The challenge of Net Zero for the **heating sector**

30%

of the EU's final energy consumption is from heating in buildings

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Overview

According to figures compiled by the not-for-profit organisation, Euroheat & Power, heating homes and buildings accounts for more than 50% of all carbon emissions in Europe. It is not surprising, therefore, that heating is considered one of the biggest challenges to bringing all gas emissions to Net Zero by 2050 – a goal set by UN member countries in the 2015 Paris Agreement at COP21.

As a leading manufacturer of world-class heating products for the residential and commercial sectors, Danfoss has compiled this white paper to analyse the complexity and scale of decarbonising heat and to explore solutions in the journey to Net Zero, from steps that can be implemented today, such as effective heating control and hydronic balance, through to the ultimate goal of global energy transformation.

Heating homes and buildings accounts for more than 50% of all carbon emissions in Europe

Combining external data with the company's own industry knowledge and expertise, the document outlines how this transformation will require an unprecedented step change in how we heat our homes and buildings. It will consider the need for a radical shift in the energy system and the scaling-up of alternative energy sources to displace our current reliance on fossil fuels.

In addition, Danfoss will look at the impact of such a major change on the production, distribution and consumption of energy, together with the need for significant market and policy drivers – and consumer action – in order to reach carbon-neutral heating.

The Challenge

Achieving Net Zero by 2050 is clearly a massive challenge for the heat supply chain as it is estimated that around 90% of the energy for this sector currently comes from fossil fuels.

These carbon-emitting fuels must be replaced by a more diverse range of sustainable sources of energy if we are to meet the target.

Amory Lovins, the American ecologist, got it right when he said that the use of nuclear powered electricity or fossil fuels to provide space heating and cooling or hot water is like "using a chainsaw to cut butter."

However, the historical, logistical and financial reasons that drive the use of fossil fuels cannot be underestimated. Indeed, some say that making the transition to alternative energy sources will require nothing short of a revolution.

According to Energy Systems Catapult, an independent, not-for-profit organisation which bridges the gap between stakeholders within the energy sector, zero carbon vectors will require an unprecedented scale-up to displace fossil fuels.

With the potential for fossil fuels consumption collapsing from ~1500TWh to ~250TWh, this could mean a proportional increase in the following energy systems:

- **Electricity: 600 - 800TWh**
- **Hydrogen: 200 - 300TWh**
- **District Heat: Up to 200TWh**

The challenges

30%
of total EU energy consumption used to heat and cool our buildings

36%
of the EU's carbon emissions comes from buildings

70%
of an average household's energy bill spent on heating and cooling

€240bn
spent by EU citizens on space and water heating per year

1in10
people in the EU struggle to heat their homes

110m
EU citizens living in buildings with hazardous concentrations of pollutants due to inefficient ventilation

The Challenge

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At Danfoss we believe the road to Net Zero requires a two-fold approach that looks at the entire system, from source to sink, and identifies energy efficiency potentials along the road.

The first is to improve overall system efficiency by, for example, ensuring optimal hydronic balance and accurate temperature control. This simple, yet often neglected no-regret measure can help reduce the overall cost of decarbonisation significantly. The second, and potentially more challenging, approach is to make sure remaining energy demand is covered by carbon neutral energy sources.

Needless to say, an energy transition requires a clear framework for action, supported by legislation, market policies and incentives to drive the transformation. Additional training for those installing and maintaining new green heating systems may also be required.

90% of the energy for this sector currently comes from fossil fuels

An increase in public and private investment in sustainable energy infrastructure and distribution networks is clearly essential in many countries; while behavioural economics could also play a role in understanding consumer attitudes towards their energy use.

Some of the toughest challenges for decarbonisation will likely require local and regional coordination and action. To sum up, key challenges and considerations could include:

- **How to decarbonise buildings and the combinations of fabric upgrades, heating systems and infrastructure required in different local areas.**
- **The future of the gas network (including the potential of hydrogen).**
- **How to minimise the costs of energy transition for consumers.**

The Impacts

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The Impacts

The scale of change required on the roadmap to carbon neutrality will have wide-reaching impacts. It will affect energy providers and associated stakeholders, housebuilders and developers, property owners, national and local government planning and policy makers, the heating industry itself and, of course, consumers.

Oil and gas are among the key trading commodities, so the transition to alternative energy sources is bound to have a global economic impact.

On the positive side, improving energy efficiency across all sectors has the potential to deliver significant economic, social and environmental benefits but only if everyone, including governments, take bolder action.

For some time now housebuilders and developers have experienced the practical and financial impacts of designing developments that comply with increasingly stringent energy efficiency regulations.

However, whilst it may be possible to build new properties to Net Zero standards, transforming existing building stock will be another matter.

According to the Committee on Climate Change around 14% of greenhouse gas emissions come from our homes, mainly from gas boilers.

In spring 2019, the UK's then Chancellor of the Exchequer Philip Hammond announced that 'fossil-fuel heating systems', including gas and oil boilers, would not be installed in any domestic new build properties from 2025 as part of the Future Homes Standard.

This is clearly a good starting point but doesn't take account of the millions of gas and oil boilers that are currently being used to heat existing UK homes.

To address this we will have to see a huge overhaul in residential heating systems to be compatible with sustainable energy solutions, whether that's hydrogen gas, heat pumps, or connecting communities to new district heat networks.

Finding a way to minimise the cost and disruptive impact of transitioning vast numbers of consumers currently using carbon-intensive systems to low carbon heating will be key to achieving Net Zero.

The Solutions

The Solutions

Having assessed the challenges and the impacts of Net Zero on heating, let's look at some of the solutions, ranging from the short-term measures that are available now to longer-term solutions and future technologies. Given the size and complexity of the heating sector it looks likely that we will see a mix of solutions operating within the market for some time. However, whatever solution is adopted, Danfoss believes an overarching requirement for effective heating control and hydronic balance will still exist to maintain optimum system efficiency and comfort for consumers.

Hydrogen: On paper, hydrogen-compatible domestic boilers could offer a relatively easy and not overly expensive replacement for the millions of existing gas boilers in people's homes. Blue hydrogen is being explored as a possible technology for this purpose as it can be produced from natural gas and the CO2 emissions and other polluting elements captured and removed. There is, however, some uncertainty at the moment about the cost of producing Blue Hydrogen on the necessary scale.

Heat pumps: The installation of heat pumps could play a major role in delivering low carbon heating. Although heat pumps still have some impact on the environment as they need electricity to run, an Air Source Heat Pump (ASHP) will typically produce around 3kW thermal energy for every 1kW of electrical energy consumed – and there is the potential to use solar thermal technology and solar PV arrays. In addition, the heat that the pumps extract, whether that's from the air, ground, or water is constantly being renewed naturally.

When it comes to choosing a heat pump solution, ASHP are generally considered easier and less costly to install than a ground source version, particularly in an existing property, because they do not use pipes buried in the ground outside to extract heat.

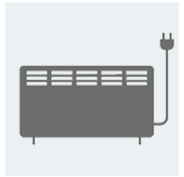
The heat an ASHP absorbs from the outside air can be used to heat radiators, underfloor heating systems, or warm air convectors and hot water in the home. This type of heat pump can get heat from the air even when the temperature is as low as -15° C. In a well-insulated property, ASHP can provide all the heating needs by themselves.

However, in older properties where it is not possible to insulate to a high enough standard for heat pumps to be fully effective on their own another sustainable heat source would be required. It should also be noted that unlike gas and oil boilers, heat pumps deliver heat at lower temperatures over much longer periods, so during the winter they may need to be on constantly to heat the home efficiently.

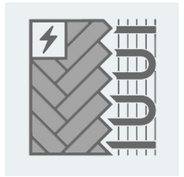
An Air Source Heat Pump (ASHP) can get heat from the air even when the temperature is as low as 15°C

Taking the UK as an example, the installation of heat pumps would have to be stepped up considerably over the next thirty years to achieve Net Zero. There is clearly an opportunity to start this process with new build properties, which the Committee for Climate Change has recommended should not be connected to the gas grid from 2025. As far as existing homes are concerned, installing heat pumps in the four million or so off-grid homes in the UK, which are currently using oil or other fossil fuels for heating, could be an incremental step towards the target.

Electrification: For decades, electrical heating systems have been associated with pollution and high energy prices. However, today it can be considered sound and environmentally-friendly to base a total heating solution on the new forms of renewable electricity. So what are the main electrical options?



1. Direct electric heat:
This is a well-established technology with no emissions at the point of use. Despite these 'green' credentials, direct electric heaters tend to be expensive to run, and if they were rolled out to vast numbers of homes and buildings it could have a sizeable effect on the national grid.
However, they may be an option where the heat requirement is relatively low, such as in small, well-insulated homes, where demand on the grid and running costs would be less of an issue.



2. Electrical underfloor heating:
Combining electrical floor heating, such as the DEVI system from Danfoss, with a renewable energy source like solar power cells is a strong alternative to other environmentally-friendly heating solutions, particularly for new homes with a high degree of insulation and low energy consumption.
Furthermore, electric under floor heating is ideally suited to the lower temperatures produced by sustainable energy systems.

The Danfoss energy+ house in Denmark, for example, shows how 40m^2 solar power cells on the roof provide more than enough energy to heat up the house, even during the long winter experienced in the northern hemisphere.

The energy+ house powers the entire electrical floor heating system plus a ventilation system with heat recovery. The heating and ventilation system is controlled via a central panel, which enables temperature setting in all rooms from one point. The electricity is "sold back" to the grid and, during the winter it can be "bought back", providing the homeowner with the potential for CO2 neutral electricity.

Heat as a Service: Another solution being considered to support the decarbonisation of heat is the concept of Heat as a Service (HaaS). With HaaS, customers would buy warm hours instead of kilowatt hours of energy under a contract, or Heat Plan, with an Energy Service Provider (ESP).

In exchange for a fixed price the ESP provides them with a home heated to the temperature they want at the times they require it.

Once a service provider understands the consumer's heating needs they can help them select the best low carbon solution for their home, and then assist in preparing the property for the new system as and when the existing system is replaced.

The fundamental logic behind HaaS is that consumers care more about their experiences than how they are delivered. Field trials by Energy Systems Catapult, who are at the forefront of this new concept, generated unique and valuable insights into how people used their heating and how much they were willing to pay to buy Heat as a Service.

The Solutions

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The energy+ house powers the entire electrical floor heating system plus a ventilation system with heat recovery. The electricity is "sold back" to the grid and, during the winter it can be "bought back".

The Solutions

Heat Networks: Heat networks, also sometimes referred to as district heating, are likely to play an important part in plans for a carbon neutral future for heat. Already at the heart of low carbon heating in towns and cities across Europe these water-based distribution networks are proven to deliver a high efficiency energy solution that can be 'plugged' into all types of renewable, sustainable energy sources.

The share of district energy in the heat and cool supply varies between countries as well as regions within countries. In the European Union district heating has an average market share of 12%, although in some champion countries such as Denmark, Sweden and Latvia, district heating covers a much higher percentage of the heat demand. In comparison the market share for the UK is relatively low.

The trend, particularly in Scandinavia, is now moving towards smaller energy networks that can be connected to a larger 'out-of-town' network at a later date. For those countries currently lagging behind in the district energy market, particularly in terms of building the necessary infrastructure, this incremental approach could be the way forward.

Cost is a major factor in driving investment in district energy, so when investigating the potential of this technology it can often be beneficial to start in places with high heat demand densities. This is because, like natural gas networks, the cost per delivered unit in a district energy network decreases as the distance travelled is reduced.

Excess heat from industry, effectively the cheapest form of heat, could be used to cover the baseload. Further research is needed to understand the role of non-baseload excess heat, especially in smaller district heating networks.

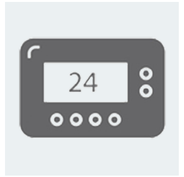
Large-scale heat pumps could also become a key element in the (re-) development of district heating systems. This is mainly because this technology can provide heat in a very efficient manner, as mentioned earlier, and creates a valuable link with the electricity sector through its use of renewable resources.

For those countries currently lagging behind in the district energy market, this incremental approach could be the way forward.

As the supply and supply sources for these networks become more efficient and varied, the marginal costs of supply heat will fall, creating more competition within the baseloads of district heating system markets. The prospect of lower costs, as well as the development of 4th generation district heating networks that offer advanced control and connectivity to different energy sources, will help to make heat networks an even more attractive option in the journey to a more sustainable energy system.

A commitment by the UK government to continue supporting the development of heat networks through a significant funding programme, together with new regulations under The Heat Networks (Scotland) Bill, are expected to drive investment in this technology across the UK over the next few years.

Some of the first schemes to benefit so far have had very positive outcomes. These include a project to design and deliver a district-wide heating network to provide cheaper and greener heat to over 1,000 homes plus community buildings in north London, using unwanted heat from the London Underground. Danfoss was delighted to be directly involved in providing a custom-designed Heat Exchanger Sub-Station which successfully connects one of the public buildings to the new heat network.



Intelligent control and hydronic balance: Whatever sustainable solutions are adopted, high efficiency heating controls will continue to play an important role in optimising overall system efficiency.

And even in a Net Zero world, homeowners will still need to control when their heating comes on and be able to turn the temperature up or down to meet their individual needs and lifestyles.

Independent tests have demonstrated the energy-saving benefits of high-efficiency electronic heating controls, such as fully programmable room thermostats and thermostatic radiator valves, as well as the importance of proper hydronic balance.

Danfoss has extensive expertise in developing advanced solutions in this field, including NovoCon® S a digital actuator that is tailor made to fit Danfoss AB-QM – the market leading pressure independent balancing and control valve. Together they establish the perfect connection between superior hydronic HVAC system performance and smart building automation solutions.

Unlike traditional analogue actuators, NovoCon® S offers many digital system parameters directly to the Building Management System via BACnet or Modbus, including exchanging accurate information about the actuator/valve position, settings, temperatures, and alarms.

All this information provides the BMS with remote access to the HVAC system status which can be used to optimise its performance, thereby improving indoor comfort for occupants and providing energy savings for building owners and landlords.

Alongside these innovative developments, Danfoss is taking heating control and optimisation to the next level using Artificial Intelligence (AI) with Leanheat software. Sensors installed in individual apartments enable Leanheat's AI to learn the building's thermodynamic behaviour and to optimally control the HVAC system and so overcome the common problems of wasted energy due to overheating and poor indoor conditions. Heating is always optimised regardless of changes in weather or other factors. Already installed in thousands of apartments, Leanheat is on track to reach 1 million installations by 2022.

> **"75% of our housing stock** is energy inefficient. To make our existing buildings more efficient, renewables and energy efficiency will have to work hand in hand"
>
> **– Commissioner Arias Canete**

The Solutions

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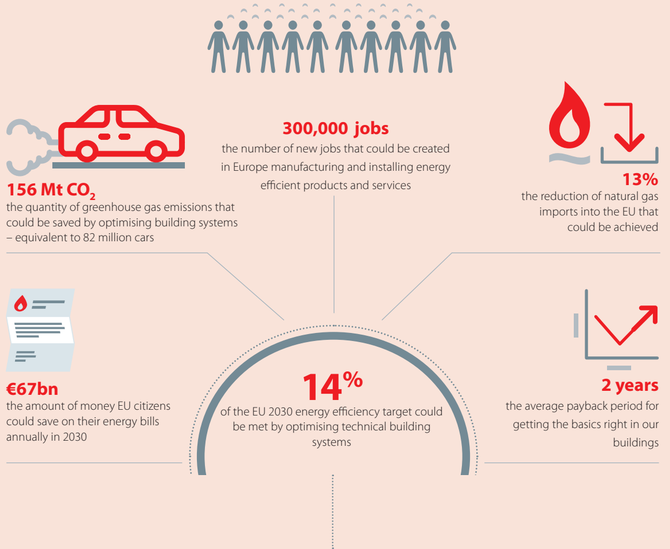
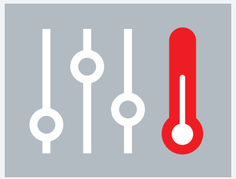
Achieving the EU's transition to a low-carbon economy by 2050 requires the full decarbonisation of our buildings. With the current 1% renovation rate for existing building stock, neither the EU 2030 energy efficiency target nor the 2050 decarbonisation target will be achieved.



Technical building systems – solutions for improvements

Space heating

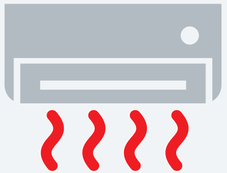


Individual room controls; automatic hydronic balancing; speed-controlled pumps

Hot water

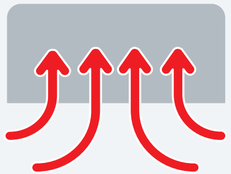
Automatic thermal balancing

Air conditioning



Individual room controls; speed-controlled compressors

Ventilation



Variable demand control

30%
average energy savings potential by optimising technical bulding systems

Conclusion and **the Future**

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Conclusion and the future

There seems little doubt that the journey to Net Zero in the heating sector is a challenge and it raises important questions such as How quickly can we deliver change? And at what cost?

The unfortunate truth about climate change is that the longer we wait, the higher the cost - and we cannot afford the high costs of inaction. However, making the transition from carbon-intensive energy to renewable, sustainable energy sources cannot be achieved in one, quick step.

That's why at Danfoss we believe the most cost-efficient solution to decarbonise our economies is energy efficiency and even small actions on different fronts, such as optimising the efficiency of existing heating systems through better balance and control, can help us move in the right direction.

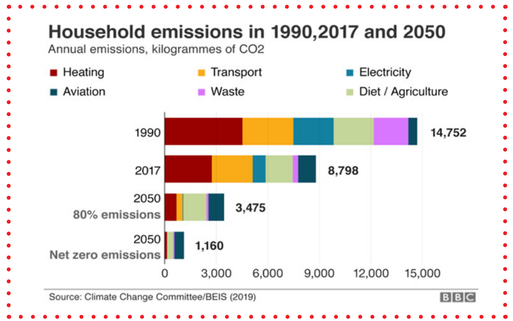
This document has explored how most future pathways to decarbonised heat, particularly residential heat, will involve a combination of solutions. These are likely to include some level of electrification to utilise renewably-generated electricity and the opportunity to explore new business models and market arrangements, for example Heat Plans, to support the decarbonisation process.

Today, 70% of all energy-related emissions come from cities, which is contributing to global warming. Intelligent district energy systems can help address this by creating smart cities in which homes and buildings are connected to a high efficiency heat network based on a sustainable energy platform.

Smart devices, including digitalised pressure controllers that automatically and dynamically balance a heat network, can also be used to maximise network efficiency and energy savings, helping to lower operational and investment costs and improve quality of supply.

In addition, the application of artificial intelligence in solutions like Leanheat offers a way to get existing homes and buildings ready to take full advantage of district heat networks by lowering temperatures. As the graph ***(below)*** shows, annual CO2 emissions from heating have been reducing since 1990, but there is still some way to go.

So to sum up, the journey to carbon neutral heating has started and we must continue this journey regardless of the inevitable bumps along the road if we are to build a better, sustainable future. Business as usual is not an option. Driven by the power of an electrified society, and fuelled by the opportunities offered by the latest technology, from digitalisation to artificial intelligence, Danfoss is dedicated to developing megatrends solutions that can help accelerate energy transition towards Net Zero and deliver a cleaner, greener heating future for all.



Sourced from BBC News, using data compiled by Energy Systems Catapult for Living Carbon Free, prepared for Climate Change Committee as part of its advice to HM Government.

For more information on how Danfoss is getting ready for Net Zero click below or contact us at Danfoss Heating UK:

Superior range and accuracy brings increased efficiency in new residential apartments

Local residents stay warm thanks to supermarket's cooling system

Energy savings and improved comfort for 56 year old apartment building

Outstanding HVAC flexibility after high-end office renovation

Record savings on central heating consumption, in family house, Køge, Denmark

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