industry is already working precisely in this direction.

### **Does a house have to be renovated first in order to install a heat pump?**

Clearly, the less energy needed to create a comfortable indoor climate, the better. That's why renovation measures to reduce heating energy demand always make sense. This applies to all heating systems, not just heat pumps.

For various reasons, full refurbishment of buildings is sometimes not possible in the short term. Fortunately, houses do not have to be extensively renovated to allow for an installation of a heat pump. Of course, the lower the heat losses, the more efficiently a heat pump can operate. Both residents' wallets and the environment benefit from using as little heating energy as possible. However, the decisive factor for the use of heat pumps is the required heating circuit temperatures.

In many older houses, the heat transfer systems are oversized. As a result, when the heating system is replaced, it is usually possible to lower the flow temperature set in the system and operate the heat pump more efficiently. In many other cases, small renovation steps have already been taken, such as replacing the windows. This is often sufficient to use a heat pump efficiently.

Efficiency can also be enhanced with the help of additional, relatively inexpensive short-term measures. These include, for example, the replacement of individual radiators. Modern radiators can transfer the same amount of heat to the room at significantly lower heating circuit temperatures. Such simple renovation measures can often be the first steps in a medium-term refurbishment roadmap to achieve further efficiency improvements.

Another common prejudice is that heat pumps can only be used with underfloor or wall heating. However, this is not only physically incorrect, but has also been disproved by thousands of heat pump systems implemented with radiators. Radiators do not necessarily require very high flow temperatures. In our [field study](#) (written in German), only a handful of the air-to-water heat pump systems that were equipped with radiators achieved average heating circuit temperatures above 45°C. In most systems, temperatures were even below 40°C.

### **Do existing buildings with heat pumps get pleasantly warm at all?**

What matters the most to residents is whether the room temperature is comfortable, even if it is very cold outside. In the first two weeks of February 2021, it was quite cold in Germany. An evaluation of 20 air-to-water heat pump systems, continuously monitored by Fraunhofer ISE, has shown that the average outdoor air temperature for the evaluated heat pump systems was -3.6°C during this very cold period (there have only been five months with average temperatures below -3.5°C in Germany in the last 50 years).

The efficiency of 17 systems (the three best in fully renovated buildings were not taken into account) was 2.3 during this period, with a range between 1.6 and 2.8. That is to say, even with such cold weather, more than twice as much heat could be extracted from the ambient air with each kilowatt-hour of electricity. The device with the lowest efficiency had to operate with the lowest average outside air temperature of -10.2°C. Additional electric backup heaters were used in only five plants and were taken into account when determining efficiency. The desired heating energy was provided by all plants.

The fact that heat pumps can be used successfully even at very low outside temperatures is also shown by the fact that they are already widely used in countries with much harsher winters, such as in Scandinavia. There are products on the market that can even operate at -25°C without additional backup heaters.

### **What happens if a heat pump is installed first and renovation is done later?**

An additional question involves renovation that occurs after a heat pump is installed: will the heat pump then be oversized? Such a refurbishment will primarily lead to an increase in heat pump efficiency. Heat pumps provide the required heat in both mild autumn and frosty winter, which means they can react very flexibly throughout the heating period. Therefore, even oversizing (except in extreme cases) is not a major technical problem. In addition, heat pumps with inverter technology, which enable their output to be controlled and thus efficiently provide a flexible output range, have now become almost standard.

This shows that heat pumps can also be used in existing buildings. Although it is always better to renovate first, this is not a prerequisite. In the vast majority of cases, a good heat pump solution can also be implemented in unrenovated (or slightly refurbished) buildings. There are many installers who specialize in such cases.

### How well do heat pumps installed in existing buildings really work?

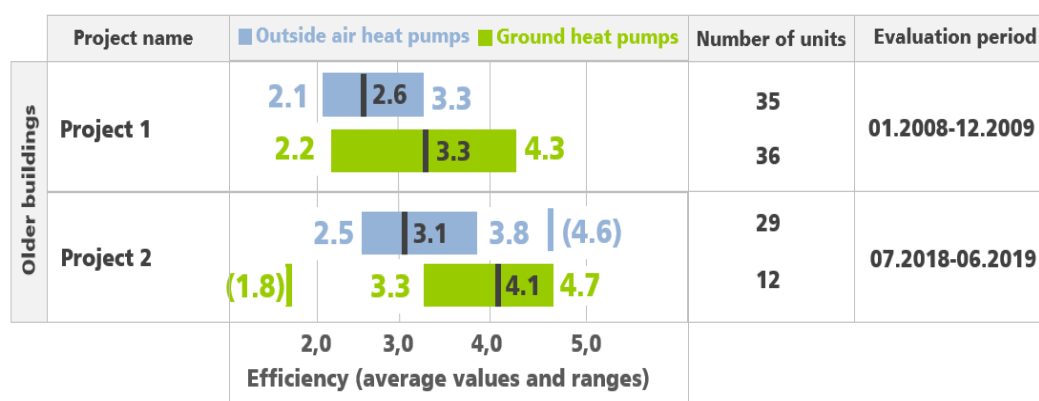
The question of how well a heat pump works can be answered by looking at several aspects and metrics. In most cases, 'how well' basically means 'how efficiently'. The efficiency of a heat pump is first determined in the laboratory under specific working conditions—in which case so-called coefficient of performance (COP) values are determined. Based on these values, it is possible to compare different heat pump models.

Somewhat more practical for end users are the performance values calculated based on the COP and certain operating parameters. These indicate what efficiency can be expected at certain outdoor and heating temperatures. This makes it possible, for example, to estimate the future operating costs of the system. Finally, there are efficiency values determined in the field under real conditions over a certain period of time (usually one year). These values are called operating figures and represent the actual efficiency achieved by the devices.

### Average efficiency values of heat pumps in operation

In the last 20 years, Fraunhofer ISE has monitored about 300 heat pumps in the field and determined the operating figures of these systems. (Evaluation of the next project with a further 50 units is expected in February 2023.) The figure below shows the results from two projects carried out in existing buildings. The projects were conducted approximately 10 years apart. The improvement in the average efficiency figures, e.g. from 3.3 to 4.1 for ground-source heat pumps, can therefore be partly explained by the technological improvement of the devices. Another reason for the different results is the different energy status of the buildings in question.

**Figure 1: Efficiency values of the heat pump systems from two field projects in existing buildings**



Source: © Fraunhofer ISE

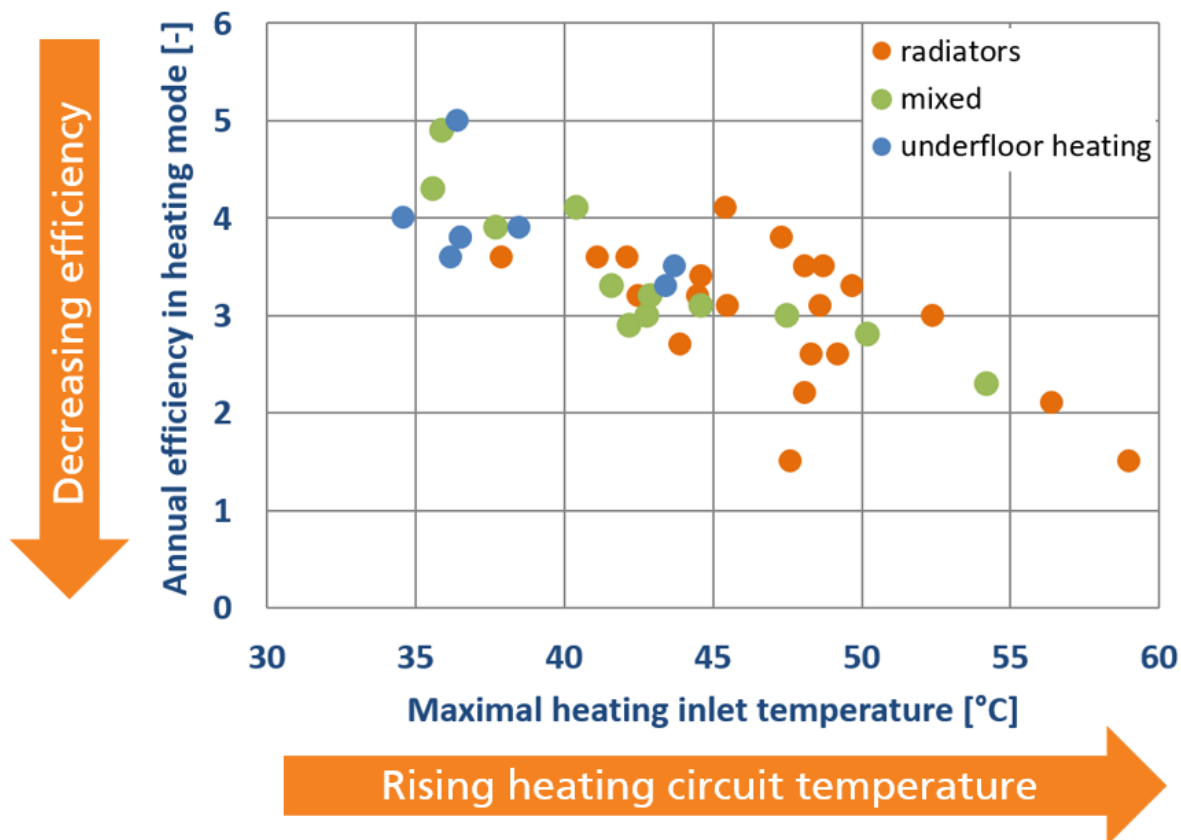
In the first project, mainly non-renovated buildings, 90 per cent of which were heated with radiators, were investigated. In the second project, although all the buildings were between 15 and 150 years old, some had been partially or fully refurbished. All efficiency values were determined for heat pump systems that served for both space heating and domestic hot water. The electricity demand of the additional electric heating elements was taken into account when calculating the values.

In the period from July 2018 to June 2019, the 29 outdoor air heat pumps in question achieved seasonal performance factors (efficiency) of 2.5 to 3.8. The mean value was 3.1. Two outliers with particularly high efficiency in fully renovated houses were not included in the calculation. For the 12 ground-source heat pumps, the seasonal performance factors were between 3.3 and 4.7, with a mean value of 4.1. For the ground-source heat pumps, a negative outlier of 1.8 was not considered. The values achieved show that, even with today's electricity mix in Germany, heat pumps cause lower CO<sub>2</sub> emissions than gas heating with solar thermal support.

### Influence of flow temperatures and different heat transfer systems

Of course, these highly aggregated values only give a rough picture of the heat pump systems investigated. An example of a more detailed evaluation is shown in the next figure. The graph shows the seasonal efficiency results of 41 air-to-water heat pumps during the provision of space heating. For each system, the achieved efficiency and the maximum (daily) flow temperature can be seen. The three colours symbolize different heat transfer systems. Houses with radiators are marked orange, those with underfloor heating are shown in blue, and those with mixed systems are displayed in green.

**Figure 2: Annual efficiency values as a function of maximum flow temperatures of 41 air-to-water heat pump systems with different heat transfer systems**



Source: © Fraunhofer ISE

A general dependence becomes clear here: the lower the flow temperatures, the higher the efficiency. Thus, the theory was confirmed in practice. And obviously, the second assumption—systems with underfloor heating tend to achieve higher efficiency values than systems requiring higher flow temperatures—has also been verified in practice.

It is noteworthy, though, that the picture is very differentiated. Most results fall between efficiency values of 3 and 4, with the mean value for all systems being 3.3. Both systems with underfloor heating and those with radiators achieved similar efficiency values. Conversely, however, the seven installations with a very similar maximum flow temperature, around 48°C, achieved an annual efficiency of 1.5 to 3.8. This enormous range of results points to other influencing factors.

For example, the systems with the conspicuously low efficiency values, around 1.5, were rather older units and had a very low standard COP. Crucially, however, the electric heater had to be used relatively often in these installations due to problems with the settings.

Thus, the heating circuit temperatures are not always the determining factor in the efficiency of the systems. This finding is encouraging for those cases where relatively high flow temperatures are necessary—good efficiency can be achieved in these systems as well. However, it also shows that it is not only the heat transfer system that is crucial, but also the careful planning, installation, and adjustment of the heat pump system.

### Average efficiency values of heat pumps are good


The research results clearly show that heat pumps as a heating source function reliably even in existing buildings and are environmentally advantageous. As a rule, the units worked flawlessly. Malfunctions occurred very rarely during operation. Further optimization can already be observed with the models that have been significantly improved in recent years and is certainly possible in the future with further innovations. Even today, however, the average efficiency values are good.

### How well have heat pumps performed in practice in partially refurbished and unrefurbished buildings?

Good examples make complex topics more accessible. But what would be a 'good' example of an old building with a heat pump? A 'good' building would be an extensively renovated house. Such a building, however, does not pose a challenge for a heat pump. In well-refurbished houses—which are, of course, the long-term goal for the entire building stock—heat pumps operate with similar efficiency and viability as in new buildings. Thus, this discussion focuses on two buildings that are rather 'bad' from an energy-efficiency point of view but are 'good' (typical) representatives of houses that have not been refurbished, or have been renovated only slightly, but still achieve good results with heat pumps.

Both houses are clearly old buildings, built 86 and 50 years ago, respectively. Both are located in the coldest climate zones in the south-eastern part of Germany. Heat pumps were installed in both houses about seven years ago, and they heat both the rooms and the domestic water. Neither building has underfloor heating.

**Figure 3: First example house**

	Year of construction	1937 (86 years old)
	Heating energy consumption	about 210 kWh per m <sup>2</sup> and year
	Energy standard	very poor, slightly renovated, windows and radiators have been replaced
	Heating system	outside air heat pump with radiators
	Efficiency of the heat pump	3.0


Source: © Fraunhofer ISE

In the first example—an older, detached single-family house—hardly any renovation measures have been implemented. Neither the walls nor the roof have been insulated. Only the windows have been replaced to meet today's standards. Accordingly, this building has a very high heating energy demand: 207 kWh per m<sup>2</sup> were calculated in the year of the evaluation.

At the time of the installation of the outdoor air heat pump, the radiators were also replaced. So-called fan convectors were installed. With this type of radiator, the necessary flow temperatures can be reduced even more significantly than with conventional convectors. They are particularly well suited for use in heat pump systems.

Despite the high heating demand, the outdoor air heat pump in this building achieved a good efficiency of 3.0. The direct-electric backup heater hardly worked at all (less than 1 per cent). Before the heat pump was installed, the house was heated directly-electrically with night storage heating. Thus, with very few additional measures, the replacement resulted in significant cost and CO<sub>2</sub> savings.

**Figure 4: Second example house**

	Year of construction	1973 (50 years old)
	Heating energy consumption	about 100 kWh per m <sup>2</sup> and year
	Energy standard	average, slightly renovated, roof was insulated 31 years ago
	Heating system	ground source heat pump with radiators
	Efficiency of the heat pump	3.7

Source: © Fraunhofer ISE

An oil boiler was exchanged for a ground source heat pump with geothermal boreholes in the second building in 2009. Both the walls and the windows are still in their original condition. The roof of the house was newly insulated well before the heating system was replaced, back in 1990. The measured annual heating consumption of about 100 kWh per m<sup>2</sup> corresponds approximately to the average of the building stock in Germany.

The heat pump system has been continuously measured in a monitoring project for several years. Although the system has the second highest average flow temperatures among the 15 ground source heat pumps studied—about 45°C—the efficiency of the heat pump is about 3.7, and annual fluctuations are minimal. As with nearly all ground-source heat pumps, the direct-electric backup heater was not used at all.

Heat transfer takes place via classic panel radiators, which were not replaced when the heat generator was replaced. The heated living space measures 170 m<sup>2</sup>. According to the residents, the monthly electricity bill for the total electricity consumption, i.e. all electrical appliances including the heat pump, is about €120 (data for in 2021 in Germany).

The two examples show impressively that heat pumps can achieve good efficiency even in houses that have not been refurbished or have only been partially renovated. In both examples, no unusual installations were used. Both houses are representative for many similar buildings, architecturally, in terms of the building fabric and in terms of the heat pump technology used.

The case of the first house also demonstrates how targeted and relatively inexpensive measures (such as replacing the radiators) can achieve a great effect. Other cases show, however, that such renovation measures can also be carried out several years after the installation of the heat pump and the house still achieves good efficiency values. In the final report of the research project WPsmart im Bestand (written in German)<sup>1</sup>, these and the other houses studied are described and analysed in detail.

### **How do we get more heat pumps in existing buildings?**

‘It works, so what are we waiting for?’ From a technical perspective, there are hardly any reasons not to use heat pumps in existing buildings today. Certainly, the challenge of finding a suitable technical solution and implementing it successfully is greater in some cases than in others. But the basic reality is that heat pumps work successfully not only in new buildings but also in existing ones. Regrettably, however, this realization has not yet gained sufficient acceptance among key professional groups such as architects, energy consultants, planners, and installers.

Technological development should move in the direction of a broader product range for existing buildings. It is particularly important to have standardized overall solutions that can be installed as quickly as possible and, ideally, at low costs. Other development goals include even higher efficiencies, quieter devices, and a switch to climate-friendly refrigerants (such as propane), but above all a further reduction in costs. Unfortunately, the investment costs of heat pump systems are currently often an exclusion criterion. Heat pumps should also be easier to install. The targeted use of digital tools and methods or artificial intelligence can make a major contribution.

It is becoming apparent that the bottleneck for the wider use of heat pumps is not the technology itself but the availability of skilled workers. The solution to this problem is certainly multi-faceted and requires stamina. However, it is very important to implement the right qualification measures now, be it in education or professional training.

The institutional level is responsible for providing the right impetus. The new, more ambitious climate neutrality targets cannot be achieved without clear resolutions and bold decisions. Currently heating oil and natural gas are subject to lower taxes in Germany than electricity. As a result, the price of electricity for operating heat pumps is almost four times higher than the price of heating oil and natural gas. However, this will change with the CO<sub>2</sub> pricing that has been in effect since January 2021, which will lead to a gradual increase in the cost of gas or heating oil. In addition, political declarations of intent by many players mean that a significant reduction in the Renewable Energy Act (EEG law) can be expected in the next few years. This will make heat pump systems increasingly attractive from an economic point of view.

## LOW-CARBON HEATING: HOW CAN WE MANAGE PEAK WINTER DEMAND?

*Matthias Janssen and Christoph Riechmann*

The EU and the UK are on an ambitious path to become carbon neutral by 2050. This will require energy to be used more efficiently and fossil fuels to be replaced by renewable sources of energy. To date, most progress in reducing emissions has been made in the electricity sector, but attention is now shifting to heating, transport, and industry.

### **Decarbonizing heating will be key to achieve net zero but is challenging**

Targeting greenhouse gas emissions from heating will be key: in industrialized countries in north-west Europe, for example, heat applications account for about 50 per cent of final energy demand.

Pursuing carbon neutrality in the heating sector also poses entirely new challenges:

- The building stock that is to be heated is very diverse. It has developed over more than 100 years with varying degrees of building insulation and different forms of ownership (e.g. owner occupiers and landlords).
- Any technical changes will potentially have a greater direct impact on user convenience and living standards than previous reforms in the electricity sector.
- For policies to be effective they need to address millions of households and commercial businesses. Reform in the electricity sector, by contrast, could initially focus on a few hundred commercial generation companies.

This paper explores possible technical solutions, achieving best value for money for energy users, barriers and market failures on the path to the transition, and possible policy approaches.

### **Technical solutions—a diverse universe where one size does not fit all**

There is broad agreement that achieving carbon neutrality in the heating sector will broadly require a combination of the following:

- Enhanced energy efficiency in buildings—predominantly through better insulation and better targeting of the spaces to heat—to lower the end energy demand required to provide a certain level of comfort.
- The use of alternative fuels harnessed to modern and efficient conversion technologies. A key element will be heat pumps using green electricity. Others might include combustion technologies using biogas, biomethane, green hydrogen, and green fuels; combined heat and power solutions where feasible; and hybrid solutions that use heat pumps alongside boilers.
- Increased use of district heating in densely populated areas.

The focus of policymakers on significantly enhancing the energy efficiency of building shells and heating systems often abstracts from the heterogeneity of the building stock and the resulting technical and economic limits of efficiency improvements. In Germany, one of the countries we have studied in greater detail, 89 per cent of today's building stock is more than 20 years old; buildings that are new or considered fully refurbished (some of them more than 20 years old) comprise only 13 per cent of the total. [About 90 per cent of heating systems are currently gas- or oil-based.](#) There is no one-size-fits-all solution to decarbonize this existing building stock. The UK is even less efficient: only around 40 per cent of homes have reached [Energy Performance Level C or higher](#) while, like in Germany, [90 per cent of homes use fossil fuels.](#)

As for heating technologies, electric heat pumps clearly have merits in relatively modern, well-insulated buildings (especially with underfloor heating). However, they are not necessarily the most cost-efficient option for all buildings. Other technologies have a role as well, especially given that the restructuring of the housing stock will necessarily be gradual.

For example, in order to realize the German government's target of a 2 per cent annual energy refurbishment rate, installers would have to carry out twice as many conversions each year in the next decade as in the last 20 years. During that time, the refurbishment rate has been continuously below 1 per cent despite considerable political efforts to increase it. The availability of fitters to install heat pumps is a clear limiting factor in the near term in both the UK and Germany, alongside current supply chain bottlenecks.



In view of the imperative for the heating sector to contribute to protecting the climate, alternative technology paths for reducing emissions should be considered and developed (or at least not politically foreclosed), in addition to further policies to encourage heat pump uptake. For example, hydrogen-based renewable or climate-neutral gases are potentially valuable options for helping to decarbonize the heating market. Depending on progress in energy efficiency and the market penetration of alternative technologies, the demand for hydrogen will be lower than the current share of natural gas in heat supply.

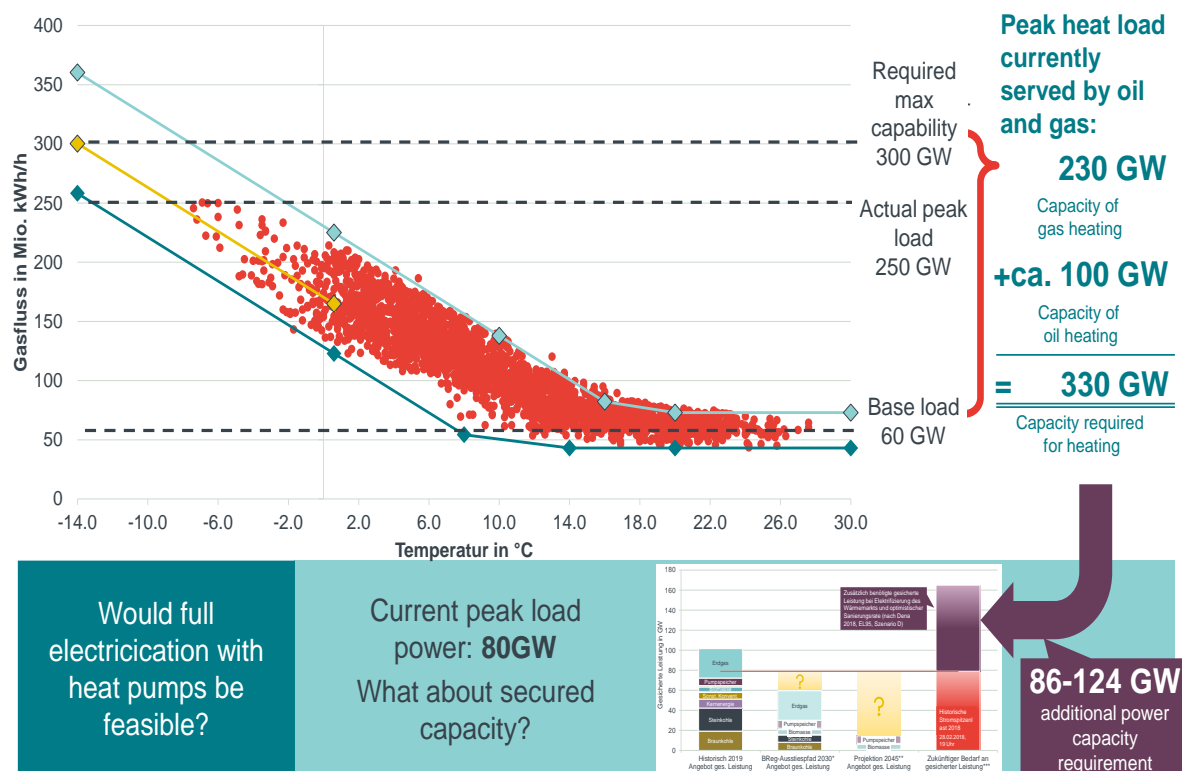
### Value added for consumers—view the system as a whole and not individual technologies in isolation

While it is vital to bear in mind the heterogeneity of the building stock, it is at least as relevant to consider the impact on the energy system as a whole of betting either on a single technology or a portfolio of technologies to reduce emissions.

A key feature of the buildings sector is that heating demand is highly seasonal. Demand in winter months is at least four times higher than in summer, as measured by the seasonality of gas usage. Heat demand is highest during the few days of the year with the coldest, sub-zero temperatures. These are also the days when heat pumps typically operate at low efficiency and when some buildings could be heated instead with direct electrical heating.

In the case of Germany we have calculated that peak gas demand, with the existing housing stock, is 250 GW. Serving such demand reliably, including on days when temperatures fall to minus 14°C, requires supply capacity in the order of 300 GW. Of this total, 230 GW can be attributed to space and warm-water heating, while the rest meets demand for industrial heat and power production. Adding required capacity that is today supplied by oil heating, we estimate a capacity requirement for space and warm-water heating of 330 GW. **If such demand were to be met solely by electric heat pumps, the current peak electricity demand of 80 GW would more than double to between 156 and 204 GW—despite the generally high efficiency of heat pumps.**

**Figure 1: Temperature-driven peak heat demand and required supply capacities (Germany)**



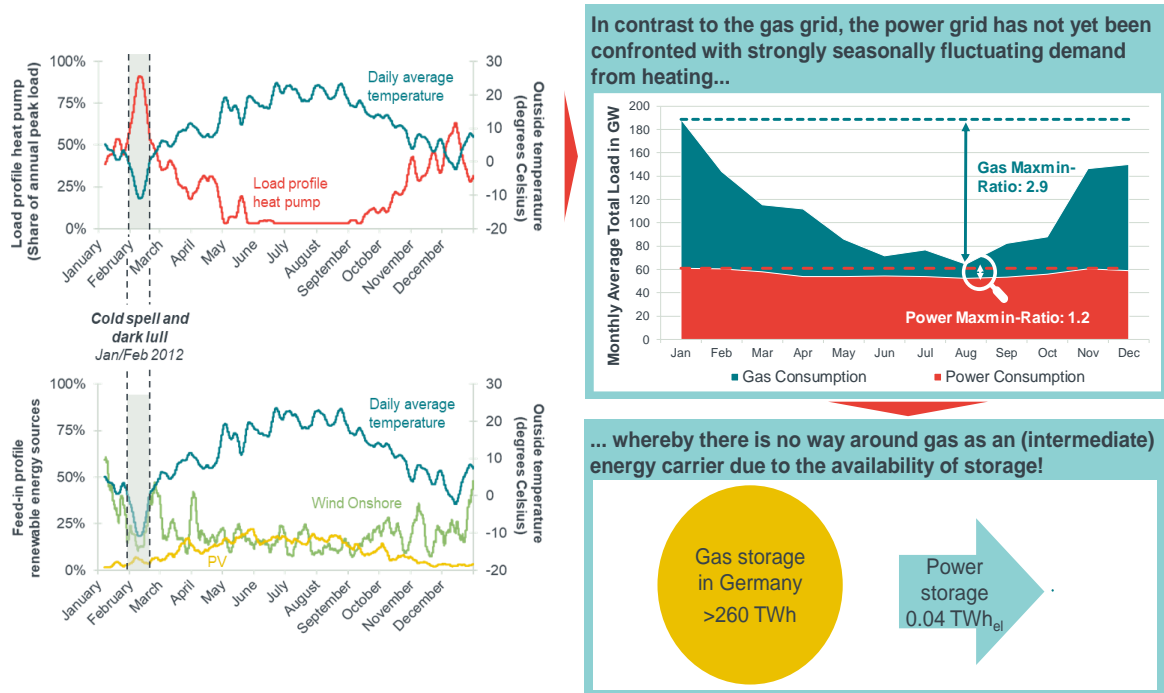
Source: Frontier Economics (2021), *The Value of Hydrogen in the Heating Market*.

Given this seasonality of demand—which is likely to diminish only gradually with increased investment in efficiency—a heating system entirely reliant on electricity to power heat pumps would be exposed to the availability and storability of electrical energy. Renewable energies in the form of wind and solar photovoltaic will undoubtedly dominate primary energy supplies in future. But their output is variable; power is not always available, particularly on cold winter days. Without a contribution from low-carbon



gas, either the electricity generation system would have to be massively overbuilt or significant seasonal electricity storage would need to be developed. But stored electricity has the disadvantage of low volumetric energy density. The required storage capacity would be prohibitively expensive and would take up large areas of space or land. Electric batteries are well suited for daily charge-discharge cycles, e.g. for electric vehicles, but not for seasonal storage cycles with intermittent wind and solar supplies.

**Figure 2: Seasonal profiles of temperature, renewable electricity production, and heat demand (Germany, 2021)**



Source: [Frontier Economics \(2021\)](#), *Die Rolle von Wasserstoff im Wärmemarkt*.

In other words, it is hard to conceive of practical ways of avoiding at least some use of low-carbon gas either as an energy carrier or for long-term (inter-seasonal) storage of electricity in any national energy system. There is therefore a future for energy in gaseous and liquid form in the heating sector, for use either directly in buildings or indirectly by helping to meet peak winter demand for electricity.

This low-carbon gas needs to be produced from renewable sources, as is the case for green hydrogen and fuels, biomass, biogas, and biomethane. Hence electrification will play a significant role in the heating sector, even if it is likely in part to be through so-called indirect electrification—the conversion of green electricity to hydrogen or other synthetic fuels. Conversely, as heating systems that use low-carbon gas may have drawbacks for users—for example, lower fuel efficiency or, in the case of hydrogen, the possible need to adapt the heating system, including changes to the gas pipes—some part of the fuel needed for inter-seasonal storage may be re-electrified before it is distributed to end consumers.

So, given the diversity in the building stock and consumers' differing heating needs, it is likely that a mix of solutions will be required. However, given the importance of gas/electricity networks, economies of scale are a major consideration. Hence regional zones where one or several options are taken up are likely to emerge. Hybrid solutions (e.g. hybrid heat pumps) are also possible and can be cost-effective. In addition, the dynamic development of various technologies makes it impossible to know how quickly their cost will fall. For example, [the cost of modular technologies that can be rolled out in standardized form has come down much more rapidly than technologies that require large bespoke infrastructure](#). Accordingly, systems and policy need to be open to alternative solutions—albeit ones based on renewable primary sources of energy.

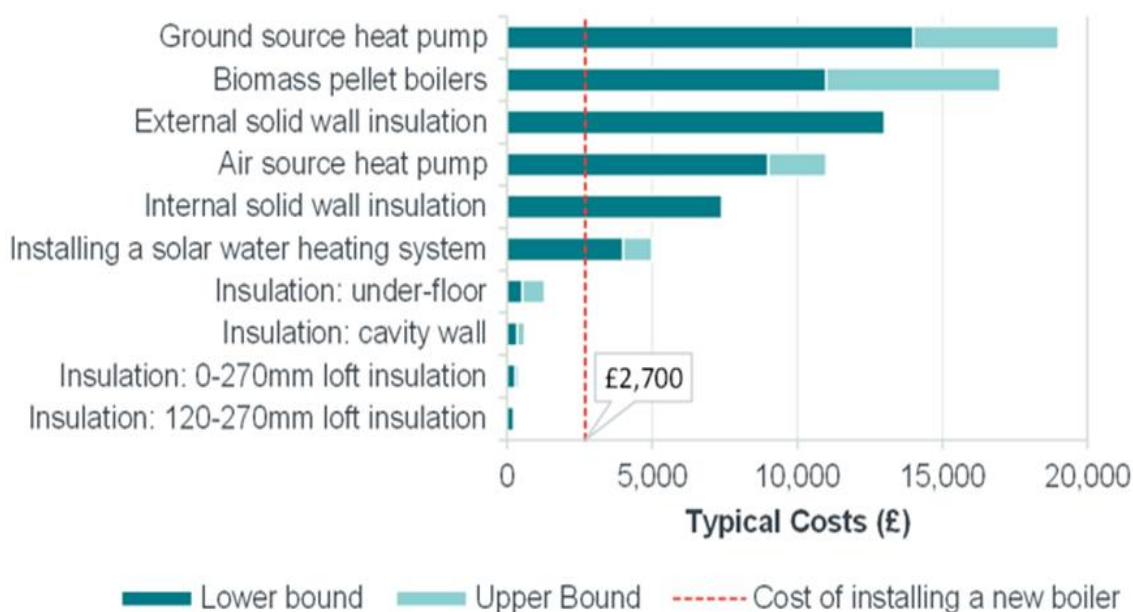
### Barriers and market failures limit a natural transition

But will remaining technologically open-minded suffice to come up with the optimal sustainable heating system? Strong doubts are justified. Various impediments and market failures stand in the way of the desired policy outcomes. It is important to understand these obstacles first before formulating appropriate policies to overcome them. Some of the most relevant constraints can be summarized as follows.

**Need for coordination.** Many of the green options are subject to major economies of scale, as they rely on networks for the transport of low-carbon gas or electricity. This means that a coordinated approach may be needed to keep costs down. In addition, some transitions will require customers in a given part of the network to switch all at the same time (for example, when moving from natural gas to hydrogen). Again this will call for some coordination.

**High upfront costs and consumer interest in rapid pay-back.** Moving away from today's dominant heating technologies of natural gas and oil burners requires consumers to replace their heating systems. In many cases this will involve new radiators and possibly even substantial additional insulation, new ventilation, or new internal gas pipes. Low-carbon heating technologies often have higher upfront costs than fossil fuel heating systems. Upfront costs are particularly important for consumers; evidence suggests they may employ very high discount rates when choosing a new heating system, though there is significant uncertainty around the estimates. (For example, a study for the European Commission found that [consumers apply discount rates of  \$19 \pm 17\$  per cent when purchasing efficient energy and transport technologies](#).) Settling on a high discount rate means people are putting much greater weight on upfront costs in their decision-making, relative to the savings to be made over the lifetime of the investment. Even if a completely new system is cost-effective in the long run, many consumers may not be able or willing to pay the upfront costs.

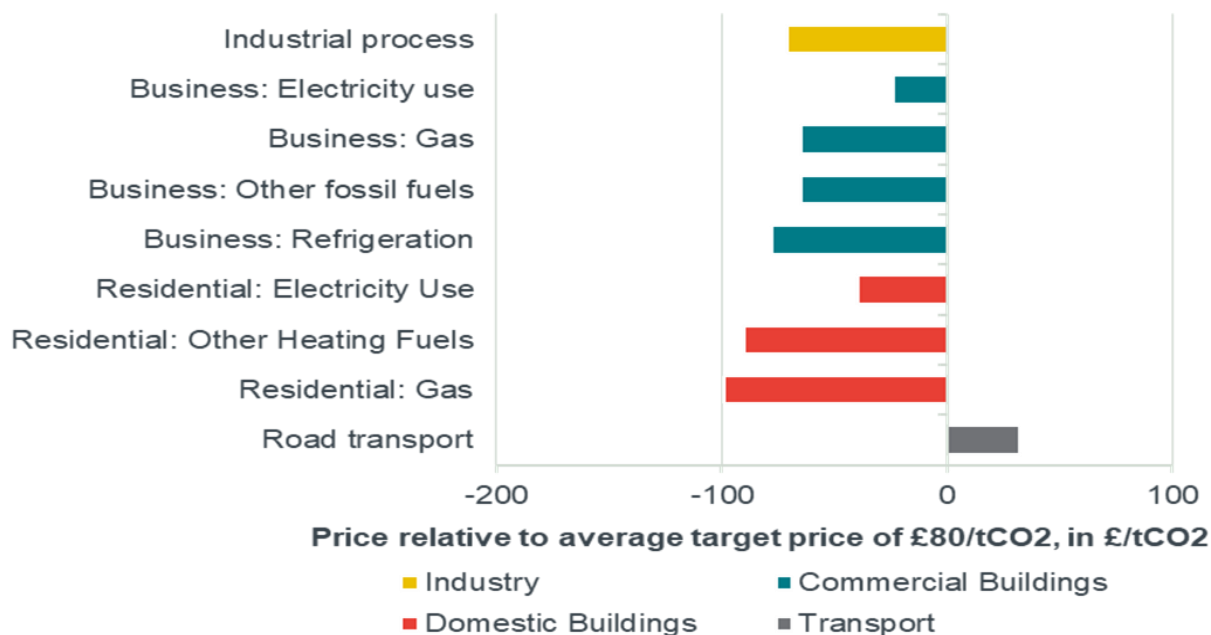
**Figure 3: Upfront costs of low-carbon heating technologies (UK)**



Source: [Energy Savings Trust \(2023\)](#), [Green Homes Grant Scheme](#).

**Immature technologies.** While heat pumps are being rolled out at scale in many European countries, hydrogen boilers and appliances are at an earlier stage of development. Further investment in R&D is likely to be required.

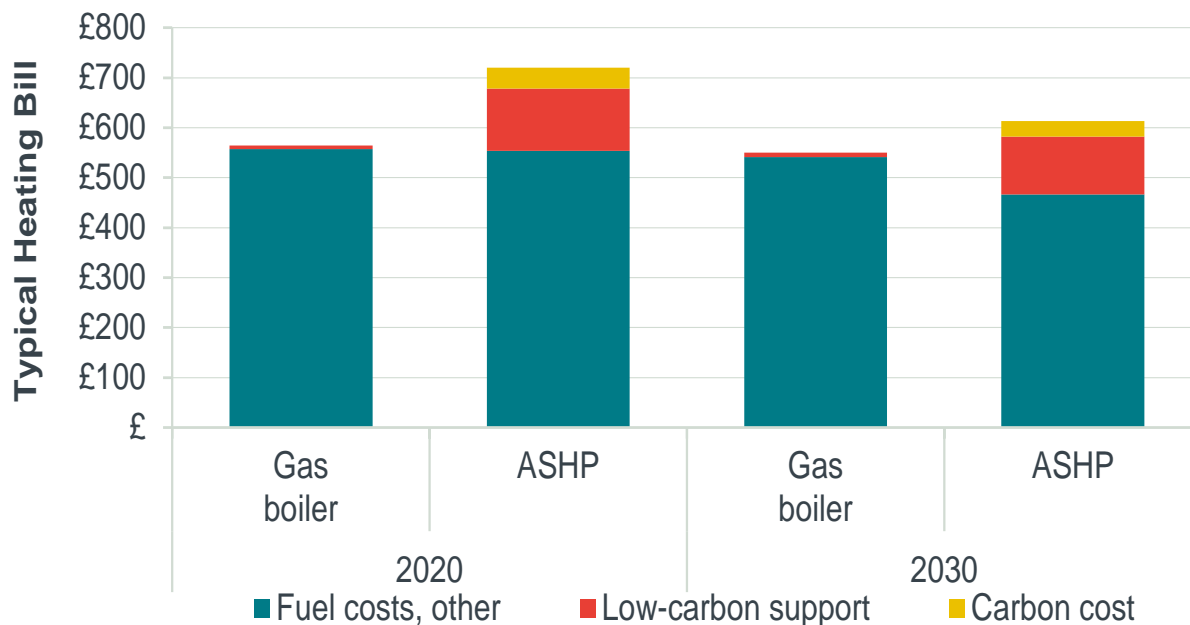
**Distortions in the current policy framework.** Emissions externalities are not fully and consistently priced in, so consumers cannot always gain from reducing emissions. There are also distortions between fuels. In many countries, there are proportionally higher environmental levies and taxes on electricity than on natural gas, for both industrial and domestic customers. This is illustrated in the figure below for the UK, based on an Energy Systems Catapult analysis of implicit carbon prices by sector.

Figure 4: Carbon price relative to average target price of £80/tonne CO<sub>2</sub> by 2030 across sectors (UK)

Source: Energy Systems Catapult (June 2020) *Rethinking Decarbonisation Incentives: Future Carbon Policy for Clean Growth*. £80/tCO<sub>2</sub> from BEIS central scenario in BEIS (April 2019) *Updated Short-term Traded Carbon Values – Used for UK public policy appraisal*.

Analysis by the Climate Change Committee shows that these differences in carbon prices can translate into variations in typical bills for consumers adopting electrified low-carbon technologies

Figure 5: Heating bills for gas boilers and air-source heat pumps (ASHP), 2020 and 2030



Source: [Climate Change Committee \(2020\)](#), *Sixth Carbon Budget*.

Carbon costs are set in line with Green Book values. As set out in the Climate Change Committee's report, electricity consumption is subject to a carbon price under the Emissions Trading System and the Carbon Price Floor in the UK, whereas there is no carbon price on gas consumption. Both electricity and gas prices include support for low-carbon and fuel-poverty schemes, at 3.5p/kWh on electricity and 2.1p/kWh on gas. Low-carbon support costs are higher for electricity as they include the costs of decarbonizing the power sector (through subsidies such as Contracts for Difference). In Germany, for comparison, this levy to finance support for renewable electricity production has recently been removed from final consumer bills. These costs are now financed by state budget and do no longer burden electricity consumption.

**Limited engagement of consumers with the market.** Apart from the high initial financial investment required, other barriers to replacing heating systems include low interest and awareness on the part of consumers (especially landlords who would be required to make necessary investments), lack of trust in energy suppliers, and risk aversion because of uncertainty about the performance of new technologies.

### **Policymaking needs to address these challenges**

Bearing in mind these challenges, the transition to low-carbon heating requires the following:

- **Comprehensive cost analysis to inform choices.** Because of the presence of externalities and the maturity of some of the technologies, policymakers will need to support low-carbon heating options. The choice of which technologies to help should be based on a whole-systems analysis, taking into account economies of scale. Such an analysis should also incorporate the [potential for future cost reductions, where technologies can be modularized, and where large, bespoke infrastructure can be avoided](#).
- **Piloting of new technologies.** Local trials should be carried out to better understand the pros and cons and system implications of immature technologies, such as hydrogen for residential heating, as is currently happening in the UK and the Netherlands.
- **Keeping technology options open.** Given the heterogeneity of the building stock as well as existing infrastructure, there is a benefit in adopting a portfolio of heating technologies. Hence policymakers should be as technology neutral as possible, and just ensure coordination where needed—for example, if it is necessary to switch over all customers in a given part of a network at the same time (e.g. when moving from natural gas to hydrogen).
- **Supply chain stability.** In the past, policymakers have often focused on giving consumers economic incentives to make changes. However, stop-start policies have not left enough time to build up the supply chain. This means that even when generous incentives have been put in place, [consumers have struggled to find qualified installers](#). Likewise, people will not switch to a certain technology (e.g. hybrid heating with hydrogen boilers) if they cannot be confident that there will be a fully developed supply chain to supply and transport the fuel.
- **Policies that recognize consumer perspectives.** Low levels of interest in heating systems and limited awareness of the benefits of alternatives, coupled with the fact that people have to decide whether to make a switch when their existing system has broken down, may significantly slow the transition to low-carbon technologies. A policy emphasis on providing incentives at key trigger points, such as when a home is being sold or renovated, may be more successful.
- **Removal of distortions in gas and electricity pricing.** Externalities are not consistently internalized across gas and electricity use at present. A rebalancing is needed to remove such distortions.

## HARNESSING THE DECARBONIZATION POTENTIAL OF DISTRICT HEATING IN EUROPE

*Aksana Krasatsenka, Michael Wiggin, and Andrej Jentsch*

District energy systems are critical solutions for the decarbonization of heat. These systems have the potential to move towards low-temperature heat, operate with 100 per cent renewables, and offer flexibility services to the electric grid. District heating and cooling networks are promising solutions, especially in urban areas where individual solutions would not make it possible to fully integrate available clean energy sources or operate efficiently for several reasons, including space or noise constraints. According to the [International Energy Agency](#), in 2021 global district heat production added up to nearly 16 EJ (exajoules), an increase of more than 10 per cent over the previous decade, but accounting only for 8 per cent of total final heat consumption globally.

Despite its potential for decarbonizing heat, district heat today still relies on fossil fuels. In 2021, 90 per cent of district heat globally was produced from fossil fuels, primarily coal (45 per cent), natural gas (40 per cent), and oil (3.5 per cent). However, even now, the carbon intensity of district heating systems is often much lower than that of individual boilers, due to the widespread application of combined heat and power generation as a backbone.

District heating systems are heterogeneous across countries and across systems with several countries leading the path towards clean district heating, in particular in Europe, which represents 20 per cent of global district heating production.

This paper discusses the opportunities for the European district heating market to exploit untapped its decarbonization potential and to contribute to broader climate objectives within the region.

### The European market and its decarbonization potential

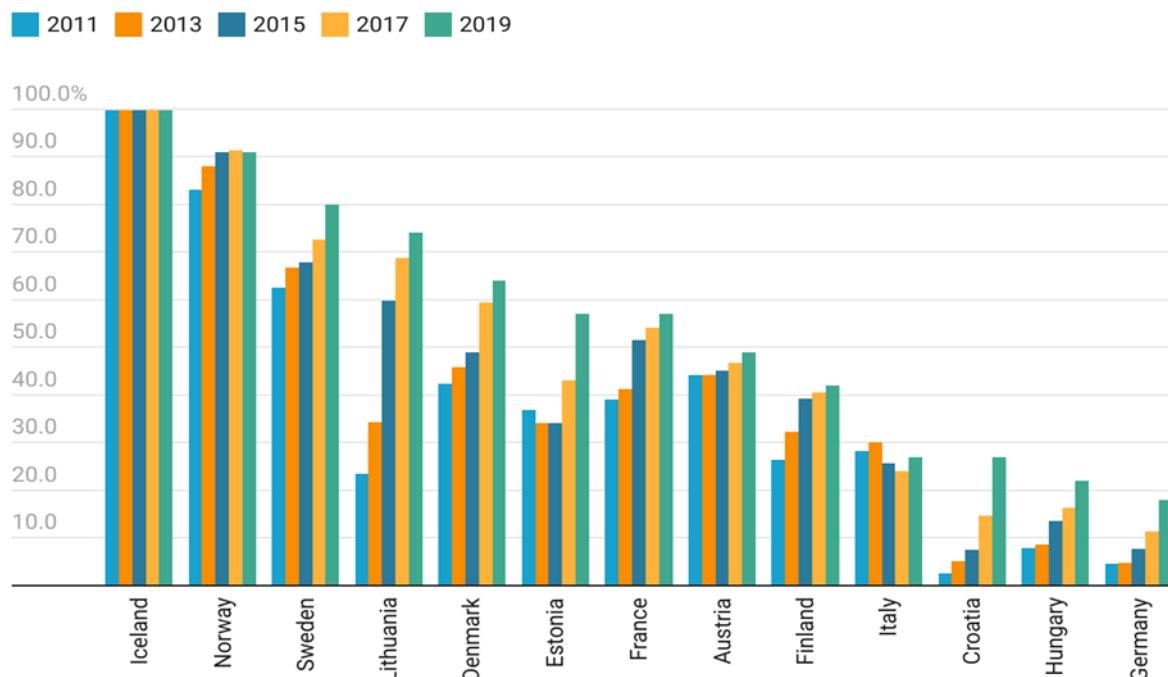
The share of district heating in Europe varies significantly from one region to another. District heating is by far the most common heating solution in the cold-winter countries in northern and eastern Europe (e.g. the Nordic and Baltic regions and Poland), whereas it still plays a minor role in southern (e.g. Spain and Greece) and some western (e.g. the Netherlands and the United Kingdom) European countries. Overall, Germany harbours the largest district heating market in Europe, followed by Poland and Sweden.

In 2019, [district heating and cooling represented 12 per cent of the European heating market](#). Despite this, a significant share of fossil fuels is still present in the district heating fuel mix, with almost half of it being natural gas. Meanwhile, nearly 30 per cent of district heating production is covered by renewables and industrial excess heat, which makes [Europe the world leader in the field of renewable district heating](#). District heating and cooling has been a gateway to deploying more renewables in home heating: the seven European countries with the highest national shares of renewable heating and cooling also have the highest shares of district heating in their heat markets (Iceland, Sweden, Estonia, Finland, Latvia, Denmark, and Lithuania).

The [DHC Market Outlook](#) data of Euroheat & Power shows that many countries have made considerable progress over the last few years in integrating renewable sources into their district heating systems:

- The share of renewable heat in Denmark grew from 42 per cent in 2011 to 64 per cent in 2019.
- More than 40 per cent of district heating is now carbon free in Finland, compared to 26 per cent in 2011.
- In France, the average renewable and recovered energy rate exceeded 60 per cent in 2020.
- Lithuania reported a decrease of around 70 per cent in CO<sub>2</sub> emissions from the heating and cooling sector since 2000.
- Both Sweden (17 per cent) and Croatia (24 per cent) have seen considerable growth in the share of renewable energy in district heating compared to 2011.

Figure 1: Share of renewable energy in district heating in selected European countries (2011–2019)



Source: Euroheat & Power (2022), *DHC Market Outlook 2022*, created with Datawrapper.

Note: the 2015 figure for Estonia and the 2019 figure for Iceland were not available; in these cases, figures from 2013 and 2017, respectively, were used. Percentages are based on district heating energy supply composition data provided by participating countries.

Approximately 60 million citizens within the European Union are currently served by district heating, with an additional 80 million living in cities which are already equipped with at least one district heating system. These numbers highlight the strong potential of district energy networks to expand and, in combination with a renewables-based generation mix, to serve as an alternative way to meet the challenge of urban densification and support the transition of the European buildings stock away from fossil-fuel heating.

In the next decade, deploying district heating and cooling will be critical to gradually phase out fossil fuels supply in heating. A [recent assessment](#) by the think tank Agora Energiewende with the help of Artelys, TEP Energy, and the Wuppertal Institute found that district heating could have the technical potential to achieve around 125 TWh (~12.5 bcm) in gas savings in Europe by 2027.

Several studies are in agreement that there is a great potential for expanding clean district heating in Europe. According to [Agora Energiewende](#), district heating could supply 20 per cent of heat in buildings by 2030, with 50 per cent of it supplied by renewables and waste heat. According to [Heat Roadmap Europe](#) data, if the urbanization trend continues and appropriate investments are put in place, district heating could meet almost half of Europe's heat demand by 2050.

However, to realize this potential, the heating and cooling sector must accelerate its transition away from fossil fuels. On this journey, there are at least three well-proven strategies for district heating:

1. Support the deployment and integration of **sustainable renewable heat sources** (such as geothermal, sustainable bioenergy, and solar thermal). These can be integrated swiftly into existing and future district energy networks to replace polluting fossil fuels. Some policies can foster the development of renewable district heating—such as the [French Heat Fund](#) (Le Fonds Chaleur), administered by ADEME (French Environment and Energy Management Agency), which provides €520 million per year for renewable heat, including investment aid for heating infrastructure.



2. Foster integration of the electricity and heating sectors—also known as **sector coupling**.
  - District energy networks coupled with large heat pumps and thermal storage can convert excess renewable electricity into renewable heat, providing cost-efficient balancing and storage to the electricity grid. According to Euroheat & Power's 2022 [DHC Market Outlook](#), power-to-heat could become a major supply source for district heating and cooling networks by 2050, reaching around 30 per cent of the energy supply in Germany and around 45 per cent in Denmark.
  - Combined heat and power can provide heat from fossil fuels and renewable sources at maximum efficiency and help balance the power grid in times of additional power needs.
  - District cooling can also play a key role in smoothing out peak demands from increasing electrification shares across sectors. It reduces the need for electrification as it can tap into alternative sources, such as free cooling from rivers and the sea. This flexibility is expected to yield significant benefits as demand for cooling increases.
3. Encourage the **recovery of waste heat** from industrial processes like paper and cement, energy production such as electrolysis, or tertiary activities like data centres. According to [Heat Roadmap Europe](#), up to 25 per cent of district heating could be supplied by industrial heat. Furthermore, urban waste heat from data centres, metro stations, tertiary buildings, and wastewater treatment plants can meet more than 10 per cent of the EU's total energy demand for heating and hot water ([ReUseHeat](#)). The substantial potential of waste heat recuperation from hydrogen should also be considered.

The above strategies are easier to implement within new networks, but existing networks, 10,000 in total in Europe, also have a large potential to progressively shift to cleaner approaches. In this regard, the district heating system of Bolzano (constructed in 1986) in South Tyrol (northern Italy)—winner of the [Global District Energy Climate Awards 2021](#) in the modernization category—shows a replicable pathway. Starting in 2008 a massive expansion took place and various measures were undertaken to implement a modernization programme, including the integration of a waste incineration plant, the construction of a large buffer storage tank, and the implementation of an innovative district heating net optimization software package (Termis). From 2013 to 2019, the number of customers connected to the district heating network increased by 60 per cent, and a strong reduction of CO<sub>2</sub> emission was achieved despite a massive expansion of the network. The maximum value of reduction was recorded in 2018 with 95 per cent compared to 2008. Due to continuous optimization, a high level should be maintained. When the investment plan for Bolzano is complete, expected by 2025, the cumulative investment will add up to €70 million, and around 7.5 million cubic metres of gas will be saved each year, avoiding about 15,000 tonnes of CO<sub>2</sub>-equivalent emissions, as much as if a virtual forest of 2,000 hectares appeared in the city.

In this particular case, the transition took around 10 years. However, there is not an average time for project deployment, as district heating projects, which occur in urban areas, are citizen-led and involve many actors and often public works. If properly supported, it can take less than three years, as demonstrated by the [ArGeo](#) geothermal greenfield district heating project in France, for which drilling work occurred from November 2013 to March 2014 (less than six months), and the construction of the network to connect around 7,500 homes occurred in around one year.

### **Economics of district heating: an integrated energy system view is necessary**

In order to meet the net-zero-emissions ambition, the building sector is required to decarbonize. Reducing energy service demand, shifting towards cleaner fuels, and improving the energy efficiency of the equipment are major strategies in this direction.

Taking into account the broader diffusion of clean energy technologies, the challenge is to determine which solutions are available, and how they compare in terms of societal cost. This goes beyond comparing clean energy technologies with their fossil counterpart and the decarbonization and expansion of existing district heating systems, and the creation of new district heating systems in many cases appears to be the solution with the least societal cost.

Key solutions that are usually considered are building-based demand reduction (deep or shallow retrofit) and either electrification through building-level heat pumps (an electricity network solution) or district heating (a thermal network solution). There is not one solution that fits all cases, and making the best choice for each case requires full societal cost accounting.



Heating is a seasonal load, in which the average heat demand is much lower than the maximum heat demand. This means that in order to provide heat, significant energy network capacity is required. In the case of a sudden deployment of a large share of individual heat pumps, electricity networks might need to be upgraded significantly, which might increase the societal cost of individual heat pump solutions if widely deployed, beyond the costs of installation and operation. These cost increases, however, will not necessarily be visible on the heating bill, thus opening the door to unbalanced economic comparisons. Heat pumps can also provide district heating. However, district heating typically integrates other sources and can support balancing the electricity grid. All costs involved in heat prices are already included in district heating prices, which makes it easy to compare it with other costs for operation.

Therefore, if individual solutions are not assessed in an integrated way, a comparison between the two solutions can be misleading. District heating can leverage economies of scale and might reduce the requirements for building and electricity grid retrofits, and in many cases, it can come with significantly lower societal costs than individual solutions.

How to compare costs and emissions savings opportunities across different solutions is an interesting future area of research. The old threshold price of current fossil fuel service limited district heating feasibility to higher-density urban areas. With a focus on zero greenhouse gas emissions, that threshold cost of service is raised considerably, and district heating can be very attractive even in lower-density areas.

## Conclusions

During the past decade, little has been done to accelerate the clean transition of the heating and cooling industry.

District heating systems can help save natural and financial resources by enabling the integration of heat from sources that are otherwise lost, such as waste heat and deep geothermal heat. The use of these heat sources can also help to keep energy prices low.

Additionally, district heating and cooling systems can help to avoid an extreme and expensive overhaul of the electrical grid, which would be required if all homes were served by electric technologies directly.

The outdated heating and cooling strategy published in 2016 for the European Union (even before its commitment to being climate neutral) requires a proper implementation framework that will match the ambition of achieving climate neutrality by 2050 and responding to the challenges brought by the current energy crisis. The Fit for 55 package is an essential step in this direction, but it is not enough to reap the full potential of renewable and sustainable waste heat solutions.

International collaboration and research can ensure that the latest findings and best practices are the basis of any district heating and cooling development in the future, thus maximizing the societal benefits of district heating and cooling.

Heating and cooling are the next frontier for renewable and sustainable energies growth, and Europe is in a pole position to lead this global race. Locally owned district heating and cooling networks providing sustainable heat are a perfect illustration of this.

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## IMPLEMENTING LARGE-SCALE INSTALLATION OF INDIVIDUAL HEAT SUBSTATIONS AS PART OF COMPREHENSIVE DISTRICT HEATING SECTOR REFORM

*Nazar Kholod and Meredydd Evans*

District heat (DH) systems were created in cities to provide heat and hot water to multi-family buildings. The first two generations of DH systems—based on steam and overheated water—supplied heat directly to buildings. These systems used different fuels, including coal, natural gas, and oil products. The third generation (also called the Scandinavian model) was designed in the 1970s to improve heat supply efficiency by using different energy sources and equipment, including individual heat substations (IHSs). The fourth DH generation uses [multiple energy sources and smart IHSs](#) to combat climate change.



According to the International Energy Agency (IEA), [the buildings sector accounts for 28 per cent of global energy-related emissions](#). The IEA considers existing DH networks as ‘[strategic assets for buildings decarbonization](#)’. Given the strategic importance of DH in the decarbonization of buildings, European countries have been expanding their DH systems.

An IHS (sometimes also called a house substation) connects the DH system with buildings; it includes equipment to transfer heat from the DH system to the building and controls to regulate heat flow. This paper reviews IHS deployment in European countries. It uses several case studies to highlight the role of policy framework, ownership rights, financing options, and other parameters of IHS deployment.

### **IHSs in Western Europe**

IHSs were developed in the 1970s and 1980s, and [a great number of IHS configurations were invented as they became popular in the 1990s](#). Typical IHSs comprise a heat exchanger, controls, and a circulation pump. They also have heat meters that allow consumption-based billing. Modern IHSs can be connected to centralized supervisory control and data acquisition systems so that DH operators can remotely adjust temperature regimes in buildings based on customers’ preferences.

Efficient IHSs with thermostatic controls and automated weather regulation can significantly improve DH efficiency and lower costs. IHSs also make it possible for homeowners to control their heat consumption. As a result, IHSs make it possible to achieve savings from additional energy efficiency measures on the demand side. To put it plainly, without IHSs, other energy efficiency measures will only lead to an increase in indoor temperatures and not to a reduction of heat bills for homeowners. IHS deployment also brings additional network efficiencies from reduced energy losses for hot water supply.

To promote the development and installation of IHSs, several international organizations developed guidelines and best practices reports. For example, IEA’s District Heating and Cooling Project published the Efficient Substations and Installations report in 1996. In 2008, Euroheat & Power, the international network for DH in Europe, developed the Guidelines for District Heating Substations, which contain a set of recommendations focusing on planning, installation, use, and maintenance of IHSs throughout Europe. The IHS became a standard part of DH in European countries with well-developed DH systems, especially in Scandinavia. [Danish companies Danfoss and Grundfos became market leaders in producing prefabricated IHSs](#). DH companies played the most important role in deploying IHSs. DH operators usually design, equip, operate, and maintain IHSs according to standard rules to secure energy-efficient operation.

DH systems are critical to decarbonizing buildings. As a result, some countries where DH systems were not popular several decades ago started developing DH to decarbonize their buildings. For example, the United Kingdom is expanding its DH networks. It recognizes that [DH could play an important role in high-density city areas in delivering low-carbon heat and can replace individual gas-fired boilers](#).

IHSs are not required by national regulation in European countries, but they are almost universal in buildings connected to DH. DH companies usually own IHSs, provide maintenance, arrange financing, and recover the investment cost through payments from the building owners and heat customers.

### **IHSs in Central Europe**

While IHSs became standard equipment in Western Europe, this was not the case in Central Europe, where DH systems were developed with little incentive for efficiency and did not have IHSs when they were created in the 1970s and 1980s. One important feature of the DH systems in the region was the use of large central heat stations instead of IHSs. Central heat stations served several buildings so that customers could not change the temperature setting in their buildings—DH companies made these decisions. As energy was cheap, many buildings were overheated. However, DH companies in Central Europe became big proponents of widespread IHS deployment to improve the quality of services and balance better heat loads when energy prices were liberated. Cities in Central and Eastern Europe installed IHSs primarily in the 1990s and early 2000s, soon after they began a large-scale transformation of their DH systems. Central European DH companies generally found that these investments were cost-effective and improved service quality and energy efficiency. Some cities relied on donor investments to catalyse the initial deployment but then moved to private financing for scale-up. IHSs were critical to keeping customers from switching to other heating sources.

IHS deployment in [Czechia, Latvia, and Poland](#) is summarized below.

### **Czechia**

IHS installation was carried out in Czechia as part of larger DH reforms and privatization. As subsidies to DH companies were phased out, heat tariffs started to rise; and installing IHSs, which improved energy efficiency, was a key measure for avoiding rapidly increasing costs to customers. DH companies have financed the bulk of IHSs, although some pilot projects have co-financed installations. Some projects have also been co-financed through an EU program that provides funding for replacing old heat distribution infrastructure. Municipalities sometimes required IHS installation to lease DH infrastructure to DH companies. For the majority of IHSs that are owned by utilities, the cost of the IHS is recovered through the tariffs for end users. The IHS owner, usually the utility or service provider, is responsible for maintenance. Requirements to create housing associations, as well as the common practice of setting aside space for IHSs during housing privatization, helped facilitate the transition from central heat stations to IHSs.

### **Latvia**

Latvia inherited a Soviet-style DH system and rebuilt it in the 1990s. The national government and municipalities have played an essential role in modernizing the DH systems. The government of Latvia adopted the State Investment Program in 1995 to replace old central heat substations with IHSs, which was the first step in Latvia's large-scale deployment of IHSs. Cities owned most DH companies and required them to install IHSs, financed with grants and loans from commercial banks. In Riga, the city council recommended installing or modernizing IHSs in all buildings, which was mostly done from 1999 to 2005. In Riga, for example, 90 per cent of IHSs were installed during the first six years of reform. Banks were willing to finance IHS installations as the payback period was short. DH companies owned the IHSs for the first several years, while customers made lease payments to cover the initial investments and interest. Now IHSs are owned by building owners, and only in rare cases can DH companies own them.

### **Poland**

Poland started reforming its DH sector in the 1990s, and DH companies have become the largest investors in IHSs since 2000. Poland introduced laws that provided broad flexibility in IHS installation. DH companies and building owners can install, operate, and maintain IHSs; however, DH companies usually serve in these roles. If the DH company owns the IHS, it recovers the cost through the heat tariffs.

The Energy Regulatory Authority of Poland has played a major role in the process of IHS installation. It developed guidelines to gradually eliminate central heat substations and replace them with building-level IHSs. According to the Building Law, all new and modernized buildings in Poland connected to the DH network must be equipped with building-level heat meters integrated into IHSs.

### **IHSs in Ukraine**

Ukraine is a very interesting case in IHS deployment. It is among the countries with the lowest levels of IHS deployment, but Russia's attack on Ukraine may rapidly change this. IHSs are essential for regulating DH systems, and their importance is even more significant in cities with damaged DH systems and buildings.

Ukraine's DH systems were created in the 1970s and, unlike in Central Europe, the DH sector had remained mostly unreformed until now. DH systems in Ukraine were designed with excess generation capacity, which led to significant inefficiencies and higher costs. Underinvestment and poor management have made Ukraine's DH systems inefficient and unreflective of customer needs. The excess capacity further grew as many customers disconnected from DH networks. The share of urban households served by DH decreased from 89 per cent to 55 per cent from 1995 to 2018. Still, [DH companies consumed 25% of natural gas in the country in 2019](#).

In Ukraine, large-scale IHS installation has proceeded at a much slower pace than in many Central European countries. Only 12 per cent of multi-family buildings with DH in Kyiv, the city with the largest DH system in the country, are currently equipped with IHSs. The key reason for the slow pace of IHS deployment in Ukraine is the lack of clear legal authority for DH companies to make investments in IHSs. DH tariffs in Ukraine do not cover all production costs, and [DH companies, in most cases, cannot include IHSs in heat tariffs](#).

Most IHSs in Ukraine have been installed with the help of international development partners, like the European Bank for Reconstruction and Development, the Nordic Environment Finance Corporation, the Deutsche Gesellschaft für Internationale Zusammenarbeit, the Eastern Europe Energy Efficiency and Environment Partnership, and others. Installing IHSs proved to be cost-effective, as implemented projects show that IHSs reduce energy consumption in the buildings by 15–30 per cent with a typical payback period of two to three years.

There are no legal requirements for installing IHSs in existing multi-family buildings; however, in new buildings, IHSs are mandatory. In the case of building retrofit, the installation of IHS is also mandatory. The key instrument for building retrofits is the Energy Efficiency Fund, and it requires IHS installation in all residential building retrofit packages it finances. However, the volume of loans from the Fund was very moderate in the past years.

This may change in the coming years. Russia's invasion of Ukraine has led to the large-scale destruction of buildings. [A preliminary analysis](#) shows that about 16,000 multi-family buildings were damaged or destroyed during the first six months of the war. All those buildings should be rebuilt or renovated with IHSs added. The government of Ukraine is also developing a comprehensive building retrofit strategy to renovate all residential and public buildings after the war. The goal of the strategy is to reduce energy consumption for heat in residential and commercial buildings to one-third of 2020 rates by 2050. The buildings sector in Ukraine is expected to be the first end-use sector to decarbonize. IHSs will play an important role in decarbonizing buildings. Also, DH systems in many cities have been damaged, and speedy deployment of IHSs in those cities will provide DH companies and customers with the means to manage heat supply. Given the importance of modern IHSs in DH supply, the large-scale deployment of IHSs should be among the mandatory measures to improve the efficiency of heat supply.

### Conclusions

IHSs became popular in many European countries in the 1980s as they improved the efficiency of DH supply. They became universal in Western Europe, and Central European countries quickly deployed them in the 1990s as part of comprehensive DH reforms. Some countries, like Ukraine, were slow in introducing IHSs, but this could change soon due to the Russian aggression against Ukraine and the energy crises that Russia caused. Climate change mitigation has become an important motivational factor for expanding DH to reduce emissions from buildings. Modern IHSs are essential for the construction of efficient and sustainable DH systems.

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## URBAN WASTE HEAT RECOVERY AS AN ENABLER OF THE ENERGY TRANSITION—POLICY IMPLICATIONS AND BARRIERS

*Kristina Lygnerud*

Cities that heat buildings with heat generated by their residents moving around, working, and living in them—this is not science fiction, it is recovery of urban excess heat. This asset exists in all cities but remains largely unexploited. The recovery of urban waste heat is characterized by high potential, high competitiveness compared to other heating alternatives, high avoidance of greenhouse gas emissions, and low utilization. These characteristics imply that barriers to increased utilization exist. In contrast to what is often assumed, technology is not the main barrier.

Urban waste heat is generated from different urban infrastructures, for example information technology (data centres), transport (metro), water (sewage), and buildings. It is a resource that could meet approximately 10 per cent of the European heat demand for buildings.<sup>23</sup> In spite of strong environmental features (no combustion, locally available), this asset is not used to any large extent.

For five years, within the ReUseHeat project,<sup>24</sup> urban waste heat recovery (also referred to as low-temperature heat recovery) implementation has been in focus. The project has realized three demonstrator sites. In two of them, urban waste heat recovery

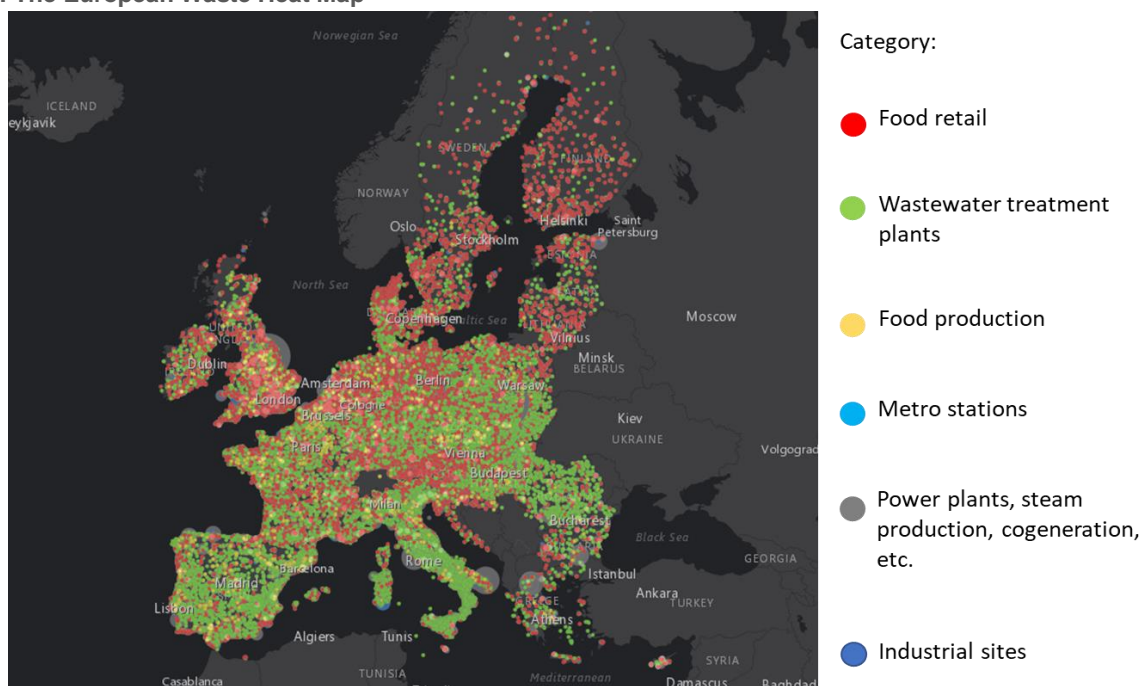
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<sup>23</sup> Lygnerud, K et al. (2022), *Handbook for Increased Recovery of Urban Excess Heat*.

<sup>24</sup> EU Commission, Horizon 2020 project, Grant Agreement 767429.

is implemented from a data centre in Germany and from a hospital in Spain. The third site was established to showcase how heat can be recovered from water in the format of a dashboard. The target group was the wider public and the idea was to create awareness about the urban waste heat recovery opportunity. Awareness was also established by means of a web-based map, referred to as the [European Waste Heat Map](#), showing the available waste heat volumes for EU 28 (urban as well as other sites, like industrial waste heat sources from previous project work). Awareness is important as it is not until end-users are made aware of alternatives that they can demand them, and without demand there is no supply.

**Figure 1: The European Waste Heat Map**



Source: [ReUseHeat project](#).

Note: The original is an interactive map with a zoom-in function to access categories and information at the local level.

The results from the data centre and hospital demonstration sites show important primary energy and CO<sub>2</sub> emission savings. Due to time constraints, the sites were not demonstrated for a full year. However, based on extrapolation of the data that were collected, the joint primary energy savings for a year from the two demonstrator sites is 6.3 GWh, along with 1,133 tonnes of CO<sub>2</sub>—this at a payback of three years for the data centre and less than two years for the hospital.<sup>25</sup>

Based on the implementations done, an important conclusion from the project is that it is not technology that is hindering urban waste heat recovery implementation. These installations necessitate the establishment of a system encompassing the waste heat source, a heat pump (depending on the temperature of the source: if it is very low the temperature level might need to be boosted), and a heat user. One important feature is that urban waste heat cannot be transported far due to its low temperature levels. Hence, the implementations need to be local, matching supply with demand. A recent study found [more than 165 low temperature system initiatives worldwide](#). This is a significant number that is continuing to increase, reflecting that low-temperature heat recovery is a new trend. The installations are found in different countries (examples are Austria, Belgium, Canada, Switzerland, Germany, Denmark, Estonia, France, Ireland, Italy, Netherlands, Norway, Sweden, UK, and USA).<sup>26</sup>

The installations do not necessitate any technical development but rely on existing technology solutions. ReUseHeat found that dependency on electricity (when installing a heat pump) can erode the profitability of low-temperature heat recovery installations—something that can be offset by an installation of photovoltaics for energy production.

<sup>25</sup> Lygnerud, K et al. (2022), *Handbook for Increased Recovery of Urban Excess Heat*.

<sup>26</sup> Averbalk, H et al. (2021), *Implementation of Low-Temperature District Heating systems*



Urban waste heat recovery solutions are not yet commonplace and cannot be purchased off the shelf. The most important technical barrier is the absence of fitters and installers that have the necessary capabilities to install the systems. If there would be demand for urban waste heat recovery installations, this hurdle would likely be lowered.

In the ReUseHeat project, analyses have been made on how to make efficient contracts and business models and how to manage risk. The main stakeholders and the urban waste heat recovery value chain have been identified. It was noted that the absence of standardization of urban waste heat recovery implementations leads to contractual discussions having to be undertaken from scratch every time an urban waste heat recovery is foreseen. This takes time and resources and constitutes a barrier for large-scale urban waste heat recovery implementation.<sup>27</sup>

In terms of business models, it has been identified that [district heating companies focus on technology over business](#). This means that when urban heat recovery is undertaken the benefits it can bring (greenhouse gas emission savings and local energy supply) are not capitalized on. Instead, the business model applied to conventional district heating is used, thereby eroding the value of the urban waste heat recovery investment. Indeed, the opportunity of district heating companies to offer their customers a diversified local and net-zero carbon heat supply is foregone. This is a loss to district heating companies as a diversified offer could increase their competitiveness.

On the issue of risk, it is identified that the urban waste heat recovery investments compete with incentivized investments in renewable energy. Furthermore, there is no EU-level policy on waste heat. As a result, an investor does not know if an investment in waste heat recovery (urban waste heat as well as other waste heat from, for example, industrial processes) can be said to be as environmentally sustainable as an investment in a renewable asset. [The uncertainty surrounding waste heat leads urban waste heat investments to be associated with a higher risk premium and cost than \(incentivized\) investments in renewable sources](#).

Given [the ambition of the EU to make Europe a climate-neutral continent, and the European Green Deal, substantial clean energy investments between 2021 and 2030 are needed](#). Against this backdrop it is relevant both to upgrade existing district energy assets and to implement new ones (such as urban waste heat recovery). One important finding in discussions with investors within the ReUseHeat project context is that the asset class of district heating is rather unknown. This is a barrier since the investors do not have the capacity to perform their standardized due diligence activities but need to engage experts to support them in their assessment. The situation is further complicated by a heterogeneous district heating market across Europe with mature, emerging, and nascent markets. Also, the size of urban waste heat recovery investments (approximately €500,000) is seen as too small to be of interest. A discussion was initiated on the possibility of bundling a number of urban waste heat recovery projects for one investor. However, bundling across national boundaries would be complex due to different regulations.

On the policymaking side it should be possible to promote urban waste heat recovery every time a public building is renovated or erected. A feasibility study of urban heat recovery could be mandatory and, if the measure is proven sustainable, it could also be implemented. One starting point for municipal heat planning can be the European Waste Heat Map. Clear action and valuation of urban waste heat at the municipal level would show that the locally available resource is too important to waste, and it would trigger demand amongst stakeholders across the value chain.

If the public sector drives demand, other stakeholders will follow. City planners will consider it for new areas. Architects will learn to include it as a standard feature. Building owners will consider it when refurbishing existing buildings or building new ones. Energy companies and support companies surrounding them (like fitters and installers) will develop the capability to establish the urban waste heat recovery systems in a standardized and efficient way. Customers will demand local produce not only when choosing their foodstuffs or transportation but also when deciding on their indoor comfort standard. Last but not least, a local, public commitment would de-risk the investment in urban waste heat sources, and investors could be attracted to invest in projects of smaller size than they are used to.

It is not only at the local level that policy support is needed to scale up urban waste heat recovery solutions. Lack of waste heat policy at the EU level is still a hindrance. The suggested updates of important directives for the energy transition (the Energy Efficiency Directive and the Renewables Energy Directive) will provide limited support for increased waste heat recovery

<sup>27</sup> Lygnerud, K., Wheatcroft, E., and Wynn, H. (2019), 'Contracts, business models and barriers to investing in low temperature district heating projects', *Applied Sciences* 9, 3142.

investments overall.<sup>28</sup> In sum, alignment of policy and actions at the EU, national, and regional levels would help enable urban waste heat recovery across the EU.

To conclude, soon, when it is no longer possible to use fossil fuels, when the economy is circular and only generating limited waste flows (to be incinerated) and residuals from forestry have an offset other than combustion, urban waste heat will be an important heat supply. The current climate urgency, in combination with a war that has forced Europe to shift away from gas, has led to a situation where we need to make the best possible use of available resources, and urban waste heat should be one. The technology and the resource are already there.

## THE CHANGING POLITICAL AND POLICY LANDSCAPE IN THE UK FOR DECARBONIZING THE BUILT ENVIRONMENT

**Colm Britchfield**

The energy crisis has dramatically altered the politics of homes and buildings decarbonization. Until recently, the need to decarbonize the built environment in the UK was a problem most politicians could happily ignore. Energy efficiency and heat decarbonization were seen as an unhappy combination of difficult, boring, and not politically salient.

Few would deny that there is a serious problem to address. The UK's housing stock is inefficient, relatively old, and heavily dependent on gas, and around one-fifth of all UK greenhouse gas emissions come from buildings. The Climate Change Committee has long identified [the UK's homes and buildings as a major obstacle on the path to climate neutrality](#).

Tentative attempts to address this over the last decade have mostly ended in failure. Grant funding for home insulation was cut sharply in 2013, leading to [a precipitous decline in the rate of energy efficiency installations and the number of people employed in the industry](#). Subsequent stop-start attempts to revive progress have led to a boom-and-bust business cycle, declining trust from the private sector, and wariness from politicians and policymakers.

But the 2022 energy crisis may have marked a turning point in the political treatment of the built environment. The ongoing explosion in gas prices has created enormous hardship, with the fuel poverty charity National Energy Action now [predicting 8.4 million households will be in fuel poverty in April 2023](#). Inflation and the cost-of-living crisis, both directly related causally to the energy crisis, have created an enormous political and policy headache for government.

### Politicians are looking for answers on energy security, inflation, and the cost of living

The UK has directly subsidized consumer energy bills in one form or another for much of the year, [at an estimated cost of £24.8 billion to March 2023](#). But this outlay has brought little in terms of political benefit. Average annual household bills in April 2023 under the revised Energy Price Guarantee are expected to be £3,000, almost triple the August 2021 rate. Meanwhile, rising interest rates and a difficult economic picture have led the government into fiscal retrenchment. These are not circumstances in which voters tend to reward politicians. If current polling trends continue, the energy crisis may indirectly bring an end to over a decade of Conservative government.

Prime Minister Rishi Sunak has concluded that subsidizing everyone's energy bills to the extent that his predecessor Liz Truss was willing to, without getting any real credit for it, is not the answer. In the November 2022 autumn statement, Chancellor Jeremy Hunt outlined a new approach. Hunt announced a new final energy demand reduction target of 15 per cent across all UK buildings and industry by 2030, created an energy efficiency task force to advise on the delivery of this target, ring-fenced existing public funding for energy efficiency and heat decarbonization, and [launched a new—if modest—energy efficiency scheme targeting low-cost measures](#). He described this new focus on energy efficiency as a 'shared mission' between [government, businesses, and families](#).

The opposition Labour party has arguably made even more of the issue, with a £6 billion per year pledge on homes decarbonization, as part of a wider £28 billion per year climate investment pledge. Across the mainstream political spectrum,

<sup>28</sup> Lygnerud, K., et al. (2022), 'Low temperature waste heat recovery could combat climate emergency—policy recommendations', *Euroheat and Power Magazine IV*.



rhetorically at least, bringing down energy bills, improving the UK's energy security, and meeting net zero are now seen as mutually complementary goals.

### **Political attention is no guarantee of policy success**

Three years after the net-zero target was set, the decarbonization of the built environment has suddenly climbed the UK political agenda. But whether the UK will capitalize on this moment of heightened political attention remains an open question.

Although the UK government is increasingly recognizing that demand-side measures like energy efficiency must play a role in energy and climate security, the energy efficiency market is fragmented and relatively weak, and current policy support is insufficient. Efficiency is also only part of the picture. Although it is understandable that concerns around costs and security have meant a short-term focus on efficiency, in the longer-term UK heat demand must be electrified.

The policy challenges in the way of meaningful progress on both electrification and efficiency must be addressed. Otherwise, the UK risks squandering rare political capital on new targets and warm words without any serious plan for delivery.

### **Progress on energy efficiency will stall again without regulatory intervention**

The [new ECO Plus scheme](#) announced by Jeremy Hunt at the autumn statement is emblematic of a dilemma. On the one hand, the new scheme—which will open eligibility for insulation grant support to a wider pool of people and dedicate a new fund to lower-cost, quicker-to-install measures—is recognition that more subsidy is needed. On the other, the relatively meagre funding envelope of £1 billion over three years is a mark of how weak the government believes the UK supply chain to be. Put simply, the Treasury has no confidence that the market would be able to absorb more money.

This is a negative feedback loop. To expand supply chains by investing in recruitment, upskilling, and manufacturing capacity, the private sector needs a stable business environment. Relatively small funding pots which can be capriciously withdrawn with little warning do not provide this environment, and historically businesses which have invested have suffered when government support is removed. This means that a smaller supply chain struggles to meet the demand that government stimulates.

Solving this problem should not, in theory, be overly difficult. Predictable demand drives investment in the capacity needed to meet it, and robust professional certification and consumer protection regimes can prevent a rush of unqualified actors. Longer-term grant funding is helpful, but regulation to drive demand is more important. The [new Future Homes Standard, due in 2025](#), should mean energy efficiency levels in new-build homes consistent with net zero if delivered. But without regulatory action on existing homes, retrofit will continue to lag behind.

Politicians are understandably wary about regulations that bring near-term costs to their voters. Therefore, the government should start with relatively low-hanging fruit—the private rented sector. The Business, Energy, and Industrial Strategy (BEIS) department has previously consulted on [plans to raise the minimum energy efficiency rating required to let out a private property](#). Bringing this legislation forward would create stable demand for energy efficiency upgrades from the [approximately 3 million homes that do not currently meet the standard](#) and help stabilize and grow the supply chain. The government should also introduce portfolio standards on mortgage lenders, with rising portfolio-average efficiency standards to encourage the development and growth of the market for green home finance.

By proceeding in stages with regulation designed to tackle emissions from homes and energy costs while sustainably building the energy efficiency supply chain, UK policymakers could progressively open political space for more ambitious regulation for the 2030s. Ultimately, point-of-sale regulation for the larger owner-occupier segment of the private housing market should be introduced. The experience of UK policymakers with the upcoming ban on the sale of new internal combustion engine vehicles from 2030 is instructive here: the regulation is far enough away that industry can prepare, and the market for electric vehicles is developing sufficiently quickly that voters do not believe they will be subject to unfair costs.

### **The government needs to commit to heat electrification or risk delaying vital private investment**

Around 85 per cent of UK homes use gas for domestic heating. For decades, cheap domestic supplies and imports meant this arrangement covered up for the poor fabric performance of UK homes, by essentially making energy so cheap that wasting it did not matter. Clearly this is no longer the case from a cost perspective (and never was as far as the climate is concerned). The only long-term solution is to transition households away from gas.

The Climate Change [Committee envisages air-source heat pumps as the primary technology for heat decarbonization in the UK](#), alongside an expansion of heat networks. The International Energy Agency recently described heat pumps as '[the central technology in the global transition to secure and sustainable heating](#)'. The energy crisis makes the case even clearer—even

with the current makeup of the UK electricity grid, switching to a heat pump reduces a home's gas demand by 70 per cent, and [all homes switching would save the UK the equivalent of 1.2 per cent of GDP in wholesale gas costs](#). In Europe, governments are accelerating the process of electrification. The Netherlands, the nearest analogue for the UK in terms of its heating mix, saw heat pump installations double in 2022 and [has legislated to make hybrid heat pumps the new standard for all new heating systems from 2026](#).

Despite this international momentum, policy support for heat pumps in the UK is quite modest. The government has a target of 600,000 installations per year by 2028, but its primary funding support mechanism to 2025 is [the Boiler Upgrade Scheme, which will only install 30,000 heat pumps per year](#). The Business, Energy, and Industrial Strategy Department has also proposed a new market-based [mechanism for low carbon heat](#), an obligation on gas boiler manufacturers coupled with a tradeable certificate scheme that will function similarly to zero-emissions vehicle mandates in other parts of the world, notably California. This new mechanism is promising and innovative, but has not yet been legislated for, and may struggle without supplementary policy and funding support.

Today, well-installed heat pumps are more than cost competitive with gas boilers to run, but there is no doubt that [further policy support and private sector innovation is needed](#) to lower and spread upfront installation costs, minimize disruption and hassle factor costs, and continue to lower the cost of electricity relative to gas. There are players in the UK energy market aiming to make installations more modular and therefore cheaper, and new green finance offers emerging, but neither is yet happening at scale. Heat pumps can be an important part of a renewable-dominated, flexible, and digitized grid, but the retail energy market is not currently offering tariffs that encourage electrification or flexible consumption. Heat electrification will need to be integrated into wider power system reform and planning as the grid decarbonizes.

Despite these challenges, widespread electrification remains the only plausible route to decarbonizing heating in the UK. However, unusually among peer nations, the UK government is still holding open the possibility of hydrogen as an option for heating at scale. A 'strategic decision' on the future of hydrogen is due in 2026, with small-scale trials and the possibility of grid blending before then. [This is in part due to the lobbying efforts of strong incumbent actors](#), particularly gas network operators seeking to avoid being left with a stranded asset, boiler manufacturers who fear industry disruption, and incumbent unions seeking to avert the possible decline of a highly unionized gas engineer workforce (although many of these workers would be obvious candidates to transition to heat pump installation).

[Numerous independent scientific studies](#) have concluded that [the economics of hydrogen for heating are exceptionally poor](#). In addition to safety concerns, there are significant infrastructural challenges to a nationwide switch, and vast quantities of renewable energy would need to be inefficiently diverted to produce green hydrogen. However, the superficial appeal of moving from burning one kind of gas to another, and the claim that it would involve minimal in-house disruption, make hydrogen an attractive proposition for politicians nervous about electrification.

Hydrogen is vanishingly unlikely to be used at scale in the UK heating system. Lobbying efforts can delay progress elsewhere, but cannot change the underlying fundamentals. However, prolonged stasis on electrification could extend the UK's reliance on gas, at a cost to the climate, consumers, and the UK's energy security goals. It is not necessarily a coincidence that a prolonged lifespan for gas in the UK would not be seen as a bad outcome by some of the corporate actors supporting hydrogen. To drive the private investment needed to make progress on electrification, hydrogen should be ruled out as a widespread option for heating and [more focus should be given to developing the hydrogen economy around industrial users](#).

## Conclusions

The energy crisis has created new political momentum for decarbonizing homes and buildings, and policymakers must not let this opportunity pass them by

The politics of UK built environment decarbonization has shifted significantly over the past year, but it remains to be seen whether increased political salience and attention can translate into policy delivery. The prize for energy security, consumer costs, and net zero is huge. But to make real progress on efficiency and electrification, new regulation and stable public investment are essential. Industry needs consistent and growing demand, and consumers need more attractive options, which can only be driven by innovation and investment on the supply side.



As a starting point, the government should act quickly where its political constraints are weakest—in the private and social rented sectors, in commercial buildings, and in new-build homes. Regulation of the remaining stock can follow, with the example of electric vehicles showing long-dated regulation is politically possible. The global energy crisis has given the UK government a political opening and a serious real-world imperative to get moving on buildings decarbonization—time will tell if it takes the opportunity.

## DECARBONIZING THE DUTCH BUILDINGS SECTOR

**Katja Kruit**

Over 90 per cent of residential and commercial buildings in the Netherlands currently use natural gas for heating and cooking. In order to meet its climate goals, which follow from the Paris Climate Agreement, it is necessary to phase out the use of natural gas and to implement new heating and cooking systems powered by renewable energy sources.

This article describes the Dutch policy for this heat transition and provides a framework for evaluating and developing a comprehensive policy package to support full decarbonization. This article is based on previous publications.<sup>29</sup>

A focus on affordability and feasibility

Although the current energy provision for buildings is quite homogeneous, future alternatives for decarbonized heating are much more diverse. Depending on building and neighbourhood characteristics, electric heat pumps, district heating, or carbon-free gas may be the best fit. Cost and feasibility studies indicate that in most scenarios, a combination of systems will have the lowest overall costs. No one system is therefore expected to become dominant in the future. However, improved building insulation is needed in most buildings to reduce energy consumption. To meet the transition goal, major renovation of buildings, heating appliances, and energy infrastructure is therefore warranted.

In the Dutch Climate Agreement, the government committed to a 49 per cent reduction of greenhouse gases by 2030 and a 95 per cent reduction by 2050.<sup>30</sup> The 2030 goal was increased to 55 per cent in 2021. For the built environment, the Dutch Climate Agreement aims to phase out natural gas for heating and increase the energy performance of buildings and to move 1.5 million of the almost 8 million dwellings to heating without natural gas. This means transitioning 150,000 existing buildings per year from natural gas heating to alternative energy carriers and infrastructure—in other words, making them natural-gas-free (*aardgasvrij*).

The policies were developed around two core principles: affordability and feasibility.<sup>31</sup> The condition of affordability has various consequences. Namely, the financial benefits of natural-gas-free heating for the homeowner are an important factor in policy choices such as the extent of subsidies. In addition, national and local governments attempt to steer choices for alternative heating towards the lowest-cost alternatives as much as possible.<sup>32</sup>

The feasibility aspect of the Dutch heat transition aims to ensure that the right conditions exist for all stakeholders to make the transition towards sustainable heating systems. A feasible transition requires national and local governments to align the interests of these stakeholders with decarbonization measures. This is exemplified by the use of voluntary and binding agreements with housing associations and heating appliance suppliers, which take into account the capacity and resources of these stakeholders and gain support for the policy objectives.

<sup>29</sup> CE Delft (2022), *The Natural Gas Phase-Out in the Netherlands*.

<sup>30</sup> Rijksoverheid (2019), *Klimaatakkoord*, Den Haag.

<sup>31</sup> Minister van Binnenlandse Zaken en Koninkrijksrelaties (2021), Kamerbrief d.d. 6 juli 2021 m.b.t. over betaalbaarheid van de energietransitie in de gebouwde omgeving, Den Haag: Tweede Kamer der Staten Generaal.

<sup>32</sup> Rijksoverheid (2019), *Klimaatakkoord: C Afspraken in sectoren, C1 Gebouwde omgeving*, Den Haag.

## Policy instruments in the Dutch heat transition

Policy instruments in the transition towards sustainable heating include the following:

- **Regulation to enforce sustainable heating for new construction.** Since July 2018, all new construction has to be built without a gas connection. While electricity and gas grid operators were previously obliged to connect all consumers to the grid, in 2018 gas distribution system operators were prohibited from connecting new construction. [In 2020, 87 per cent of new homes were built without a gas connection.](#)
- **Regulation of energy performance of office buildings.** Voluntary and binding performance agreements with housing associations have led to an average energy performance label of B in this sector. Residential buildings currently have no energy performance requirements.
- **Gradual rebalancing of energy taxes on gas and electricity to decrease the tax rate on electricity and increase the rate on gas.** In this way, households and businesses are incentivized to move away from natural gas.
- **Subsidies and loans for insulation and sustainable heating such as heat pumps.** Recently, the loan conditions were expanded to make them available for low-income households.
- **District-oriented approach.** Municipalities were obliged to develop local heating plans where they give an indicative time path for realizing decarbonized heating, neighbourhood by neighbourhood. A national programme provided additional funding to municipalities for realizing gas-free heating in pilot areas. However, other than providing information and limited financial support to homeowners, municipalities lack the policy instruments to implement the local heating plans.

Up to 2021, policies were mainly focused on financial support (subsidies and loans), learning, and communication, but lacking in stronger measures. The current government has presented more binding instruments to bring the goals within reach. These include the following:

- As of 2030, minimum energy performance standards will be introduced for rental homes. Housing corporations and private landlords [will not be able to rent out property with a low energy label.](#)
- Energy performance standards for heating appliances, which will de facto [make hybrid heat pumps \(or better\) mandatory when a house's heating installation is replaced](#), will be introduced from 2026.
- A blending obligation for gas fuel will increase the amount of renewable biogas in the gas mix.

Due to the increase of energy prices in 2021 and 2022, the government introduced a mix of measures to support the affordability of energy. Focused measures include an allowance for households at risk of energy poverty and funds for municipalities to take energy efficiency measures in energy-poor households. General measures include a one-off increase of the fixed energy tax rebate and, starting in January 2023, a price cap on energy up to average usage.

## Comprehensive policy package

A broad range of policy instruments are needed in order to reach the full emission reduction potential in the building sector. These policy instruments, when well designed, will strengthen each other over time:<sup>33</sup>

- Financial support such as subsidies create an economic incentive for decarbonization measures. This can be designed for first movers on one hand, or to support those with less economic means.
- Pricing (e.g. of CO<sub>2</sub>) creates a level playing field for zero-carbon solutions and a market for innovation. Pricing measures have a wider scope than financial stimulus because they apply to the entire market. However, not all people respond to price signals (price inelasticity) or are able to respond, e.g. due to split incentives between tenant and landlord.
- Regulatory instruments ensure that decarbonization measures are taken, trigger points are utilized, and new customs and habits are formed. Regulatory instruments such as standards and minimum requirements serve as backstop policies to ensure that the full potential is met.

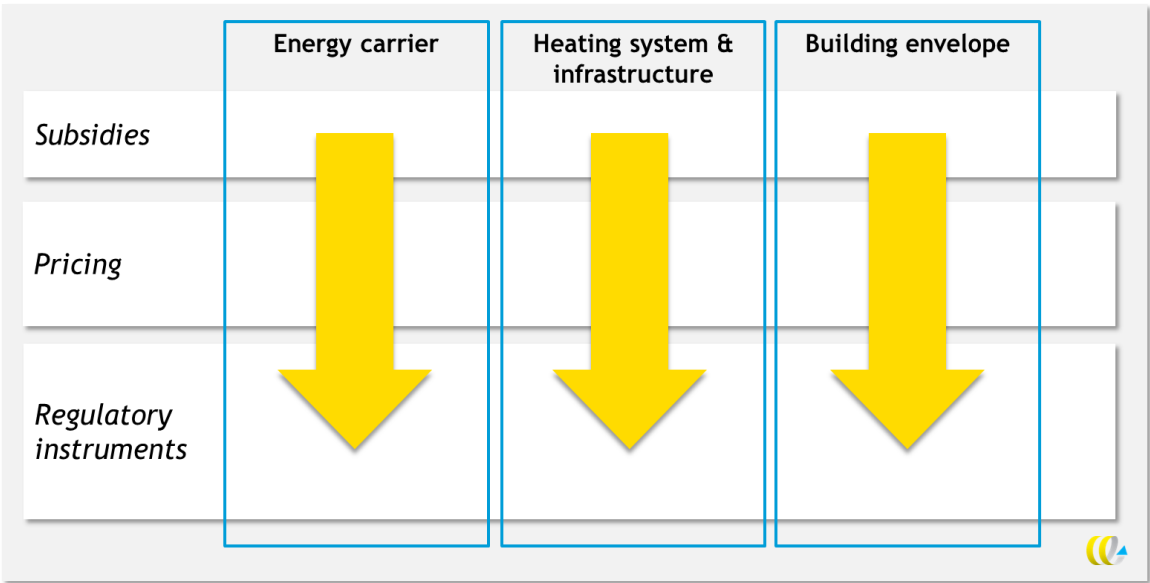
<sup>33</sup> CE Delft and Climact (2020), *Zero Carbon Buildings 2050*, European Climate Foundation.



These core policy instruments should be supported by financing instruments providing the ability to invest, informative instruments to create awareness and enable informed decisions, and policies to stimulate innovation.

For the built environment, the heat transition requires investments in several main areas: improvement of the building envelope, a switch of heating systems and infrastructure, and decarbonization of the energy carriers. In each area, the conditions are right to move from voluntary measures towards stronger regulatory instruments.

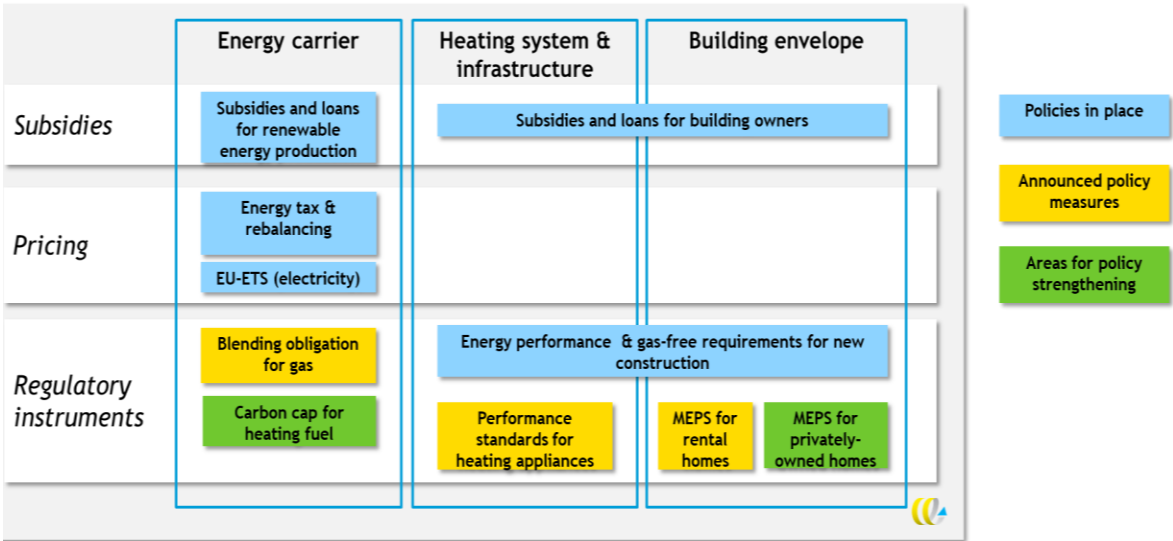
Figure 1: Policy framework for the heat transition in the built environment



Focus areas for policy strengthening

In order to fully achieve the Dutch heat transition, the potential in all three areas (energy carrier, heating system and infrastructure, and building envelope) must be fully utilized. We mapped the policies discussed above to the framework in the figure above. Two areas stand out in which there is obvious room for policy strengthening.

Figure 2: Policy framework with key Dutch policies



ETS = emissions trading scheme; MEPS = minimum energy performance standards.

The first area is performance standards for privately owned homes. Current subsidies for insulation, the current energy prices, and tax levels make single or double insulation measures attractive. However, at the current prognoses, deep renovation is still not financially favourable in many situations. Regulatory instruments can deliver more far-reaching results. Currently, only new construction and office buildings are subject to a minimum energy performance requirement. In May 2022, mandatory performance standards were introduced for rental homes from 2030. Such regulations could be further expanded in the future to include privately owned homes as well, in order to completely phase out low-energy-performing buildings.

The second policy option is a carbon cap for heating fuel. After energy efficiency measures are taken, the remaining energy demand must be decarbonized. In the current energy tax system, there is no incentive to increase the percentage of renewable energy in the electricity or gas mix. A CO<sub>2</sub> tax or a CO<sub>2</sub> budget system would put a price on CO<sub>2</sub>, favouring renewable energy in the mix. A CO<sub>2</sub> budget system could include trading of CO<sub>2</sub> emission rights. The EU Green Deal package proposes to introduce a European emission trading system for buildings and road transport; such a system would provide a backstop to ensure full decarbonization of the gas mix.

### Conclusion

Decarbonization of Dutch building stock has largely depended on 'soft' policy measures (subsidies and energy tax). Due to the current technical and financial feasibility of decarbonization measures, it is a crucial moment to move to a comprehensive package that ensures long-term measures.

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## A COMPARISON OF HEATING MARKETS: WHAT THE DUTCH CAN LEARN FROM THE DANISH

*Jacob Janssen and Annelies Huygen*

The Netherlands is a country of natural gas. Almost all households are connected to the gas grid for heating and cooking. However, a plan outlined by the government calls for them to seek other, sustainable sources for their energy supply. Dutch energy policy is now directed at creating [aardgasvrije wijken](#), neighbourhoods that will not rely on natural gas as their energy source. Heating networks are thought to be an attractive alternative for many urban neighbourhoods, but in many cases they need to be built from scratch. A new challenge for Dutch municipalities is therefore the development of district heating systems and, in general, the sourcing of their own energy supply, since gas supply is organized at the national level. Moreover, Dutch consumers do not look favourably at district heating. On the other hand, in Denmark, district heating is greatly popular among consumers, and it supplies energy to about two-thirds of the population. This paper provides some insights into what the Netherlands can learn from the Danish approach to district heating.

### The Dutch district heating sector

In the Netherlands, [about 6 per cent of energy users are connected to district heating](#), about 0.5 million buildings. Such connections are mostly concentrated in large cities like Amsterdam, Utrecht, and Rotterdam. Previously, district heating companies were in public hands, belonging to the various municipalities. During the 1980s and 1990s, the organization of these companies changed: district heating companies of different municipalities merged into larger companies, and almost all of them were then privatized. Currently, five companies supply about 85 per cent of the energy for the district heating market; three of these five are private and supply about 75 per cent of the energy. So the market is rather concentrated in the hands of a few commercial entities.

Most district heating systems in the Netherlands only have one or two main sources of supply. These systems, depending on the heating technology and heat source, are categorized as either high-temperature systems (supplying heat at 90–130°C) or medium-temperature systems (supplying heat at 70– °C).

In 2019, in a public [Climate Accord](#), it was agreed that 500,000 extra buildings would be connected to a heat network before 2030. According to this plan, an average of 50,000 extra buildings per year should be connected to a district heating network.

However, in 2021 there were [only 15,000 new connections, concentrated in newly built neighbourhoods](#). Apparently, it is very difficult in already existing areas to switch the energy system from natural gas to district heating, despite large subsidized programmes.

### The Danish district heating sector

The Danish heating sector differs considerably from the Dutch one. First, since the 1973 oil crisis, district heating has featured prominently on the Danish government agenda. As a consequence, more than 64 per cent of households are connected to a heating network. Thereafter, the development of entirely new district heating systems in Denmark stalled for some time. However, recently new initiatives have gained momentum, as a result of the current energy crisis.

Second, the Danish heating sector is less concentrated than the Dutch one. More than 400 district heating companies are active in the country, most of which are cooperatives. Others are public, mostly owned by the municipalities, but with ledgers that are separate from those of the municipalities themselves. A few others, less than a dozen, are privately owned. The public companies are the most important. Although they do not represent the majority numerically, they account for most of the district heating energy production. [Danish heating companies are not for profit](#); in general, it is not allowed to take out profits from the company. Other parties in the district heating sector—such as consultants, contractors, and technology providers—are allowed to make a profit.

At the moment, there is a lot of attention on making the networks more energy efficient, for instance by lowering the temperature in the district heating network, or by digitalizing the system for monitoring and optimization purposes. Many district heating companies are lowering the grid temperatures, in order to be able to diminish heat losses and to better integrate local low-temperature heat sources.

### Tariffs and transparency

The system with respect to tariffs and transparency differs in the Netherlands and Denmark. In the Netherlands, there is a national price cap for district heating consumer tariffs. This price cap is based on the cost of natural gas, according to the principle of ‘no more than otherwise’ (*niet meer dan anders*): customers of the district heating grid should not pay more than what consumers of natural gas pay. The price is set by the Authority for Consumers and the Market. When prices of natural gas rise, for example due to higher taxes, district heating prices also rise.

Even though tariffs of most Dutch energy providers remain well below this price cap, [they are still a lot higher than those in Denmark](#). In 2022 the average Dutch tariff was about twice as high as the Danish average. Each company sets its own tariffs, which are more or less the same for all the different projects they have. Due to this system, there is no transparency on the costs of district heating. At the moment, there are plans to change this system and to switch to cost-based charges. It would be worthwhile to examine the Danish approach to this specific issue.

In Denmark, heating tariffs are based on the total costs of the specific system. Thus, each energy and heating system has its own tariffs. Accounting rules prescribe the accounting format. Prices in Denmark are based on the costs of the heat supply, and the costs that may be passed on to the customers are regulated by the Danish Utility Regulator following the rules set out in the Heat Act. This means that it is not allowed to arbitrarily charge the customers other costs. The regulator oversees the tariffs. Mostly, there is no need to investigate individual cases. Investigation can happen, for example, when extraordinary expenses or complaints are filed to the regulator.

Every year, the regulator compiles a list of the tariffs charged by the different district heating companies, from the cheapest to the most expensive. This gives customers a tool to navigate and compare the market, and district heating companies have an incentive to be among the cheapest on the market. The Dutch sector may learn from this practice, in order to increase transparency, switch to cost-based prices, and ultimately offer customers better value for their money.

### Choosing the supplier

Municipalities in the Netherlands are not accustomed to being involved in the supply of energy, in the setting of heating tariffs, nor in sustainability. They have to give permits for new projects, but it is very difficult for them to evaluate the plans. When heating companies apply for a permit to supply heat, there is almost no market competition. The official price cap, set by the regulator (the Authority for Consumers and the Market) and the municipalities, is assumed to be sufficient as price regulation.



This cap applies to all heating companies and cannot serve as an instrument for obtaining the lowest prices possible. In addition, very often the suppliers receive extra state subsidies, since district heating is thought to be unprofitable. Usually, the amount of the subsidy is calculated on the basis of models specific to district heating, and not on the real cost of the energy supplied to the customer. In this respect, the Dutch system lacks transparency. As a consequence, local authorities find it very difficult to make a sensible choice, to distinguish best practices, or to learn from other projects.

In Denmark, on the other hand, consumer prices are at the heart of the whole process of energy distribution. Before infrastructural investments are made, an analysis is carried out to examine how these will influence tariffs. When district heating companies apply for a permit, they have to provide a [standardized analysis of the project that calculates its societal and economic impact](#). This kind of analysis is compulsory in order to acquire approval for a district heating project and the accessory municipal guarantee. The analysis consists of a comparison between two or more alternatives, where externalities are included, such as costs of emissions, but taxes are excluded. The municipality mostly will approve the project if it has positive socio-economics and positive company economics and prices for existing consumers on the network are not increased.

The analysis parameters are standardized and set by the Danish Energy Agency, but the different municipalities are allowed to adapt them to the local situation. This ensures that different heating projects in different areas are evaluated on the basis of comparable analysis and methodology. The socio-economic analysis helps municipalities and heating companies to develop accurate cost estimates. This improves the planning and approval process. The analysis contributes to price transparency and favours the best practices.

To summarize, the Netherlands can learn from Danish practices for developing new district heating systems. Standardized parameters would help municipalities to better evaluate the socio-economic costs of the projects, to compare different projects fairly, and ultimately to make informed decisions.

### Heat sources

The cost of heat production often makes up a big part of the total costs, and improving the efficiency of this production could have a big impact on consumers' bills.

In Denmark, there are often multiple heat sources for a single district heating network. Diversification and coordination of the heat sources are factors that keep the cost of the energy at a minimum. For example, when prices of electricity are at their lowest, it is possible to store electric energy as heat and use it later. Furthermore, there are [publicly available tools](#) to help district heating companies with planning and selecting their heat sources. Also, these tools help local decision-makers, who approve the projects, to understand and weigh the benefits of new investments and their influence on the cost of heat.

In the Netherlands, on the other hand, most district heating systems only have one or two heat sources, such as an oil refinery or an incinerator. Huge pipes connect these sources of heat to consumers. Subsidies for sustainable heat sources, such as waste or residual heat, favour this practice. To be able to acquire these subsidies, it is necessary to use the source during many hours a year. Due to this system, diversification is not profitable.

Lowering the costs of heat sources in the Netherlands would require more than only changes in the subsidies system. District heating companies have little experience with coordinating various heat sources simultaneously. Having tools to help make decisions about heat sources, just like in Denmark, would enable municipalities, cooperatives, and other entities to make informed decisions about adding new sources to their systems and to use them efficiently.

### Technology catalogue

In Denmark, [a public technology catalogue](#) gives insight into the costs and specifications of different technologies. This represents an invaluable tool in the hands of all parties involved. The municipalities, the Danish Energy Agency, and citizens' cooperatives are able to use this catalogue as a benchmark for the costs of district heating projects. This catalogue describes the costs and lifespan of the various technologies and components of district heating networks. It also contains data on the future prices of fuels, electricity, and costs of externalities such as CO<sub>2</sub> emissions. The Danish Energy Agency regularly updates this catalogue with the help of national and international experts and of stakeholders in the district heating sector. Such an active dialogue with the stakeholders also reduces the time for municipal approvals of district heating investments, since all controversies and disagreements between stakeholders have been already dealt with during the compilation of the technology catalogue.



In the Netherlands, the introduction of such a catalogue would provide much knowledge on the costs of district heating networks. Cost indicators are present in the existing models, but there is no transparency on how the costs are determined. A general and objective overview of the costs of the various technologies would enable municipalities and other parties to properly assess the proposed projects.

### Conclusion

Denmark is ahead of the Netherlands on district heating. Aside from the technological differences, the Danish system provides more transparency to help decision-makers and stakeholders to make better-informed decisions. Moreover, the Danish system greatly benefits from tools such as better accounting rules, standardized socio-economic and cost-benefit analyses, heat sourcing tools, and the above-mentioned technology catalogue. Thanks to these, municipalities and other parties are able to judge the projects more fairly, taking into account the local situation. These instruments work together with cost-based regulation. Each of these instruments helps local decision-makers, but as the tariffs must be cost-based, there is a mechanism by which costs are kept low with local oversight.

In the Netherlands, people can learn a lot from Denmark about district heating. They also can profit from these lessons when developing the most modern energy grids with integrated heating and cooling and closely interconnected electricity systems. Making use of the lessons from Denmark with respect to transparency and well-informed decisions may lead to modern, sustainable systems at low costs that are attractive to consumers.

## SUCCESSFUL POLICIES FOR A JUST ENERGY TRANSITION: THREE SOLUTIONS FROM POLAND'S RESIDENTIAL ENERGY SECTOR

**Jakub Sokołowski and Maciej M. Sokołowski**

The energy transformation of Poland's residential sector began in the early 1990s, transitioning from a centrally planned to a market-based economy. Many indicators suggest that it reached a tipping point in 2022 following Russia's invasion of Ukraine. The transformation of Poland's residential energy sector is critical to achieving the country's energy and climate policy goals for two reasons. First, households in Poland utilize 90 per cent of all coal consumed in the EU's residential sector.<sup>34</sup> Second, in 2020, almost 80 per cent of the coal used for individual heating in the residential sector in Poland was imported from Russia.

In this light, we examine the trajectory of change in Poland's residential sector during the decarbonization process from the 1990s to 2022, highlight how the Russian invasion of Ukraine may affect the process beyond 2022, and provide policy recommendations based on our findings.

### The change

Changes in Poland's energy sector started in the 1990s, intending to achieve energy security through a stable energy supply. This phase mirrored the sharp transition to a market-based economy. It was focused on utilizing domestically extracted coal, increasing the competitiveness of energy companies, and encouraging international cooperation.<sup>35</sup> On the way to Poland's accession to the European Union in 2004, policymakers focused on following energy-related environmental targets. These targets became concrete commitments with the acceleration of European climate policy, implying the decarbonization of the industry and large-scale, coal-based energy plants.<sup>36</sup> However, until the early 2020s, governmental policies in Poland did not stimulate transformation to the point where the residential sector could be decarbonized effectively. Only in 2021 did policymakers adopt a new energy policy to achieve a just (i.e. providing equal opportunities for regions and communities

<sup>34</sup> Eurostat (2021), *Supply, Transformation and Consumption of Solid Fossil Fuels*.

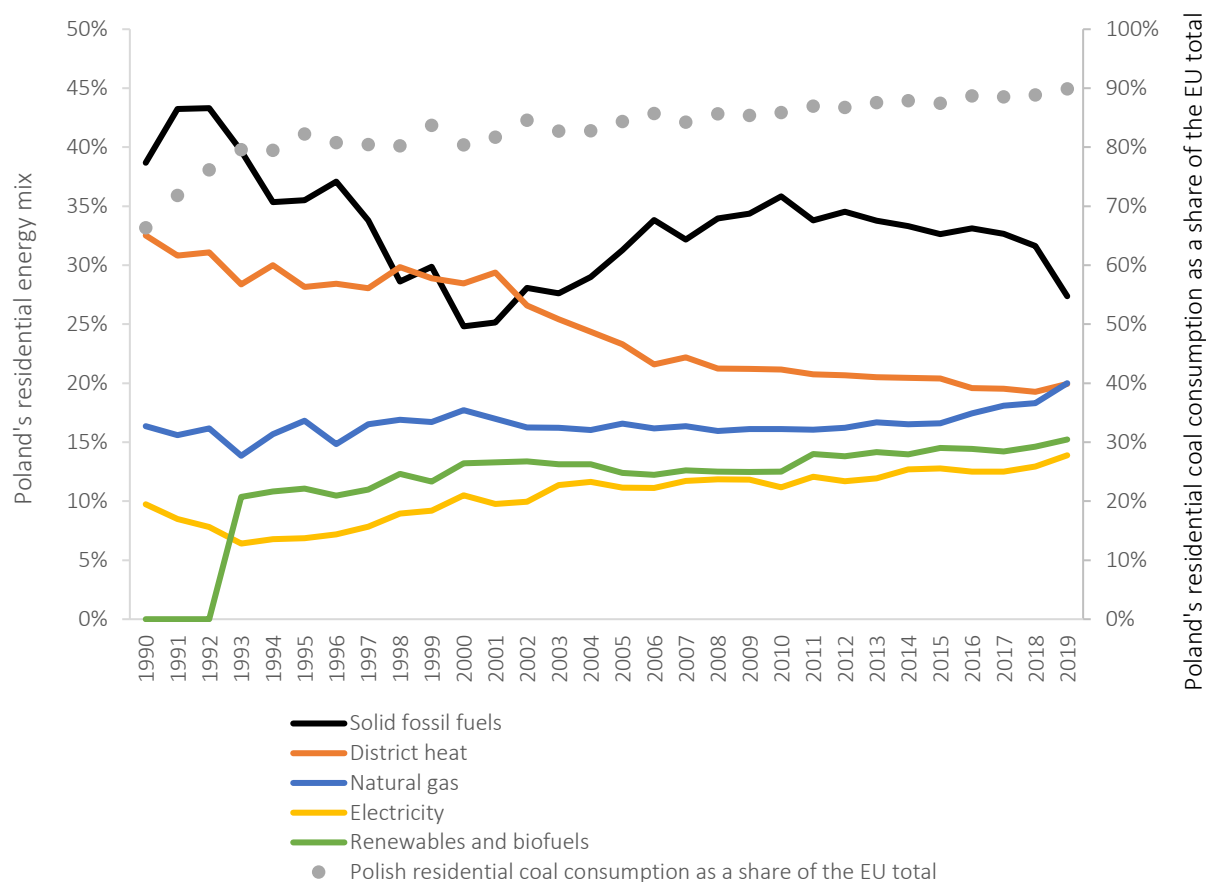
<sup>35</sup> Serafin, R., and Żebrowski, M. (1994), Environmental management in Polish economic and political reforms, in C. Carraro, A. Haurie, and G. Zaccour (eds.), *Environmental Management in a Transition to Market*.

<sup>36</sup> Kudelko, M., and Suwala, W. (2003), Environmental policy in Poland—current state and perspectives of development, *Energy & Environment* 14(5), 737–750; Sokołowski, M. M. (2018), Burning out coal power plants with the Industrial Emissions Directive, *Journal of World Energy Law & Business* 11, 260–269.

negatively impacted by the process, and introduced through bottom-up initiatives) and low-emission energy transition, as well as complete coal phase-out in the residential sector by 2040.

In this context, the share of solid fossil fuel use declined from around 40 per cent in 1990 to about 30 per cent in 2019. Coal remained a significant energy source, and Poland has had the EU's most coal-intensive residential sector, lagging behind the European general decarbonization trend.<sup>37</sup> In 2004, Polish households accounted for 83 per cent of total coal consumption in the EU's residential sector. In 2019, this share increased to 90 per cent. This stark disparity resulted from inadequate policies (e.g. lack of subsidies for low-carbon solutions), causing households to switch from old coal stoves to more energy-efficient but still coal-intensive heating systems.

**Figure 1: Residential heating sources: Poland's mix of different fuels and district heat (solid lines), compared with Poland's share of EU residential hard coal consumption (dotted line), 1990–2019**



Source: Sokołowski, J., and Bouzarovski, S. (2022), Decarbonisation of the Polish residential sector between the 1990s and 2021: a case study of policy failures, *Energy Policy* 163, 112848.

Following unsuccessful decarbonization attempts in the residential sector through local, bottom-up support programmes, in 2016 Poland's first regions passed anti-smog legislation.<sup>38</sup> These local laws, which restricted solid fuels and solid-fuel-based heating sources, had a slight positive effect on air quality and reduced the use of coal stoves.<sup>39</sup> Moreover, two support programmes were launched in 2018 and 2019: Clean Air, offering subsidies for investments in more efficient heating technologies, and My Electricity, aimed at the growth of small-scale photovoltaic installations.

<sup>37</sup> Süsser, D., Ceglaz, A., Gaschnig, H., Stavrakas, V., Flamos, A., Giannakidis, G., and Lilliestam, J. (2021), Model-based policymaking or policy-based modelling? How energy models and energy policy interact, *Energy Research & Social Science* 75, 101984.

<sup>38</sup> Zysk, J., Olkusi, T., Kogut, K., Szurlej, A., and Surówka, M. (2019), Assessment of the impact of the implementation of air protection programs, anti-smog resolutions and the 'Clean Air' program on CO<sub>2</sub> emission, *Polityka Energetyczna—Energy Policy Journal*, 133–154.

<sup>39</sup> Sokołowski, J., and Bouzarovski, S. (2022), Decarbonisation of the Polish residential sector between the 1990s and 2021: a case study of policy failures, *Energy Policy* 163, 112848.

The Clean Air programme, with a nearly €20 billion budget, provides subsidies for investments in clean heating technologies and thermal retrofits. These subsidies cover up to 90 per cent of investment costs, depending on household income, since paying for this technology has been a challenge for low-income households. Additionally, until September 2021, the program allowed subsidies for investments in individual coal-fired central heating systems that were more energy efficient than the outdated individual coal stoves. By mid-2021, around 100,000 solid-fuel-based installations had been subsidized through the programme, accounting for about 40 per cent of all newly installed heating systems in the Clean Air programme.<sup>40</sup>

The My Electricity programme, based on a one-time subsidy of about €1,000, has boosted Poland's renewable energy sector, yielding promising results. The programme sought to increase electricity production from photovoltaic micro-installations (2 to 10 kW). Individual households willing to generate electricity to meet their demand benefited from this incentive, and the direct subsidies provided through this programme significantly contributed to Poland's prosumer market development. [From 2020 to 2021, the number of prosumers rapidly grew from 50,000 to more than 750,000.](#)

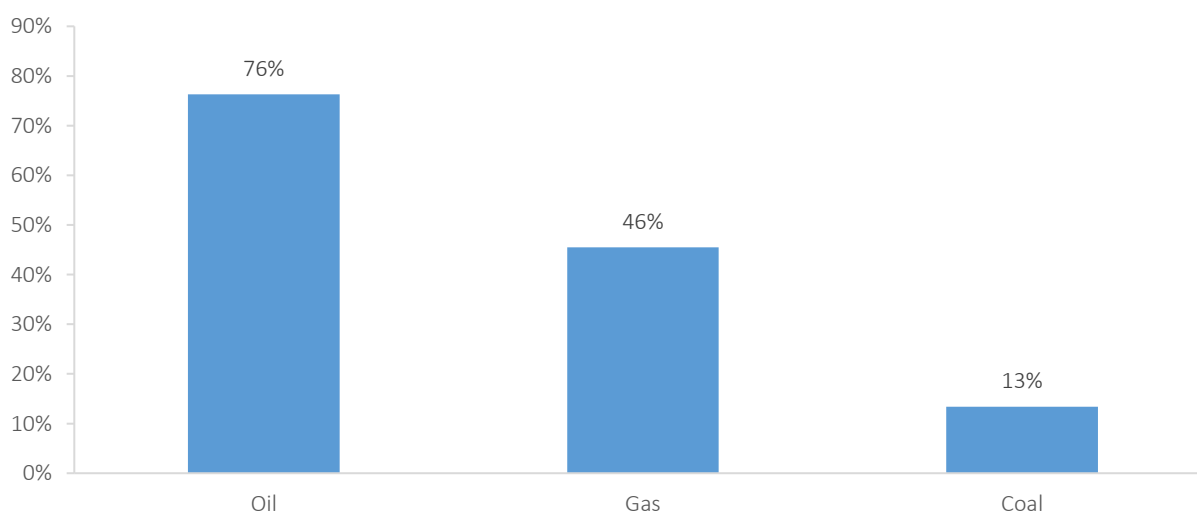
Up to 2021, these support instruments produced relatively positive outcomes, assisting in financing almost one million residential energy installations. Together with strengthened anti-smog resolutions encompassing the entire country, these programmes can support Polish households in moving towards decarbonization.

### The crisis, the invasion, the future

The late 2021 energy price crisis, driven by increased demand for gas after the COVID-19 pandemic, shifted the focus of climate policy goals to mitigating energy price hikes. In Autumn 2021, in response to inflation pressure, the Polish government reduced the VAT rates for electricity (from 23 to 5 per cent), natural gas and district heating (from 23 to 8 per cent) and lowered the excise tax on energy products to zero. Since 2022, the Polish government has also provided substantial safety nets from the state budget for energy-poor households (about €1 billion per year). Although the tax breaks are regressive and favour more affluent households that consume more energy per capita, these solutions generally also help less affluent households affected by the energy crisis.

Russian aggression in Ukraine has pushed energy security further to the centre of Polish energy policy. [In 2020, Poland imported 35 per cent of its energy and 13 per cent of its coal from Russia.](#) Importantly, [80 per cent of imported hard coal was used in households](#), as domestic coal supplies district heating and electricity production. Poland stopped importing Russian coal by the end of March 2022, while Russia halted all natural gas exports to Poland at the end of April 2022, but the Polish stocks were sufficient to weather the gas shortage in 2022.

**Figure 2: Imports from Russia in gross available energy, 2020 (% of Poland's total supply)**



Source: Authors' elaboration based on Eurostat (2022), [EU Energy Mix and Import Dependency](#).

<sup>40</sup> Sokołowski, J., and Bouzarovski, S. (2022), Decarbonisation of the Polish residential sector between the 1990s and 2021: a case study of policy failures, *Energy Policy* 163, 112848.

Antosiewicz, Lewandowski, and Sokołowski, in *The Economic Effects of Stopping Russian Energy Imports in Poland* (2022), calculated the impacts of price hikes on the Polish economy and households following the Russian invasion of Ukraine. It is predicted that GDP will decrease by 1.3–4.2 per cent by the end of 2023. The most significant negative impact would be caused by a spike in oil prices, which would decrease GDP by an average of over 80 per cent across all scenarios. Rising coal and gas prices would have a more negligible impact on GDP, causing a decrease of only 0.5 per cent if they increased sharply by the end of 2023. The effects of these price increases would be felt more significantly by low-income households in relative terms, while high-income households would be most affected in absolute terms. If energy prices rise by about 30 per cent by the end of 2025, the impact on households would be about 1 per cent of their monthly income. If energy prices rise significantly, the impact on disposable income for low-income households (first decile) could be as high as a 6 per cent drop after paying energy and fuel bills, while the impact on high-income households (tenth decile) would be about 1.5 per cent.

### Discussion and policy conclusions

We propose to address the energy crisis's distributional repercussions through tax and benefit incentives aimed primarily at low-income households. To tackle the 2022 crisis, exacerbated in Poland by domestic coal shortages, the Polish government introduced a new set of relief measures for the residential sector. One of these measures was a coal allowance (a one-time payment of about €640) for individuals who heat their homes with coal.

The proposition was countered with a civic initiative to support low-income people regardless of their heating source. The measures introduced by the Polish government should be improved by introducing [either a lump-sum transfer for all households](#) that would help reduce income inequalities or a targeted allowance for low-income households (e.g. in the form of an energy voucher<sup>41</sup>).

Furthermore, we argue that realizing end-user potential is critical to achieving residential sector decarbonization by 2040. However, this is unlikely to happen with a bottom-up approach because end-users rarely examine their beliefs about energy use and choose to upgrade their heating source based on personal initiative alone. On the one hand, fuel price rises (e.g. via the emission trading system) can motivate better-off households to decarbonize. On the other, energy-poor households should be safeguarded from increased fuel prices because avoiding a carbon lock-in is more difficult for those who cannot afford thermal retrofits or investments in clean heating sources.

Seen in this light, public institutions should play an essential role in guiding end-users through the energy transition, supporting those who are likely to fall behind. This is a crucial requirement for a just energy transition.<sup>42</sup> Without adequate institutional support, some individual households may be reluctant or unable to participate in the energy transformation to climate neutrality. Others may switch from coal to gas heating, resulting in a similar future fossil-fuel lock-in, and we assume that in the next decade, gas will be treated in climate-energy policies in the same way that coal is now. All of these scenarios would result in the overall failure of the country's energy policy.

From this perspective, we propose three policy solutions to improve housing and heating conditions during the energy transition. Their application is not limited to Poland and may extend to other countries experiencing similar challenges. These solutions are as follows:

1. Prioritize thermal retrofit programmes and district heating connections, as well as the full financing of energy-related investments for energy-poor households.
2. Provide direct compensation for higher energy expenditure for end-users who invest in new low-carbon and energy-efficient heating sources, and recognize the needs and issues faced by these residents in energy-related policies.
3. Instead of replacing old and rundown individual housing units, raise funds and investments for the renovation of social housing stock.

These actions complement each other, comprise a broad framework of transformative activities, and follow attempts by the Polish government to incentivize social buildings (e.g. via social housing initiatives or the multifamily buildings prosumers programme, launched at the end of 2022).

<sup>41</sup> Sokołowski, J., Frankowski, J., and Mazurkiewicz, J. (2021), *The Anti-inflation Shield or an Energy Voucher: How to Compensate Poor Households for Rising Energy Prices?* IBS Policy paper 5/2021.

<sup>42</sup> Sokołowski, M. M., and Heffron, R. J. (2022), Defining and conceptualizing energy policy failure: the when, where, why, and how—the search for the just solutions, *Energy Policy* 161, 112745; Sokołowski, M. M., and Kurokawa, S., 2022, Energy justice in Japan's energy transition: pillars of just 2050 carbon neutrality, *Journal of World Energy Law & Business* 15, 183–192.



## DECARBONIZING RESIDENTIAL HEATING IN NORTHERN IRELAND

**Ryan Madden**

As of 2019, the residential sector accounted for [14 per cent of Northern Ireland's \(NI's\) total greenhouse gas emissions, primarily through the use of fossil fuels for heating](#). This figure has declined since 1990; however, progress in emissions reduction has been slow, with only a 21 per cent decrease in emissions from the residential sector since 1990. To compensate for this slow rate of progress, the UK government's statutory body for climate change, the Climate Change Committee, has recommended that at least [25 per cent of heat supply in NI](#) should come from low-carbon sources by 2030, which underlines how much work needs to be done.

### Why is Northern Ireland's residential heating sector so carbon intensive?

A majority of industry experts highlight NI's dependence on oil to be extremely problematic, with the most recent statistics suggesting [as much as 68 per cent of homes are still fuelled by oil](#), along with the fact that [72 per cent of the population use open or closed fires as secondary heating solutions](#), with coal and peat common fuel sources in the region. This statistic becomes truly startling when we compare it to other areas of the UK, [where only 3 per cent of households in England and Wales rely on oil](#) for household heating.

There are a variety of reasons why NI is so dependent on such carbon-intensive heating sources, including a shortage of gas network infrastructure and a lack of political will. It can also be linked to the region's lower level of income compared to the rest of the UK and Republic of Ireland (RoI).<sup>43</sup> Lower incomes also mean that many householders in NI feel unable to pay the upfront capital costs for efficient gas boilers or other low-carbon heating sources (such as heat pumps or solar panels), so continue to purchase small quantities of oil at inflated prices.

It is estimated that [50 per cent of houses](#) in NI were built before minimum building thermal performance standards were established in 1973. The poor energy efficiency within NI homes means that potential heat energy is lost at a disproportionately high rate (with climate and affordability implications). This not only increases the amount of fossil fuels being used to heat homes, but also means homeowners spend a significant amount of income on heating. This is linked to fuel poverty (households spending 10 per cent or more of their income to stay warm), which is a huge issue in NI, [as 34 per cent of households](#) were believed to be in fuel poverty in early 2022, based on Consumer Council research, an increase of [12 per cent from 2016](#).

While a complex issue, a few key drivers can explain the region's high levels of fuel poverty. Firstly, there is an overdependence in NI on oil for space heating, and a high proportion of the housing stock that is poorly insulated, as well as lower wages and households dependent on welfare transfers. The current [energy crisis](#) threatens to exacerbate fuel poverty in NI and highlights the importance of ensuring energy efficiency within homes.

[The delays in creating a Climate Bill](#) and up-to-date energy strategy and inadequate building regulations have all been cited as factors for the lack of progress in energy efficiency in NI. However, followers of politics in this part of the world will be no stranger to the lack of political will to address climate change, with former Environment Minister Sammy Wilson previously labelling the scientifically proven phenomenon as a 'con'. Aside from climate change denial at the highest levels of local government, some of the hesitancy to introduce new climate-change-related policy in NI was linked to the lack of a functioning devolved government from January 2017 to January 2020; with its collapse infamously caused by a failed [Renewable Heating Incentive \(RHI\) scheme](#). Whilst the main talking point around the RHI scheme was the loss of taxpayers' money, the closure of the scheme means there is still no publicly available financial support for new renewable heat projects in the region, and this has paused heat decarbonization initiatives. Meanwhile, the Department for the Economy recently produced [a long-awaited new energy strategy for NI](#), which sets the foundation for energy targets well into the next decade. However, there has thus far been no mention of a renewable heat target in the strategy, which again casts doubt on how serious government departments are about addressing this issue.

<sup>43</sup> NI's median salary of £28,000 is £3,000 lower than the UK average, with studies also estimating that on average residents in the RoI earn the equivalent of almost £4,000 more in annual household disposable income.



### The transition away from oil

So, we have recognized the carbon-intensive nature of residential heating and its root causes, but how do we go about tackling it? The progress NI has made in moving away from coal and oil is undoubtedly a positive step, as both have significantly higher emissions than natural gas, producing approximately 0.34 kg and 0.27 kg of CO<sub>2</sub> for every kilowatt hour of energy delivered, compared to just over [0.2 kg for natural gas](#). Natural gas is often touted as a cleaner fuel source, and its proponents claim that it is a 'bridge fuel' that will allow society's heating needs to be met whilst we make a full switch to zero-carbon sources of energy.

However, this transition to natural gas is problematic, as it is recognized that to reach decarbonization targets, a shift from natural gas to alternative low-carbon sources is required as soon as possible. This has been reaffirmed by the International Energy Agency, who have advised that to reach net-zero emissions targets by 2050, no new fossil fuel boilers should be sold from [2025](#). Conversely, the gas network continues to expand within NI as the region seeks to catch up with the rest of the UK and RoI. One such example is the ongoing [Gas to the West project](#), which is aiming to connect 40,000 additional residences and businesses to the gas network over the next decade.

### Decarbonizing the gas network

But what if we were able to leapfrog natural gas and substitute it with a less carbon-intensive fuel source? Some have suggested using the gas infrastructure to pump green hydrogen into homes. Provided the electric current used in the production of green hydrogen comes from renewable energy, it can be categorized as a zero-carbon fuel, as aside from the infrastructure no greenhouse gases are released from its production. This would also tie in with the region's vision of becoming a '[green hydrogen leader](#)', as NI's public transport authority currently operates buses powered by green hydrogen, with plans to [produce green hydrogen locally](#) in the near future. Or perhaps a more feasible alternative could involve injecting biomethane into the gas network. Given the predominance of NI's agriculture sector, there is significant potential to use agricultural and food waste in anaerobic digesters to provide a low-carbon source of fuel to homes.

However, the scalability of both technologies in the near future is uncertain, and hydrogen has not been used to heat homes anywhere in the UK yet.

Whilst biomethane is beginning to enter the heating mix in the RoI, it is untested in NI and there is a distinct lack of infrastructure for biomethane injection here. Additionally, both technologies would cost hundreds of millions to implement on a regional scale, with costs likely to be pushed back onto local consumers who are already dealing with the dilemma of '[heating or eating](#)' as a result of the energy price crisis. Implementing these technologies would require NI to take a leadership role; however, as anyone reading will be aware, this would be uncharted territory for a region that has historically followed Britain's lead.

### Electrified heat

Of course, NI does not have to become totally reliant on utilizing the gas infrastructure. Electrified sources of heat such as heat pumps have long been promoted as having a prominent role to play in the decarbonization of the Residential Heating Sector (RHS). Studies carried out by researchers at Ulster University on the predicted 2030 heat pump supply on the island of Ireland show that heat pumps have the potential to [reduce CO<sub>2</sub> emissions from fuel source heating in residences by 40 per cent](#). Given the significant wind resources available to NI (it produced almost 50 per cent of its electricity from wind in 2020), electrification through heat pumps would appear to be an attractive option. Heat pumps, recently heavily promoted in [the UK government's Net Zero strategy](#), could also remedy the problems that will be faced in rural areas that are unlikely to be connected to the gas network.

Despite their high efficiency rates, industry experts have noted that a transition to heat pumps will put increased strain on the electrical grid as demand for electricity rises, which will necessitate investment to upgrade the grid's infrastructure so it can meet the demand.

### The best of the rest

Studies which have included NI in an 'all-Ireland heat map' show that if governments on both sides of the border made appropriate investments in infrastructure and created complementary policies, district heating [could potentially meet 57 per cent of the island of Ireland's heat demand](#).

There are currently [94 district heating schemes](#) in NI, only one of which supports an area that exceeds 100 homes, underlining heat networks' distinct lack of scale of in NI. Conversely, it evidences that there are no knowledge or technical barriers to overcome, unlike for alternative low-carbon heat sources, and it could be uniquely suited to the growing urban hubs of Belfast and Derry. Unfortunately, similar to other low-carbon heat technologies in NI, the theme of a lack of framework or support mechanism for district heating continues. This also holds true for carbon capture and storage technology. Whilst studies have



shown that there is potential to store close to **100,000 tonnes of carbon** in the region, it has not been proven in practice and may encourage society to continue emitting greenhouse gases from residential heating in the expectation that we can simply store it under ground. The **Climate Change Committee** has noted that there is limited carbon capture and storage potential in NI, suggesting nature-based solutions such as rewetting peatlands and reforestation are better options for the region.

### Fabric-first approach

When thinking about decarbonization strategies it can become easy to develop an unhelpful obsession with emerging technologies to tackle the issue. However, the way forward may be a lot less complex than that. Implementing retrofitting initiatives within homes has been cited as one of the most feasible options for heat decarbonization and is an avenue NI could pursue, given that the resources to retrofit residencies are widely available. Even basic retrofit measures, such as having more insulation put into loft spaces or upgrading to a boiler with heating controls, can deliver **significant energy savings** and be installed in homes with minimal disruption.

From an estimated **780,000 domestic properties in NI**, over half have a Standard Assessment Procedure rating below band C, with only 4 per cent of houses achieving a Band B or above. When combined with the fact that roughly 60 per cent of houses in NI were built before 1980, housing in NI can be categorized as old and inefficient. This is very much a 'low hanging fruit' on the quest to decarbonize residential heating, as significant emissions reductions could be achieved in a short time frame. This is in keeping with the Belfast Climate Commission's **Net Zero Carbon Roadmap for Belfast**, which highlights that decarbonizing residential and commercial buildings is the most cost-effective and carbon-effective strategy for the city.

In order to reach net-zero targets by 2050, the rate at which retrofitting measures in the region are being implemented will have to at least **double and perhaps treble annually**. Given the scale of the task, cross-border collaboration with the RoI should be leveraged to counteract any potential labour or skills shortages.

### Research into retrofit

Recently completed **research** used decision-making software known as the Analytical Hierarchy Process tool to carry out a desk study on the effectiveness of common retrofit options. A comparison of the retrofit options is outlined below, in terms of their performance in relation to potential CO<sub>2</sub> reductions, capital cost, annual fuel cost reductions, and ease of installation in a typical NI home.<sup>44</sup>

**Table 1: Comparing retrofit options**

	Potential CO <sub>2</sub> reductions (tonnes of CO <sub>2</sub> e) if implemented in all suitable NI homes 0.476*	Average capital cost of one installation 0.288*	Average annual fuel cost reductions from one installation 0.175*	Ease of installation (average time taken to install by two labourers) 0.059*
<b>Loft insulation (300 mm thickness)</b>	218,654	£225	£165	5 hours
<b>Double glazing windows (post 2006)</b>	193,112	£4,900	£79	2–3 days
<b>Cavity wall insulation</b>	88,160	£1,000	£183	5 hours
<b>Heating controls for wet central heating</b>	399,744	£400	£187	7 hours
<b>Suspended floor insulation</b>	103,600	£1,000	£87	2–3 days

\* Denotes the relative weighting and importance of each category.

<sup>44</sup> The data employed for this study was extracted from the following reports: Building Research Establishment (2019), *Cost to make dwellings in Northern Ireland energy efficient*, Building Research Establishment (2021), *Cost of carbon savings in Northern Ireland's housing stock*, Northern Ireland Housing Executive (2018), *House Condition Survey - Main Report* and The Scottish Government (2015), *Developing the regulation of energy efficiency of private sector housing (REEPS): modelling improvements to the target stock*.



## Results

Heating controls performed well when measured against all criteria, outperforming other options by a considerable margin.

It is interesting to compare what the theoretical impact on total greenhouse gas emissions would be if every home suitable for heating controls in NI were to adopt them. Emissions attributable to the RHS in NI totalled 2.86 MTCO<sub>2</sub>e as per most [recent estimates](#). Therefore, the data in the desk study suggest that if heating controls were adopted in every potential home, this would lead to a 13.97 per cent reduction of emissions from the RHS.

If this was extrapolated to NI's total greenhouse gas emissions (20.9 MTCO<sub>2</sub>e), it could lead to a reduction of 1.9 per cent of emissions. These calculations were based on the potential savings from homes with an average Standard Assessment Procedure rating of C and below, meaning the same CO<sub>2</sub> savings are unlikely to be achieved in a more efficient home. However, they do evidence what can be done with a smaller financial output compared to other technical solutions listed in this article. Whilst 1.9 per cent may not sound like much on the surface, that is huge impact for just one piece of technology, and when used in conjunction with complementary retrofit measures, its impact would be amplified.

## Recommendations

There is no 'silver bullet' approach, and any strategy will likely have to include a combination of measures alongside retrofitting. Therefore, a diversified strategy that focuses on the points below would be most effective in ensuring a deep decarbonization of the RHS.

- In the short term, emphasis should be placed on adopting a 'fabric first' approach and engaging in a mass retrofit program of residential buildings over the next 7–10 years. This should include a timeline of targets that will help drive efforts towards energy efficiency across the housing stock.
- Increased subsidies to encourage low-income households to implement energy efficiency retrofit measures should be prioritized—particularly heating controls and insulation.
- Beyond this, pilot testing should be undertaken to understand how emerging low-carbon heating technologies perform in different types of NI homes.
- Local government should develop a replacement for the RHI scheme which can deliver financial support to households for low-carbon technology without repeating the mistakes of its predecessor.
- As many rural homes off the gas grid as possible should change their primary heating source to heat pumps or alternative low-carbon heat sources.
- Finally, all-island collaboration with the RoI should be utilized to overcome the skills shortage and lack of supply chains for low-carbon technologies in NI, as well as sharing competencies and resources to maximize decarbonization potential. This will be particularly important for alternative fuels being moved around the island's gas network.

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