CHURCH HEATING

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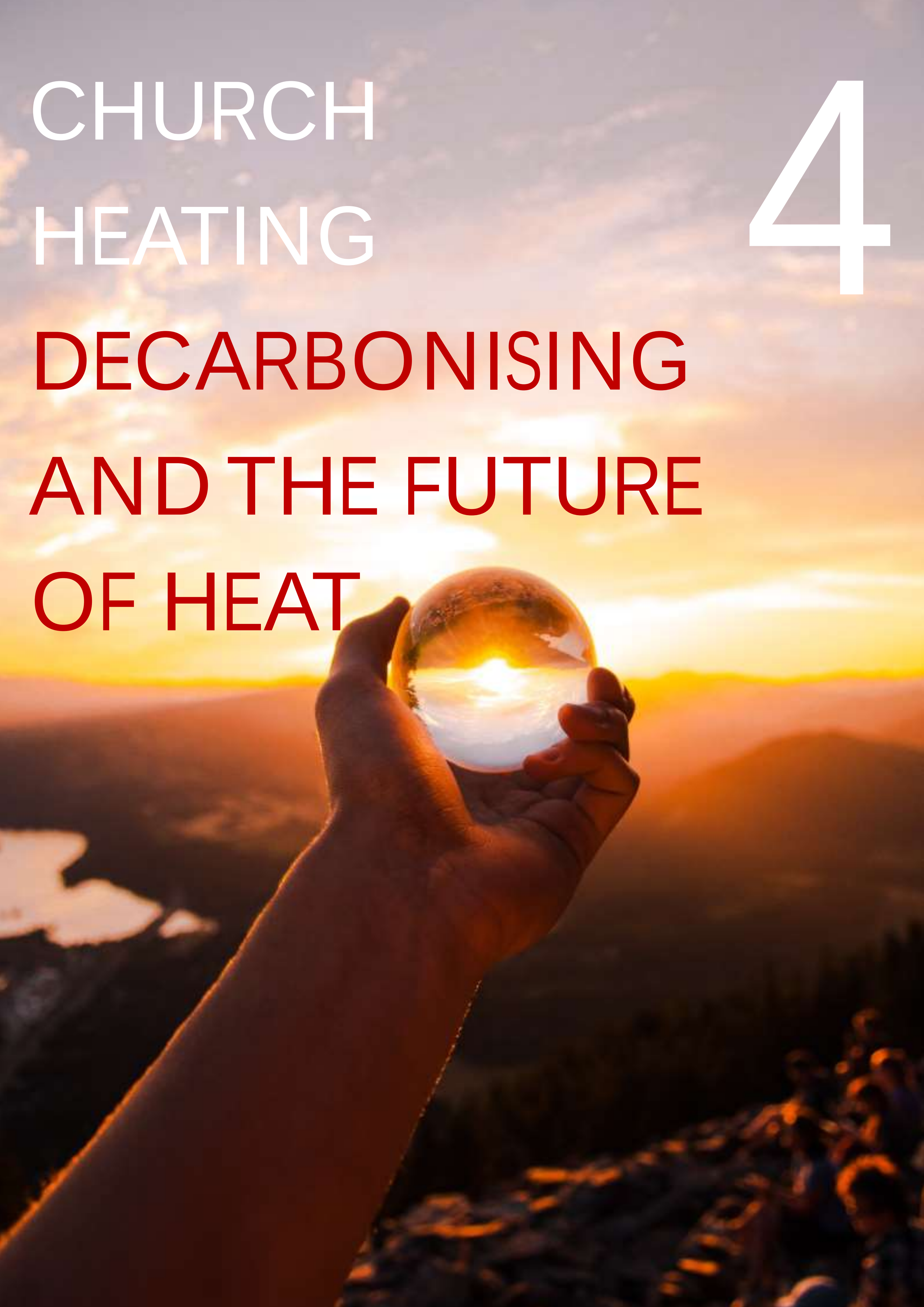
DECARBONISING AND THE FUTURE OF HEAT



CHURCH HEATING

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DECARBONISING AND THE FUTURE OF HEAT

4a Introduction

When planning a new heating system, you need to keep the future in mind. How will the climate change? Which new technologies will become effective and affordable, and which current technologies will become redundant? What sources of funding might come, if we wait? And what changes will be driven by future regulation?

We know that decarbonising heat is vital. Around a quarter of the total UK's greenhouse emissions come from central heating, so to meet net zero carbon we need to reduce the emissions released by burning gas, oil, and other fossil fuels in our buildings.

So, what might be 'the future of heat'?

There is no one answer to this. Experts see four main approaches to decarbonising heat;

- electrification of heating including different types of electric heaters, heat pumps and hybrid boilers,
- a switch from natural gas to hydrogen,
- a switch from natural gas to biogas,
- and district heating.

The final answer is likely to be a combination of all four, to different degrees, in different in different locations.

It is hard to keep a note like this up-to-date, in such a rapidly changing area, At the time of writing, the government's new heat strategy is still awaited. This guidance note is based on four key sources:

- the CBI's report: Net Zero : The Road to Low-Carbon Heat
- an article on net-zero home heating in The Guardian
- the Zero Carbon Britain report from the Centre for Alternative Technology
- information from the UK Committee on Climate Change, including Cleaning up the UK's heating system.

4b The importance of efficiency

No matter what the future of heat looks like, reducing the amount of heat we *waste* will be vital. This means cutting heat loss, through steps such as draught-proofing and insulation, improving the efficiency of heating systems, through steps such as installing timers and controls and through basic maintenance such as clearing out sludge from radiators.

Improved heat retention in a building, through better insulation, also allows the thermal mass of the building to act to naturally smooth out the demand for heat.

The rate of heat loss also affects the solutions open to us. Heat pumps, for example, work much better in buildings with low heat loss, because they heat water to a lower temperature than a conventional boiler, so they offer a gentler heat over a longer period. If the heat loss is high, they will struggle to get the building up to a steady desired temperature.

One of the primary tools in heat efficiency is ensuring that heating only takes place *where it is needed* and *when it is needed*. This raises the question of whether you should be warming the whole volume of air in the church (space heating) or warming the people direct ('people heating '). We are all used to space heating in our houses, but rooms in our homes have ceilings at 3m or less and lots of dividing walls. When you have an enormous open church building with 10m+ roofs, then different approaches are needed.

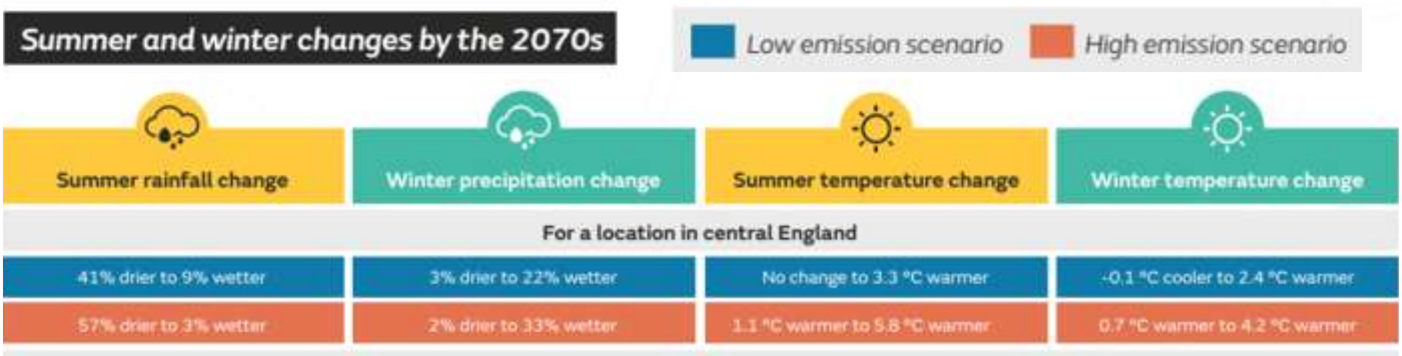
This is covered much more fully in section 1 on heating principles and section 3 on heating approaches. You can also refer to our guidance on Energy Efficiency.

The UK Climate Projections from the Met Office are for warmer weather throughout the year, across all areas of the UK, with the degree of warming being greater in the summer than the winter. So the amount of heating you require may become less over time, and your church may increasingly become a cool sanctuary during hot summers.

Some more modern churches and halls may become uncomfortably hot in summer, and need to consider how to keep the building cool enough to be usable.

Winter precipitation is expected to increase significantly, potentially making the air inside your church damper and harder to heat. Summer rainfall is expected to decrease significantly, but when it rains in summer there may be more intense storms.

Below: UKCP18 headline findings, Met Office.
All results are for the 10th-90th percentile range for the 2060-2079 period relative to 1981-2000.



4d Why do we need to decarbonise heat?

In June 2019, the UK government committed to reduce carbon emissions to bring all greenhouse gas emissions to net zero by 2050. Our own General Synod has set an even faster target of planning for net zero carbon by 2030. If these targets are to be met, there is an enormous challenge to tackle: heating.

Warming the country's buildings and homes is responsible for around a quarter of the UK's greenhouse gas emissions. (That's more than 10 times the amount of CO_2 created by the aviation industry.)

Around 80% of churches use gas as their primary source of heating, with around 7% on oil. These are the very fossil fuels contributing to climate change.

The church energy audit analysis in 2020 showed that, from a sample of over a hundred churches, 84% of all energy use went on heating, with the remainder being used for lighting and other uses such as AV systems.

There have been huge steps forward over the last decade in 'decarbonising electricity', with major shifts away from oil-, gas- and coal-fired power stations towards renewables such as wind, solar, and hydro. However, heat is different because it is generated *locally* in homes, businesses, and other buildings, meaning that any transition requires over 20 million individual interventions that will need to be coordinated nationally, regionally and locally.

So, greening this system is a huge challenge by any measure. How could the challenge be met?

4e Solutions

Solution 1: Electric heating – including modern electric heaters, heat pumps, and hybrid boilers

If a church switches its heating from gas/oil to electricity, and purchases the electricity from 100% renewable sources (or generates it on site from solar PV panels), then their heating becomes 'net zero'.

There are many different electrically-powered options.

Heat pumps use electricity to extract heat from the air, the ground, or sometimes a nearby lake or river. In the case of an air source heat pump, it works like a fridge but instead of sucking heat out of a food compartment, it pulls heat out of the air and channels it into the building, where it is used to heat water, which is piped to radiators for central heating, and can be stored in a tank for hot water.

There are also 'air to air' units, which simply work like an air conditioner in reverse, sending warm air inwards, although these are less efficient and very difficult to integrate sympathetically into a heritage environment.

But because heat pumps produce water at a lower temperature than existing boilers, it requires buildings to be much better insulated, be less draughty, and often to have larger radiators, capable of delivering more heat from a large surface areas. For busier churches with a heat demand throughout the week, heat pumps can be very effective when combined with underfloor heating, offering low level background heat all week round.

Below: Heat pump at Lympne, St Stephen.

Electric heating can also be provided to churches and halls through solutions such as pew heaters, heating mats, heated cushions, far infra-red-panel heaters, portable heaters, and modern chandelier heaters.

Localised heating, near where people are sitting, can be far more efficient than space heating. And because far-infra-red panel heaters heat *surfaces* rather than heating the *air*, they do not have the problem of the hot air rising towards the ceiling. In smaller rooms, new generation storage heaters offer a flexible and low cost solution.

Hybrid boilers are now coming on to the market, which combine an air source heat pump with a conventional gas boiler. Because the gas boiler can kick-in on cold winter days, the heat pump can have a smaller capacity. This smaller size allows the installation of a hybrid boiler to a wider range of buildings, at a lower installation cost. Hybrid boilers are not a zero carbon solution however, because they still use some natural gas, and so they are only seen as a *transitional* technology, unless in the future they switch to using hydrogen instead of gas.

With churches which have an intermittent heating demand, hybrid boilers are likely to have less benefit. Typically the gas element is used at times of peak heating demand, to get the church temperature up from cold, with the air source heat pump then being able to take over to *maintain* heating after the initial peak. For churches which only heat up for a few hours every other day or so, the heating system will almost always be running at peak, with little opportunity for the heat pump to kick in to cover the lower demand periods.

With all of these forms of electric heating, the technology already exists. The main barrier to installation is more one of cost; either installation cost for heat pumps or operational costs for other electric solutions. Electricity currently costs around four times the cost of gas per unit of energy. However, the price gap is expected to narrow over time. Also, since these forms of heating—if well designed—are more efficient, the costs can be comparable.

Solution 2: Hydrogen heating

Hydrogen is abundant in the natural world and according to its advocates could power the next generation of gas appliances cleanly and efficiently.

"The attraction of hydrogen is that for a lot of consumers, they wouldn't notice any difference. Customers would continue to use a boiler to heat their homes in a similar manner to natural gas," says Robert Sansom of the Institution of Engineering and Technology's energy policy panel. He is the lead author on a study conducted by the institute called *Transitioning to Hydrogen.*

Together with colleagues, Sansom assessed the engineering risks and uncertainties associated with swapping our gas network to hydrogen. Their conclusion is that there is no reason why repurposing the gas network to hydrogen cannot be achieved. That's not to say it would be easy, though. Technological and practical hurdles exist because there is no blueprint for such a conversion: there is nowhere in the world that supplies pure hydrogen to homes and businesses. The UK would have to pioneer everything.

A future conversion to hydrogen would parallel the way the gas industry converted from town gas to natural gas in the 1960s and 70s. At that time, the UK undertook a nationwide programme to convert 40m appliances over a decade. Whole streets were converted at a time.

Some manufacturers have already begun to develop 'hydrogen-ready boilers'. These would run first on natural gas and then, after a servicing visit, hydrogen. This offers the potential to future-proof a decision to install a new gas boiler, ready to switch to hydrogen in the future.

Also working in hydrogen's favour is that for the past 20 years, the gas industry has been systematically replacing the metal pipes in its 'iron mains ' network with yellow polyethylene ones, because the old metal pipes were corroding. Around 90% of the pipes will have been replaced by 2030. This is good news for hydrogen because the gas reacts with the old metal pipes, making them brittle, whilst the polyethylene is safe.

Although the consumer may not experience so much disruption, significant challenges for the gas industry remain. For example, the National Transmission System, which is the network of pipes that supplies gas from the coastal terminals to the gas distribution companies and other major users, is made of metal. This would need to be protected from embrittlement in some way before any switch to hydrogen could take place.

Also, hydrogen is not found on Earth in a pure state. Instead, it has to be extracted from other substances.

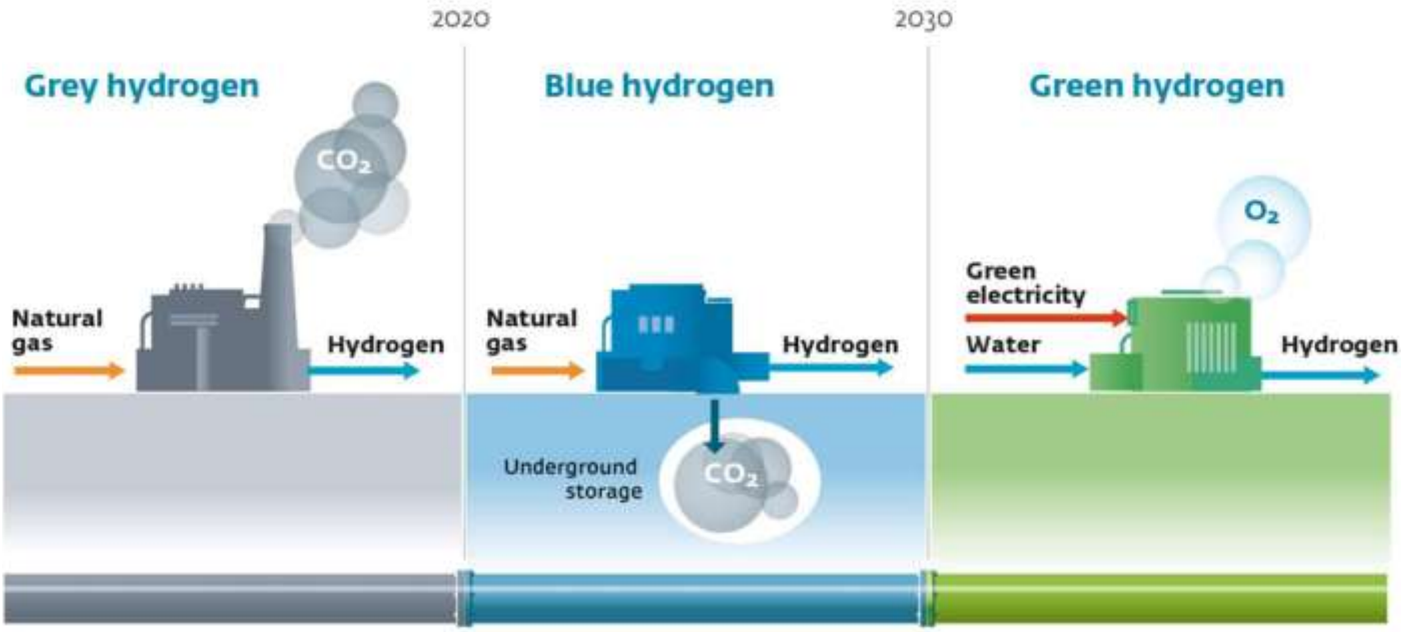
The extraction of hydrogen from methane (natural gas) creates carbon dioxide as a by product, so large scale carbon capture technology would need to be developed to prevent it escaping into the atmosphere. (This is known as 'blue hydrogen') Although carbon capture and storage is a technology that the UK will have to develop anyway in order to reach net zero by 2050, it will add to the cost.

But natural gas is not the only substance that contains hydrogen. Water does too, and the hydrogen can be freed by a process called electrolysis, which doesn't create any carbon dioxide. (This is known as 'green hydrogen '.) To make it totally green, which is the ultimate hope, this electrolysis process could be powered by wind and solar farms, on a large scale, or by an array of solar panels on the roof.

The *Zero Carbon Britain* report from the Centre for Alternative Technology envisions another role for hydrogen. They model a huge increase in renewable electricity, particularly from off-shore wind, combined with a 60% reduction in energy use. 'Spare' electricity, generated when the country is demanding less than the renewables are supplying, would be used to create hydrogen from water, and then to convert this hydrogen plus CO_2 into synthetic methane. The synthetic methane can then be stored, piped, and used in the *existing* gas infrastructure; being burned in existing gas plants to create carbon-neutral electricity when demand outstrips supply.

There is so much uncertainty currently about the role of hydrogen in the government's future heat strategy, that it is hard to be sure what role it might play.

Below: Grey, blue and green hydrogen. Source: Gasunie



Solution 3: 'Green' gas

- Companies are starting to offer 'green gas', but care is needed because this can mean one of three things;
- bio-gas formed as a natural waste product from landfills, the anaerobic digestion of food waste, waste water treatment facilities, and agricultural waste,
- bio-gas for which a crop has been specifically grown in order to produce the gas (this has an environmental impact, dependent on what the land would otherwise have been used for), and
- conventional natural gas which the company has paid to offset, and are labelling as 'green gas'.

Bio-gas is a combination of methane, carbon dioxide and minor amounts of other chemicals. It can be upgraded to bio-methane, which is chemically exactly the same as natural gas (which is methane) and so can be stored, transported, and used just like natural gas.

It can replace some of the natural gas in our existing gas infrastructure, somewhat reducing the greenhouse gas emissions of using gas.

Buildings can switch to a 100% bio-gas tariff for their gas in the same way that they can switch to a100% renewable tariff for their electricity. This makes their existing gas heating net zero carbon. However, these tariffs are much more expensive plus there is only a limited supply of truly sustainable bio-gas. Bio-gas is likely to play a role, but a limited role, in decarbonising the UK's heat.

Solution 4: District heating

The third potential solution to decarbonising heat is called district heating. It envisages water being heated at a central facility using waste heat from industry or green sources such as solar power. The hot water is then delivered to many homes and buildings simultaneously through a network of heavily insulated underground pipes.

District Heating solutions are surprisingly common, with around 14,000 heat networks across the UK supplying about 2% of heat to domestic and non-domestic buildings. They already exist in areas of Birmingham, Southampton (using geothermal energy) and recent developments around the Thames Gateway (mainly using heat from waste incineration or the waste heat from DRAX biomass power station). They are also very common in Europe.

District heating can significantly reduce the carbon footprint of heating but the downside is that it requires extensive work to roll it out on a national scale, installing water pipes under the streets.

It is more likely to be relevant in a town, city, or industrial area; where the buildings are relatively close together, or where there is a natural local heat source, such as the use of a disused coal mine, just announced in South Tyneside.

Combining these solutions

The CBI's commission on the decarbonising heat concluded:

"There is not a one size fits all solution… the UK public has a variety of approaches currently available to them that can be delivered by UK based businesses delivering new skills and jobs. Solutions include heat pumps, hydrogen fuelled boilers or even district heating. All exist and are ready to be deployed. However, in each and every case there is a significant scaling up of production required.

Building on the success of reducing the carbon intensity of our electricity supplies, heat pumps offer one of the most efficient solutions to low-carbon heat. But installing millions of these will require a major shift in consumer attitudes and can often require major heating technology and energy efficiency upgrades in the home. Hydrogen boilers may appear a simple solution, but the availability of low-carbon hydrogen in the volume and cost required to heat the nation's home remains a great unknown. It appears a mix of solutions, including these, hybrid technology and other heating options will be the answer. This must be delivered hand in hand with improvements in thermal insulation of the UK's housing stock."

All the options for us to decarbonise our heating systems, at scale, will require significant disruption and cost. However, with heating making up the majority of our energy use, action is needed. What will drive this change?

4f What will drive change?

Regulation

It is expected that, at some point, the government will regulate to end the installation of new gas and oil boilers. They have said that they plan to consult on regulatory options to phase out the installation of fossil fuel heating systems in off gas grid buildings. The date for any phase out in non-domestic buildings is not yet known.

The CBI's Heat Commission has *recommended* that government should:

- Mandate the phased switch over from existing natural gas boilers to other solutions like heat pumps and hydrogen technologies, including heat networks.
- From 2035 all new heating installations should be low-carbon. No new natural gas burning boilers or systems should be installed and only net-zero compatible technologies like air source or ground source heat pumps, hydrogen burning boilers or heat networks should be deployed.
- From 2023 no new domestic oil-fired boilers should be installed.
- After 2025 all new domestic boiler installations must be part of a hybrid system or be 'hydrogen-ready'.

Funding

The government has been putting funding into low carbon heat for some time, for example with the Renewable Heat Incentive for domestic and non-domestic buildings, the Green Homes Grant, and the Public Sector Decarbonisation Fund.

They are currently consulting on a new 'Clean Heat Grant Scheme', to replace the Renewable Heat Incentive. This would help with decarbonising heat in domestic and small non-domestic buildings via upfront grants for heat pumps and, in limited circumstances, biomass.

With domestic heating, the Department for Business, Energy & Industrial Strategy has launched a £16.5 million 'Electrification of Heat Demonstration Project'. The project aims to demonstrate the feasibility of a large-scale transition to electrification of heat, by installing heat pumps in a representative range of homes.

Government coordination

The UK government are developing a new policy framework for the long-term future of heat; a 'Heat Policy Roadmap' setting out the key steps required to make decisions on heat decarbonisation, which they aimed to publish in 2020 but has not yet been released at the time of writing (March 2021).

To make such large-scale changes in our heating infrastructure around the country will requite considerable coordination at national, regional, and local level. It is clearly not something an individual church can set in motion, although if – for example - plans for a district heating system are being developed locally, a church can choose to support the plans.

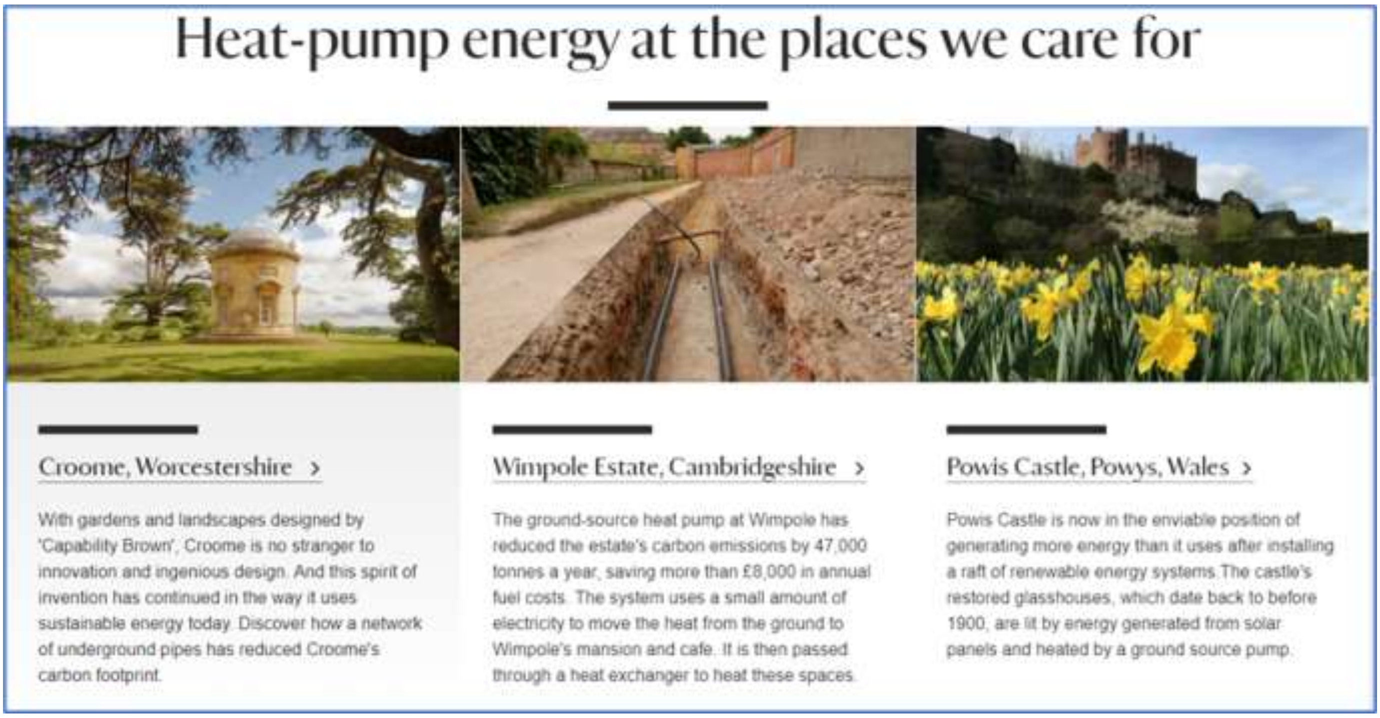
4g Is change like this really possible?

There are examples of change around the country.

The National Trust aim to produce 50 per cent of the energy they use from renewable sources by 2021. Heat -pumps, using pipes buried deep beneath the ground to extract the heat that is trapped there, are helping them to achieve this.

The National Trust already use this kind of energy at 83 of the places in their estate and will be installing 20 more heat pump projects during the next five years.

Each green circle on the Church of England's online renewables map (below) shows an installations of heat pumps or biomass somewhere in a church. There have already been dozens of installations.



Above: **Examples of energy sources shown on the National Trust website, and the Church of England's online** renewables map.

And finally, you can find cases studies of net zero carbon churches on our website. These churches have become 'net zero' through installing new electric heating alongside improved energy efficiency and other measures.

For example, St Michael's and All Angels, Withington (pictured, below) has reached net zero by installing solar panels, cutting the hours they run their floodlighting, switching to LED lighting, installing electric pew heating, and other energy efficiency improvements.

The recent report on the first year of the Church of England Energy Footprint Tool showed that in 2019, 5% of our churches were already 'net zero carbon'.

Having looked at the Future of Heat, in the next section we help you look at the current situation in your own church, with a Heating Checklist you can complete (Section 5). After this, you can read about Heating Pitfalls to avoid (Section 6), and then start to move towards a solution for your church with an Options Appraisal (Section 7).

Left: Solar panels at Withington, St Michael and All Angels.