Mitsubishi Electric Guide to Commercial Renewable Heating

Information Guide 71

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Mitsubishi Electric Guide to Commercial Renewable Heating

This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today.

This guide accompanies a series of seminars, all of which are CPD certified.

Contents

Introduction

The UK is on the path to a green revolution. In June 2019, the UK government set a target of achieving net zero national greenhouse gas (GHG) emissions by 2050 - the first country in the world to do so. This means we are aiming for a **100% net reduction** in GHG emissions against 1990 levels.

This target, now a legal requirement, means that the UK must cut emissions (particularly carbon) across the whole economy, including transport, energy supply, industry and the built environment. The Climate Change Committee (CCC), which advises government, has said that the goal is ‘feasible but challenging’.

Over time, the UK’s net zero goals have become more ambitious and more focused. In 2020, we saw a new emphasis on developing the ‘green economy’- developing new technologies and creating jobs. This activity has been driven in part by the 2021 COP26 United Nations climate change Summit which the UK is hosting in Glasgow. The government is keen to lead by example and urge other countries to adopt similar ambitious objectives.

The net zero target has generated a range of new and proposed legislation on energy use and adoption of low carbon technologies across industries. There is also an opportunity for new approaches to building design and operation to flourish, and to encourage building owners to adopt low carbon building services technologies.

Mapping the way to net zero

Government has published a number of reports detailing its route to achieving emissions reductions. The Climate Change Act was introduced in 2008, setting the original target of an 80% emissions reduction against 1990 figures by 2050. The Act provides a framework for government reporting on its progress towards the goal. And it also established the Climate Change Committee as advisor to government on methodologies such as carbon budgeting.

The *2017 Clean Growth Strategy* was developed as one of the government obligations arising from the Climate Change Act (to prepare proposals and policies for meeting carbon budgets). It focused on moving towards cleaner economic growth, with an emphasis on the low carbon economy as a source of opportunity and jobs. It stated: "The low carbon economy could grow 11% per year between 2015 and 2030."

The 2017 Strategy highlighted the built environment as a significant source of emissions, with **heating in buildings and industry creating around 32% of total UK emissions**. As a result, the Strategy focuses on the energy efficiency of homes through Energy Performance Certificates (EPCs) and other tactics such as requiring higher efficiencies for domestic gas boilers.

In November 2020, government published its *Ten Point Plan for a Green Industrial Revolution*. It builds on the earlier Clean Growth Strategy. The Plan is to increase energy efficiency across the economy and grow offshore wind and nuclear energy generation. Use of natural carbon sinks in the form of reforestation and exploring options for man-made carbon capture technologies are also on the agenda.

The Ten Point Plan points to growth in areas such as low carbon transport, zero emission vehicles and green finance. Its proposals for buildings include higher efficiency standards for homes and driving heat pump installations for heating and hot water to 600,000 per year by 2028.

Mapping the way to net zero

Shortly after the Plan was launched, the Climate Change Committee published its *Sixth Carbon Budget* in December 2020, as required under the Climate Change Act. This pushes even harder on the carbon target, recommending an interim target of a 78% cut in UK emissions against 1990 levels by 2035 – and a 63% reduction from 2019 levels.

Part of the CCC's sweeping vision is that high carbon options for heating in buildings are phased out, replaced by electric alternatives. And that UK electricity production is zero carbon by 2035, with offshore wind growing from the projected 40GW by 2030 to 100GW or more by 2050.

There is no doubt that this is an ambitious proposal that would bring significant changes to how buildings (domestic and commercial) are designed and operated. The CCC identifies four pathways which it says aim to: "reduce emissions in buildings to zero by 2050 at the latest." Its pathways are:

- **Upgrade all buildings (domestic and commercial) to EPC level C over the next 10 to 15 years**
- **Scale up the market for heat pumps as a critical technology for decarbonising space heating while maintaining quality** (this is accompanied by a phase-out of gas boilers in all buildings)
- **Expand the use of heat networks in areas such as cities using 'anchor' loads such as schools and hospitals. Fossil fuel combined heat and power (CHP) is to be phased out and replaced with low-carbon or waste heat CHP systems from the mid-2020**
- **Prepare for a "potential role' for hydrogen heat**

Future developments

To support the journey to net zero carbon over the next few years, a number of changes to legislation are on the horizon. For example, Part L of the Building Regulations (*Conservation of fuel and power*) for dwellings and non-dwellings will be updated.

Anticipated updates to the Building Regulations include fuel weightings that reflect the UK's move to renewables for generating electricity. This means that electric heating and hot water systems will be given greater priority when calculating potential carbon emissions from buildings. A new SAP10.1 (Standard Assessment Procedure) is already available that includes these new weightings. It is understood that Part L relating to dwellings will be updated first, followed by regulations on non-dwellings.

In related legislation, government will also be advancing the Minimum Energy Efficiency Standards (MEES). Since April 2018, property in the non-domestic private rented sector (PRS) must achieve an EPC rating of E before landlords can grant a new lease or renew an existing tenancy. From 1st April 2023, this standard will also apply to continuation of an existing lease.

Currently, government is exploring options for setting higher EPC requirements. Level B is the 'preferred trajectory'. This would require all non-domestic privately rented buildings to achieve an EPC of B by 1st April 2030 (if the measures required are 'cost effective'). The alternative route is to set the target at C by 1st April 2030.

Low carbon heating, such as heat pumps, is regarded as an important element of achieving these higher energy performance standards in non-dwellings. The consultation on MEES has now closed.

There is also an increasing interest in improving the embodied carbon of buildings. The CCC raised this issue in the recent Sixth Carbon Budget, proposing the introduction of **"mandatory disclosure of whole life carbon in buildings and infrastructure to facilitate benchmarking as soon as possible."**

In January 2021, CIBSE (the Chartered Institute of Building Services Engineers) introduced *Technical Memorandum TM65: Embodied carbon of building services equipment - calculation methodology and guidance*.

Environmental Product Declarations (EPDs) can be used to show the embodied carbon of a product. If an EPD is not available, manufacturers can supply information for a mid-level product embodied carbon calculation as set out in TM65. The Technical Memorandum includes a form for manufacturers to complete.

TM65 advice on achieving low embodied carbon in building services includes specifying equipment with long lifetimes and products that can be demounted and re-used. Low GWP refrigerant use and low leakage rates are also important. This would affect choice of technology such as heat pumps which include refrigerant.

Mapping the way to net zero

The non-domestic Renewable Heat Incentive (RHI) was set to close in March 2021, but has recently been extended to March 2022 for projects in the pipeline, after which date it is due to close[1]. However, government is already exploring options for a replacement programme such as the Clean Heat Scheme. The proposal is that it may offer initial capital payments to overcome barriers to purchase.

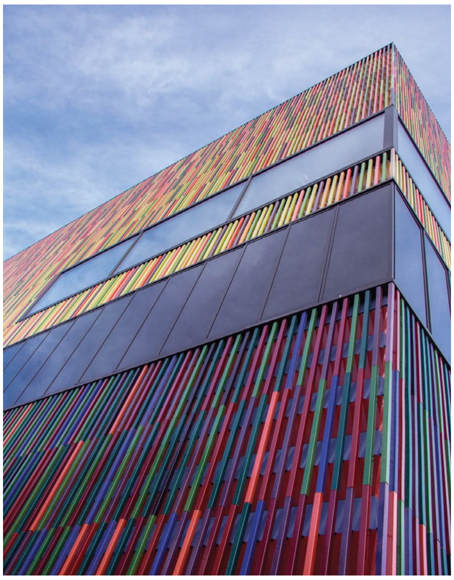
Government is also consulting on the Future Buildings Standard (which closes in April 2021). This will inform the development of the next iteration of Part L of the Building Regulations relating to non-dwellings (new and existing).

Although the Standard is not yet finalised, it is clear from the consultation that government is focused on lifting energy efficiency requirements for new non-domestic buildings. The aim will be to deliver a 27% improvement on new non-dwellings compared to current Part L standards.

Low carbon heating systems will be central to achieving this goal, and the consultation document states:
"We anticipate that the installation of heat pumps will play an increasing role in delivering low carbon heat for buildings built to the Future Buildings Standard. Heat pumps come with the same low-carbon benefits as direct electric heating, but deliver heat much more efficiently, as they capture renewable heat from the atmosphere."[2]

The Future Buildings Standard proposal also suggests that wet space heating systems should be designed to operate with a flow rate of 55ºC or lower in the final heating circuit (in order to be prepared for use of heat pumps). This is in addition to the use of suitable emitters. The aim is that tenants of non-dwellings will not face disruption when low carbon heat is installed in the future.

For building services professionals, the message from government is clear: specifying and installing the heating and hot water systems of yesterday will not suit the buildings and policies of tomorrow.



The green grid

As government and CCC reports highlight, a crucial development for the UK's net carbon policy is the decarbonisation of its electricity grid. Natural gas remains a significant fuel for UK electricity generation. However, the UK's reliance on coal for electricity production has fallen dramatically over the past decade, while our use of renewables is growing.

Renewable energy sources accounted for 40.2% of total electricity generation in 2020, at 29.4 TWh (terawatt hours). The main source was offshore wind, an increased boosted by added new capacity. The Ten Point Plan includes growth of offshore wind from 24GW in 2020 to 40GW by 2030, including 1GW of floating offshore wind.

The closure of coal power stations has accompanied this growing renewable electricity generation, shifting the UK's energy mix. The government's Energy Trends report from December 2020 shows that electricity generation in the whole of the UK from coal was down 30% on the same period in 2019. Government will phase out the UK's remaining four coal plants by October 2024.

Electricity generated by fuel type (TWh – terawatt hours)

	1990	2000	2010	2018	2019	% in 2019
Coal	229.8	120.0	107.6	16.8	6.9	2.12%
Oil	20.7	13.6	10.5	9.5	9.2	2.83%
Gas	0.4	148.1	175.7	131.5	131.9	40.62%
Nuclear	63.2	85.1	62.1	65.1	56.2	17.3%
Hydro	5.6	5.1	3.6	5.5	5.9	1.82%
Wind & Solar	-	0.9	10.3	69.8	77.3	23.3%
Other renewables	-	4.3	12.3	34.8	37.3	11.48%
Total electricity generated	**319.7**	**377.1**	**382.1**	**332.9**	**324.8**	**100%**

Source: Energy in Brief, December 2020, BEIS

In December 2020, government published its Energy White Paper titled: *Powering our Net Zero Future*.
It reiterates the commitment to reduce our reliance on fossil fuels:

"Our success will rest on a decisive shift away from fossil fuels to using clean energy for heat and industrial processes, as much as for electricity generation."

Heating and hot water - the end of natural gas

CCC figures show that heating and hot water production in buildings are the largest contributors to emissions from the built environment. The CCC's Sixth Carbon Budget points out that in 2019 direct building emissions (caused by heating and hot water production) were 87 $MTCO_2e$ (metric tonnes of carbon dioxide equivalent).

The UK has achieved higher levels of building energy efficiency over the past decade however, the CCC points out that: **"Progress in delivering emissions reductions (in the built environment) has broadly flattened since 2015."** Heating and hot water production are therefore crucial targets for future emissions reductions. We must decarbonise our heat.

The CCC's Sixth Carbon Budget sets out a net zero pathway for buildings that very much relies on new approaches to heating. While energy efficiency measures can contribute around 34% of emissions reductions, says the CCC, "low carbon heating dominates the picture from 2028".

Government has already stated that installation of gas heating in new homes from 2025 is no longer permitted, and this is included in the Future Homes Standard.

The Sixth Carbon Budget also recommends a gas heating phase out in commercial buildings by 2033. It also states that public buildings should move faster, with a deadline of 2030: **"The faster pace in public buildings allows the government to meet its targeted 50% reduction in emissions by 2032."**

The CCC's vision for building heat and hot water is that: "Buildings shift on to low-carbon heat networks, high efficiency and flexible electrification along with some hydrogen near industrial clusters."

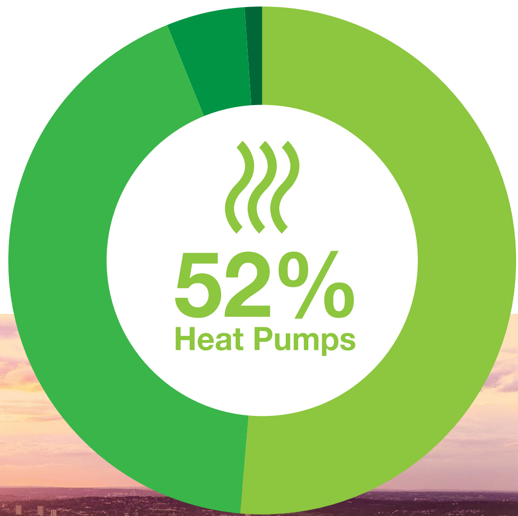
Government is exploring hydrogen as an option. However, as the BEIS research from 2019 mentions: “Replacing natural gas with hydrogen in an everyday setting - piping hydrogen to homes and businesses through the existing gas network - is a new and untested position.” It has not been attempted in other countries, so there are no examples to follow.

The government has a target of 5GW of low carbon hydrogen production capacity by 2030, and it plans to trial hydrogen for heating in neighbourhoods and towns by the same date. The Ten Point Plan emphasises that the success of the hydrogen approach is only possible when accompanied by the growth of carbon capture and storage infrastructure. Hydrogen’s application at scale for heating and hot water is therefore unlikely to happen quickly.

No single technology can be the solution for replacing our current reliance on natural gas. However, time is pressing and finding solutions that can make a difference in the next decade is crucial. The CCC’s goal is that by 2030, 37% of public and commercial heat demand is met by low carbon sources. Of this 65% of heat demand is met by heat pumps; 32% by district heating and 3% by biomass.

And by 2050 the CCC believes that all UK heat demand is met by low carbon sources:

- **52%** Heat pumps
- **42%** District heating
- **5%** Hydrogen boilers
- **1%** New direct electric heating



Heat pumps - the decarbonised future

Heat pumps are therefore central to the decarbonised future. As noted above, government has set a target of 600,000 heat pump installations per year by 2030. The CCC estimated that 19 million heat pumps will need to be installed by 2050 to achieve the net zero goal - a massive increase from current installation numbers (in 2018 heat pump sales were around 27,000 units according to the UK's Heat Pump Association (HPA)).

One of the reasons for government's strong support of heat pump technology is its energy efficiency. Generally speaking, for every 1kW of electrical energy used, a heat pump can produce 3kW of heat energy. While the UK's electricity is becoming 'cleaner' every year, government regards efficient use of this supply as crucial for long-term success. Without efficient technologies, it will be difficult to meet electrical demand from renewables and low-carbon sources alone.

Ecodan CAHV Monobloc Air Source Heat Pump

Application of heat pumps in buildings combined with the greening of the UK's electricity grid will make a significant reduction in the country's carbon emissions. As the HPA identifies in its report (*Delivering Net Zero: A Roadmap for the Role of Heat Pumps, published in 2019*): **"Running on electricity is an extremely efficient process, heat pumps make the most of the widespread growth in renewable electricity generation over the past decade to provide a cleaner power source for heating."**

In fact, the carbon reductions from use of heat pumps in buildings will increase over time as the grid moves further away from fossil-fuel generated electricity. The benefits of this shift are therefore both immediate (i.e. the short-term switch from gas) and long-term (as the CO_2 emissions from electricity generation fall even further).

While there is never a single solution for a challenge on the scale of national carbon emissions reduction, heat pumps are well-known, tested and scalable. There can be little doubt that, as a ready-to-go technology, they offer a genuine alternative to current space heating and hot water approaches.

As the CCC indicates, meeting the 2050 net zero target through the built environment means: **"Minimising costs and disruption (which) means working as much as possible with existing technology lifetimes - particularly the heating technology stock."**

Applying heat pumps for commercial heating & hot water

Specifiers looking for an alternative will find that heat pump technology has evolved over the past five years. This allows them to be applied more widely for commercial heating and hot water systems, but it is important to select the right heat pump for the project.

There are also a few general points to bear in mind when applying heat pump technology. For example, when considering the application of heat pumps in a project, it is important to be aware of energy efficiency metrics. The Seasonal Coefficient of Performance (SCOP) is the overall performance of a heat pump using electricity across the heating season. It is calculated by taking the reference annual heating demand and dividing that by annual energy consumption for heating (details on the calculation are included in BS EN 14825).

Designers should also examine the specific application they are working on in order to calculate a specific SCOP for that project. This will help to properly assess the carbon reduction and operational cost savings moving forward.[3]

Heat pumps also have a lower ΔT than traditional gas-fired heating and hot water systems. However, this is not an issue for the system performance, as it can be mitigated by application of low-loss headers and three-way valves. This will maintain the correct flow of water through the heat pump and ensures that delivery of heat to emitters remains steady.

The right heat pump for the job

The range of heat pumps on the market is now much wider than it ever has been. This means it is possible to select exactly the right equipment for the client’s requirements.

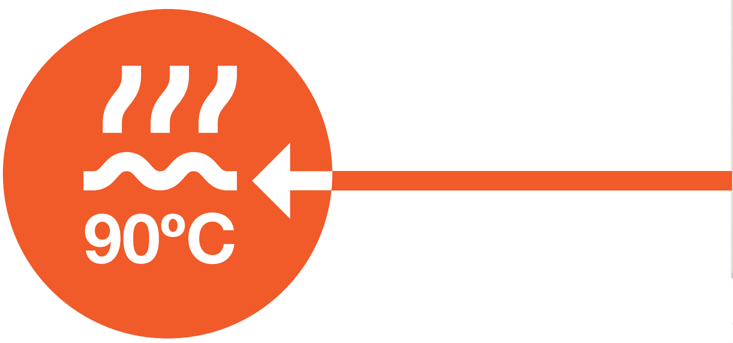
In the past, heat pumps were regarded as highly effective for supplying low temperature space heating. But recently, high temperature heat pumps have entered the market, offering hot water supply up to 90ºC. This means that heat pumps can now be applied in projects with requirements for high demand of sanitary hot water with high peak demands (such as hotels, hospitals and leisure centres). As a result, there is no need to use a gas boiler in the system.

There are a number of areas to consider when applying heat pumps for commercial hot water. Volume and temperature requirements are key to correct sizing of the system. It’s also crucial to understand if the hot water usage profile will be steady across the day, or experience peaks.

For example, Mitsubishi Electric recommends that, with its high temperature Ecodan QAHV heat pump, the sanitary hot water load should be achieved at the lowest required design ambient temperature where the heat pump is located. This is so that the system can be sized to achieve the target hot water temperature efficiently - and in a suitable timeframe.

Other heat pumps offer options for a modular approach, so that a number of heat pumps can operate as a multiple system. One benefit of this approach is that the multiple unit system can cascade available units on and off to meet the head load from a building.

For example, the Mitsubishi Electric Ecodan CAHV Monobloc Heat Pump can work as a 16 unit system, allowing for 0.5kW increments of capacity, from 18kW to 688kW, providing a significant level of modulation. It provides water flow temperatures from 25ºC to 70ºC.



Ecodan QAHV Monobloc Air Source Heat Pump

Heat pumps with other technologies

Modern heat pumps can be applied in buildings alongside other technologies to boost the renewable element of a project - and to reduce the requirement for heat energy.

For example, used with on-site photovoltaics (PVs), less electrical energy from the grid is required to serve the building and the electrified heating system. This dual renewable approach can also lower the size of PV array needed to meet building regulations, reducing capital costs.

Another example of heat pumps being successfully combined with other technology that is attracting more attention is the 5th generation low temperature ambient loop. Heat is generated via a central source using low carbon technology such as heat pumps, and environmental sources such as air, water or ground source - but at lower temperatures than a traditional boiler (around 10ºC to 30ºC flow, rather than 60ºC to 90ºC flow).

Water source heat pumps, such as the Mitsubishi Electric Ecodan Hydrodan, are then placed around the building to boost the temperature to useable levels at the point of demand. The benefit is that the lower temperature water generation requires less energy to produce, reduces overheating in corridors and greatly improves transmission losses.

Heat recovery and heat pumps

It's likely that the move to efficient electric heating will impact other building services systems. As the commercial gas boiler market shrinks, specifiers will need to consider other options for their projects.

As space heating is likely to be dominated by heat pump technology, it is not unreasonable to expect that the cooling-only chiller market, and the VRF markets (where the same parent heat pump technology is being deployed) will transition towards heating and cooling. This means that we might expect to see a transition to reversible heat pump chillers, with heat recovery capabilities in the system.

By re-using heat that has been generated in the building (for example, when rejected by the cooling system) it is possible to save significant amounts of energy, reducing long-term operational costs.

Heat recovery offers a number of benefits for today's built environment. For example, inner city projects may require HVAC equipment with a small footprint, which may close off the option of a large capacity heat pump. However, heat recovery systems can be included within the HVAC plant, with little to no impact on space requirements.

Heat recovery systems that make use of heat pump technology can be particularly useful for mixed-use developments or large offices, where heat profiles are diverse. Heat can be captured from the cooling process and used to reduce heating requirements in other areas of the building (or to pre-heat domestic hot water).

You can find more information on heat pump chillers and the different methods of heat recovery, in the **Mitsubishi Electric CPD Guide to Heat Recovery Chillers.**[4]

Conclusions

As the UK moves down the path to a net-zero carbon future, building services professionals can lead the way by encouraging clients to take a new approach to heating and hot water in commercial buildings.

The heating equipment we install today will be in a building for at least a decade. Against the backdrop of the government's green revolution, this is a significant point for specifiers to bear in mind.

Installing a heating system based on fossil fuels might leave the building as a 'stranded asset' in the future. Not only will the operational cost of a fossil-fuel based system increase, but the building owner may find they are forced to switch heating systems again as carbon targets tighten.

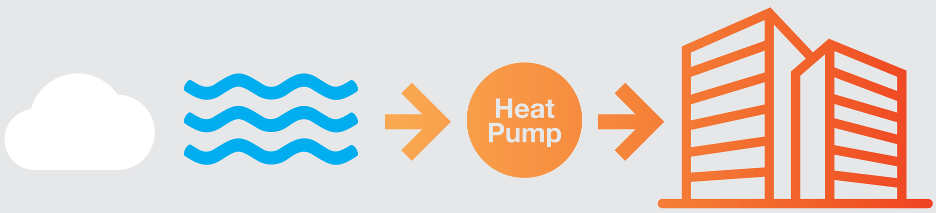
It is very likely that specifiers will find themselves looking for new options for heating and hot water provision. This may not always be a direct heat-pump-for-gas-boiler-swap (though this is now possible). Instead, specifiers may apply heat pump chiller solutions that also provide heating, for example. These are already available on the market.

For engineers and installers, the message is that they need to stay aware of the latest heating and hot water technology systems in order to offer the best solutions that stand the test of time for clients.

Heat pumps and how they work

A heat pump is a device that moves heat energy from a lower temperature environment (e.g. the outdoor air; the ground; or a nearby water source) to a higher temperature environment (inside a building) to provide space heating and sanitary hot water. It does this by circulating refrigerant around a compression / expansion cycle. This heat can then be transferred around a building via water (e.g. through radiators or underfloor heating) or air (via fan coils).

The most significant benefit of heat pump technology is its highly efficient use of electricity. **For every 1kW of electricity used by the system, it produces 3 to 4kW of heat energy** (depending on factors such as outdoor temperature and system type).



Conclusions

The UK's greenhouse gas emissions

Six greenhouse gases are named in The Climate Change Act:

- **Carbon dioxide**
- **Hydrofluorocarbons**
- **Methane**
- **Nitrous oxide**
- **Perfluorocarbons**
- **Sulphur hexachloride**

Carbon dioxide is the most significant of these gases, in terms of volume present in the atmosphere and its impact on the global environment which we see in the form of climate change. Carbon is largely produced by the burning of fossil fuels (coal, gas, oil).

The CCC refers to 'direct' and 'indirect' carbon dioxide emissions from buildings. Direct emissions arise from the use of fossil fuels to produce heat and hot water. Indirect emissions are caused by use of fossil-fuel generated electricity for lighting, cooling, IT and appliances.

Why net zero?

The UK's greenhouse gas emission target is net zero – not gross zero. A gross target would require a total eradication of all GHG emissions, which is impossible. As the Institute for Government (IfG) states:

"A net zero target recognises that there will still be some emissions but that these need to be fully offset."

Offsetting carbon is one of the main thrusts of government policy. Research is underway to investigate both natural carbon sinks (e.g. forests and seas) as well as man-made carbon sinks to boost the removal of carbon. But reducing the UK's emissions is still key to achieving net zero. As the IfG points out:

"When the amount of carbon emissions produced are cancelled out by the amount removed, the UK will be a net-zero emitter. The lower the emissions, the easier this becomes."

Useful links

The Ten Point Plan for a Green Industrial Revolution
www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

Climate Change Committee: Sixth Carbon Budget
www.theccc.org.uk/publication/sixth-carbon-budget/

Part L of the Building Regulations
www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l

Minimum Energy Efficiency Standards (MEES) for Non-domestic private rented properties consultation:
https://beisgovuk.citizenspace.com/heat/non-domestic-private-rented-sector-minimum-energy/

Energy White Paper: Powering our Net Zero Future
www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

Clean Growth Strategy (2017)
www.gov.uk/government/publications/clean-growth-strategy/clean-growth-strategy -executive-summary

Heat Pump Association: Delivering Net Zero: A roadmap for the role of heat pumps
www.heatpumps.org.uk/resources/

Institute for Government (on the net zero target):
www.instituteforgovernment.org.uk/explainers/net-zero-target#:~:text=What%20is%20the%20legal%20status,%E2%80%9Cat%20least%20100%25%E2%80%9D

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1. www.gov.uk/government/publications/changes-to-the-renewable-heat-incentive-rhi-schemes/changes-to-rhi-support-and-covid-19-response#:~:text=On%2011%20March%202020%2C%20the,the%20Non%2DDomestic%20Renewable%20Heat

2. The Future Buildings Standard – Consultation on changes to Part L
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/956037/Future_Buildings_Standard_consultation_document.pdf

3. **www.cibsejournal.com/cpd/modules/2018-10-wat/**

4. Mitsubishi Electric Guide to Heat Recovery Chillers
https://library.mitsubishielectric.co.uk/pdf/book/67_HEAT_RECOVERY_CHILLERS#page-1

To receive a CPD seminar on 'Commercial Renewable Heating', you can call your Mitsubishi Electric Regional Sales Office to arrange an in-house presentation of this information.

If you would like to receive invitations to future CPD events, please email **livingenvironmentalsystems@meuk.mee.com**

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Note: The fuse rating is for guidance only. Please refer to the relevant databook for detailed specification. It is the responsibility of a qualified electrician/electrical engineer to select the correct cable size and fuse rating based on current regulation and site specific conditions. Mitsubishi Electric's air conditioning equipment and heat pump systems contain a fluorinated greenhouse gas, R410A (GWP:2088), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R1234ze (GWP:7) or R1234yf (GWP:4). *These GWP values are based on Regulation (EU) No 517/2014 from IPCC 4th edition. In case of Regulation (EU) No.626/2011 from IPCC 3rd edition, these are as follows. R410A (GWP:1975), R32 (GWP:550), R407C (GWP:1650) or R134a (GWP:1300).

Effective as of April 2021

Green Gateway greengateway.mitsubishielectric.co.uk