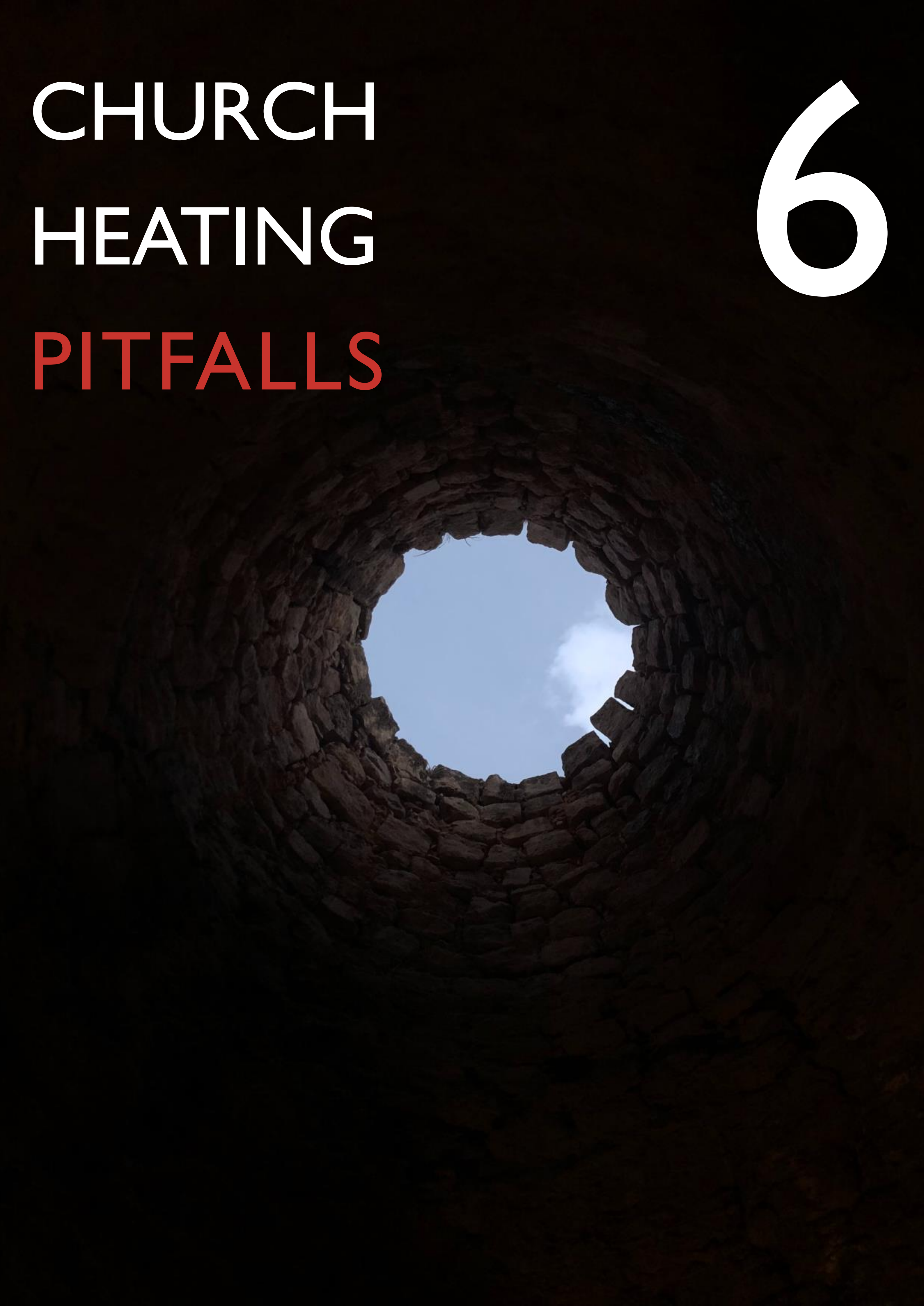
CHURCH HEATING PITFALLS

6



CHURCH HEATING

This guidance is issued by the Cathedrals Fabric Commission for England pursuant to its powers under section 3(3)(a) of the Care of Cathedrals Measure 2011, and/or by the Church Buildings Council pursuant to its powers under section 55(1)(d) of the Dioceses, Mission and Pastoral Measure 2007. As it is statutory guidance, it must be considered with great care. The standards of good practice set out in the guidance should not be departed from unless the departure is justified by reasons that are spelled out clearly, logically and convincingly.

All images Archbishops' Council unless otherwise stated.

Cover: Sergio Santana; pp. 4-6,16: Paul Hamley; pp.14-15: Tobit Curteis; pp18-19: Matt Fulford; pp. 20-21, 23: Andrew More

Issued by the Cathedral and Church Buildings Division, August 2021.

PITFALLS

6a Common pitfalls

This section of our guidance helps you learn from decisions that have caused others to make costly mistakes.

Hopefully, it will help you chart a smooth path, avoiding these pitfalls.

Heating systems are a major investment for any church, and so making the correct decisions, about when to make changes and what changes to make, are important to get right first time. The right solution for one church can be totally wrong for another. Once you have a system installed, it can also go awry if run improperly.

So, what are these common pitfalls, and how can you avoid them?

Asking yourself the wrong question right at the very beginning

It can be very natural to fall into the pitfall of starting with the question, "how will we make the whole church warm?"

This seems natural, because domestically we ask "how can we make our house warm?" At home, we heat up all the air in a room, using radiators or underfloor heating. This 'space heating' approach works well with rooms of a domestic scale, with modest ceiling heights.

A church is a completely different prospect: trying to heat all the air in the space of a church or cathedral is inefficient and (often) unsuccessful. Instead, we need to start with a focus on making the people who use the church comfortable, whilst preserving the historic interiors and fabric of which we are custodians.

***Solution**: Instead of asking "how will we make the whole church warm?" ask yourself "how can we make church users comfortable, whilst preserving our historic interiors?" This different starting point may lead to a very different end point.*

Focussing only on heating, and forgetting about heat loss, draughts, and damp

It is an easy mistake to make to plunge straight into a heating project thinking only about boilers and radiators, and ignoring heat loss.

At home, your boiler and radiators are probably perfectly capable of keeping the rooms warm in winter as long as the windows are closed. Open the windows, and the heat loss becomes much higher, and will outstrip the heat input to the room from the radiators. It is exactly the same in your church. When heat input is greater than heat loss, the room gets gradually warmer. When heat loss is greater than heat input, the room gets gradually colder.

There is heat loss through the surfaces of the roof, exterior walls, windows, and floor, and it is caused by any problematic draughts, for example gaps around windows and doors, and through gaps in the roof.

If we can take actions that reduce this heat loss, we will need less heat input from radiators or other emitters to warm the room, which will use less fuel and save money. But! Many of our historic buildings are designed to 'breathe', so need ventilation, and many of our buildings suffer from damp, so need good air circulation. You may need advice on what can be done.

High humidity and damp buildings also undermine comfort and so sources of unnecessary moisture should be addressed at the outset. The best place to start your heating project may well be to repair the roof and clear the gutters!

***Solution**: Before commencing any heating project, ask yourself first, "how can we reduce heat loss and dampness from the building?" Re-read your latest QI report, and find out what it recommends. Carry out recommended basic maintenance to make the building wind and water tight. Review the 'Practical Path to Net Zero Carbon' guidance and see what changes you could make. Consider commissioning an energy audit (see the Parish Buying website or ask your DAC). If you have historic fabric or interiors, get expert advice about what you can do to reduce heat loss whilst preserving these elements.*

Below: **Thermal image showing heat loss from cold air coming under a church door.**

Leaping straight to systems changes, before considering simple changes like cushions and rugs

It is easy to think "people are cold, we need to sort our heating system," without first considering the body heat which is being lost into the surfaces our church-users are in contact with. People generally arrive in the building warm, but lose their body heat to the surroundings.

We all know how cold a pew can feel in a church which has not been heated for a week, or how cold our feet can get resting on a wooden or stone floor during a long service.

Using pew covers or cushions can increase comfort significantly as well as reduce heat loss. The use of floor matting or sections of carpet (porous and not plastic backed) can also reduce heat loss through the feet.

(Note: Pew covers or cushions will need to made out of certified fire-proof materials as will carpets, mats, kneelers etc.)

Solution*: Look at how to reduce heat loss from the body by simple and low-cost local measures such as pew cushions and (porous, not plastic-backed) matting, rugs and runners.*

Failing to look ahead, or looking ahead with rose-tinted glasses

There are two potential pitfalls which often afflict heating projects; not thinking ahead about the future use of the building (assuming "the future looks like the present") or being overly optimistic about the future use of the building (assuming "if it's warm, they will come").

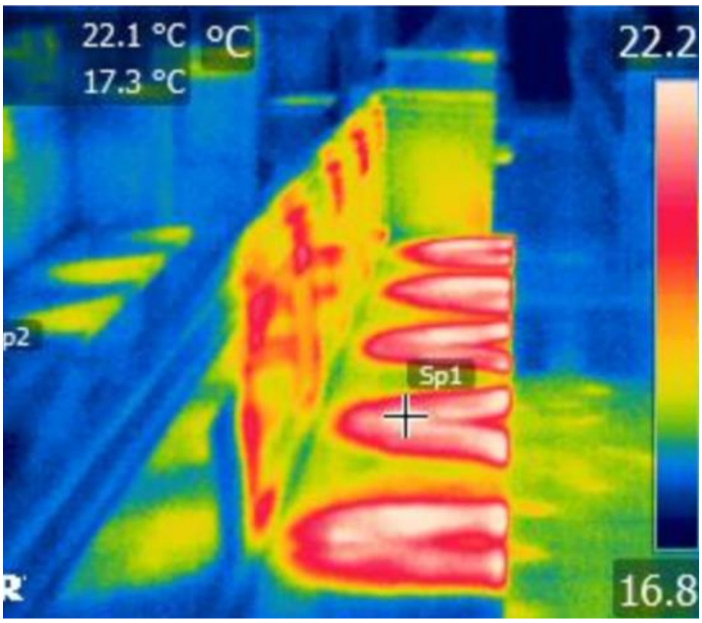
The former can lead to an under- or over-sized system, and to radiators being installed in places where they won't be needed.

The latter can lead to an over-specified and expensive system, such as installing underfloor heating and a heat pump in a church used only twice per week.

Solution: *Consult widely with current church users and, where you can, potential future church users. Ask them to think forward a few years, and describe how they see the church being used. Ask them how much of a difference the heating could make.*

Ask yourself hard questions: if your village already has a popular community centre, or another church in the benefice with better facilities, think hard about the realistic future usage of the church. Test your assumptions.

Below: **Thermal image showing how body heat is lost into a pew with no cushion.**



Thinking about the temperature of the air, not the comfort of the people

It is very easy to fall into the trap of thinking only about the number on the thermostat, rather than the comfort of people using the church.

Church spaces are large, with complicated air flows, so often the temperature will vary significantly from place to place in the church. One number on a thermostat simply does not cover this complexity. In the same building, at the same moment, the person sitting close to a thick stone wall or in the down-draught from a large window may be uncomfortable, whilst the person sitting in the back pew in the nave next to one of the only radiators may feel comfortable. Wearing a coat or not will make a real difference, as will sitting on a pew cushion and having your feet on a floor covering.

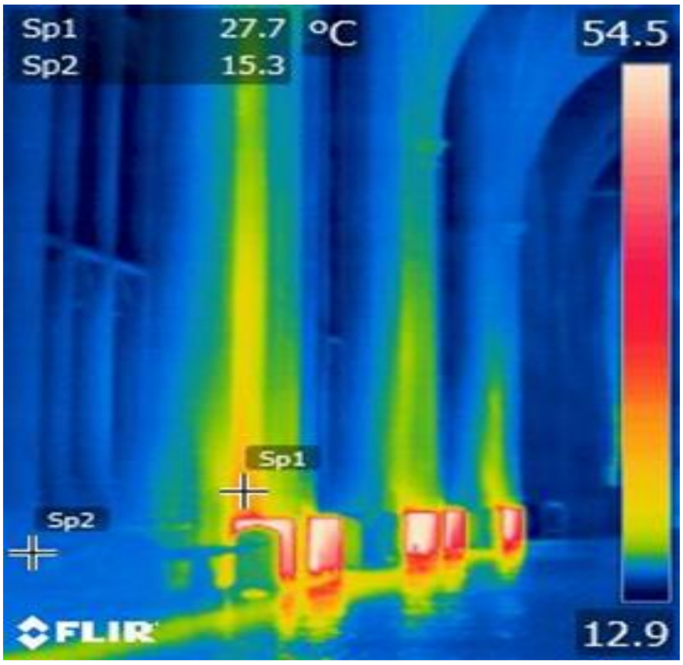
Traditional convective radiators make buoyant air rise, so the whole building fills from the top down to provide heat for people on the ground. Pew heaters will keep people warm where they sit, but perhaps not affect a thermostat on the wall at the back. Modern far infra-red radiant heaters will warm the surfaces but not the air, and so the thermostat will not move, but people will feel comfortable. (The nature of the heat will not be what they are used to, however, since the heat is localised and the air remains cool, like standing in the glow of a fire with your face warm and your back still cool).

For all these reasons, you need to talk to people about their comfort, rather than just look at a single number on a thermostat.

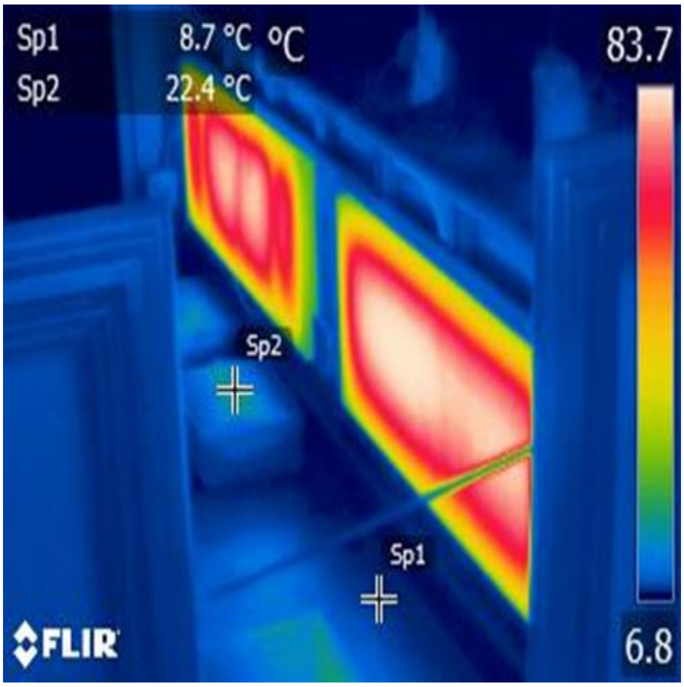
***Solution**: Consult with church users about comfort not about temperature. Do they feel comfortable when they are in the building? What makes the difference from person to person, and from place to place? Identify spots where people are uncomfortable, understand what is causing this, and think through what could be done.*

Consider carefully whether you need to space-heat your whole building (something which might be appropriate if the building is used by large numbers of people every day and the conditions can be kept constant) or want local heating close to the people (generally more appropriate for occasionally-used buildings with smaller congregations)?

Below: **With convective heating, such as from conventional radiators, the majority of the heat produced goes towards warming the air, which then rises towards the ceiling. Not until all the air is warmed from ceiling down to pew height do people benefit significantly.**



Below: **With radiative heating, such as from infra-red radiant panel heaters (or from the sun, or from the glowing coals of a fire), surfaces, not air, are warmed by the radiation, targeting the heat to where it is needed.**



Thinking only about temperature and forgetting humidity

It can be easy to think only about temperature: we set our thermostats and check the number when we feel cold. However, humidity affects comfort and energy use, because sitting in a cold damp church is less pleasant than a cold dry church, and damp air takes more energy to warm.

Cycles in humidity from low to high can be damaging to our church interiors. The higher the relative humidity in the church, the more likely it is that moisture will condense on cool surfaces when the heating is turned off and the building cools down. Cycles of warming and cooling, with their associated episodes of condensation, can cause damage to sensitive materials from water (and even mould), cracking (from rapid drying), or salt activity (from cycles of both). Cycles of evaporation and condensation can damage historic masonry and glass.

High levels of humidity are often caused by liquid water sources such as damage to the walls and roofs allowing local water ingress or defects in the rainwater disposal system and underground drainage. This will always result in a building, even one with lots of heating, feeling uncomfortable.

Solution*: You can understand how temperature and humidity varies in your building by using low-cost data loggers and analysing the findings.*

If you can see visible condensation or mould on historic fabric, then speak to your QI architect or your DAC.

If commissioning a new heating system, speak to the person designing the system about effects on humidity and how this will be maintained within parameters which are safe for the conservation of the building fabric and the sensitive artefacts. If you have particularly sensitive fabric and furnishings you may need to take specialist advice on this. Using data loggers to monitor the space is worth considering.

Ensure that unnecessary sources of moisture, such as damage to the building or defective rainwater disposal systems, are addressed at the outset.

Below: **Moisture is penetrating here from the broken downpipe. It should be repaired urgently, to allow the wall to dry out. Dealing with repairs like these will reduce humidity inside the church, making it easier to heat, more comfortable for church users and reducing the risk of damage to fabric from mould growth or cracking.**

Below: **Water from damaged rainwater goods is pooling at the base of the wall and penetrating the church wall and foundations. Rainwater goods and drainage should be repaired, plants should be cut back and the wall appropriately re-rendered.**

Assuming a major overhaul is needed, before exploring all avenues to fix what you have

If your heating has broken or is failing to meet your needs, it can be easy to leap straight to thinking you need a new system. However, it can be much cheaper and easier to fix what you have.

Environmentally, making what you have keep working may well be the best solution too, since there is an 'embodied carbon' in manufacturing the materials a new system requires, and transporting them to site.

It may be that a particular component needs to be serviced or changed but that the majority can be retained.

A short term repair may give you the breathing space to make plans, although be sure that the repair is safe; if you have a gas boiler, ensure that any installer is Gas Safe registered and, if you have an oil boiler, they need an OFTEC certification.

***Solution**: Before commencing a heating replacement project, explore all options to get your current system working well. Later, there are a number of specific suggestions for different components of the system. Even if this only wins you another year, that will still give you time to do a full options appraisal of what to do next.*

Thinking about the parts, not the whole

A trap to avoid is considering the individual parts of a heating system (i.e. the boiler / the radiators / the pipework) without considering the whole system. Your boiler can be amazing, and have the right capacity for your needs, but if the radiators are in poor condition / too small / in the wrong place you'll still be cold. Similarly, if the pump is failing then the boiler and radiators will not be able to produce sufficient heat.

***Solution**: stand back and review the whole system (the heating checklist in section 5 of our heating guidance can help you with this). A heating advisor can estimate the heat loss from the building, the heat capacity of the boiler, and the heat emitted by your radiators, and help you work out which one to tackle first.*

Getting the wrong advice

Think of a heating project as having five parts: research (done by the church), design (by a professional), installation (contractor), operation (church) and maintenance (contractor). They can sometimes be undertaken by the same person but usually are not.

Even the best general heating engineer or installer may have little idea, if any, about the effect of heating on the conservation of your building and furnishings. So, total reliance on the engineer who services your boiler, or on a local plumber, to advise on your church's heating is likely to severely limit the options which are considered.

To get broader advice on pew heaters, panel heaters and heat pumps requires speaking to a heating advisor and/or building services engineer. Many DACs have a heating advisor who may be able to offer a certain amount of free advice, or you can commission someone. If you are commissioning, then look for someone with church experience and ask for recommendations from other parishes, from the DAC, or the CIBSE Directory.

For churches with historic fabric and interiors, specialist advice is needed before any significant changes are made to the heating system, or before attempting to reduce heat loss through altering the fabric. You need to ensure damage is not inadvertently done that will be expensive to remedy.

It can also be easy to be swayed by visiting another church where a particular heating solution is working well, without thinking through whether that solution is right in your own circumstances.

***Solution**: Always have your architect or DAC Heating Adviser on board to ensure that the PCC becomes an informed customer. If this is not possible, or does not go far enough, you may also wish to commission a building services engineer.*

If you have historic fabric or interiors, contact your DAC to see if they have an appropriate member or advisor who can advise on the particular needs for your historic interiors, such as stained glass, wall paintings, or timberwork, for example. If they don't, you can consult the national Church Buildings Council for further specialist advice.

Wherever possible, choose site visits to churches with similar characteristics to your own in terms of usage, age and size. Your DAC can help you identify these churches. You can also find examples on the online renewables map.

Rushing your decisions

A common pitfall is waiting until your current boiler breaks before thinking about what to replace it with.

This time pressure, combined with the fact that like-for-like replacements don't require full faculty, will often lead to a knee-jerk like-for-like replacement of a gas or oil boiler with a new gas or oil boiler, without thinking through the options.

Solution*: As soon as your QI or another inspection report indicates your boiler has fewer than five years of life left, form a team to manage the replacement project and start considering your options.*

Installing a new system but not trusting it, so keeping the old system as well

Some churches will install a new heating system, perhaps pew heaters or panel heaters, but not be convinced it will work, and so retain their old heating system. This can lead to them running both systems, wasting energy and money, and 'cluttering up' the church with multiple emitters.

Solution: *Take time to carry out your research and planning, and then have confidence in the new system.*

To build confidence when going from a conventional boiler and radiator system to perhaps electric pew heaters, could a trial be possible in a small area? Then you can experience the quality of the heating. Turn off the radiators in this area and temporarily install a sample of the new heaters.

Take time to visit another church that has the system you are considering and talk to the users, so you can see how it works to give you confidence.

Accepting the design for a system, but only implementing part of it

Sometimes heating systems are designed with a number of parts, for instance background air heating and local radiant pew panels, which together provide thermal comfort. If used separately these systems often do not work and even cause more discomfort, for instance by causing cold down drafts.

Solution*: Make sure you understand how the system was designed and manage it in that way.*

Using heating systems incorrectly

Different heat emitters provide different types of heating. Radiant pew heaters are generally intended to provide local immediate heating and not to heat the main church air mass. As a result, the air might feel cold walking into church while it may be cosy in the pews.

Sometimes, because this design is so different to our houses, the system is thought to be 'failing' and people leave on radiant heaters for hours in a doomed attempt to heat the church air. As well as failing to do so this can be extremely expensive.

Solution*: Understand what your heat emitters are intended to do and use them as they were designed. Before changing to this solution visit a church that already has one installed to see the effect of how they work and what type of comfort it can provide.*

Thinking too narrowly about the financial costs of your heating system

Often, the team formed to plan a heating replacement focusses only on the capital outlay. They compare two or three approaches, and opt for the one with the lowest capital cost, because less fundraising will be required. Whilst this is very natural, it is important to think more broadly about all the kinds of cost that will be incurred.

Solution: When planning a heating replacement consider four kinds of cost:

- The one-off up-front capital cost,
- The annual operational cost (gas, oil, or electricity) for the life of the system,
- The maintenance costs (spare parts and labour) over the life of the system,
- The replacement cost, at the end of its working life.

An effective approach, recommended to all churches, is to establish a future works plan and a sinking fund to save for the maintenance and eventual replacement of your system.

f you estimate that your current heating system will need £2,000 of maintenance over the next 10 years and then a replacement costing £18,000, can a sinking fund be established into which the church saves £2,000 per year? This can be daunting for a cash-strapped church struggling to pay parish share and clear the gutters, but so is the alternative—being faced with a bill for thousands (or tens of thousands) of pounds and no money in the bank when the heating breaks down. At least saving some of the costs will create match-funding for grant applications when the time comes.

Thinking about fund-raising for heating simply for comfort, rather than for conservation and community

Heating replacements designed *just* for improving comfort are rarely grant funded. However, if your heating is also intended to improve the conservation of the building, encourage greater community use, and produce environmental benefits *whilst* improving comfort, then there may be funders willing to become involved.

Look at your project in these terms and see if the heating is in fact part of a wider conservation and development project when considering applying to funding bodies.

Solution*: Consider whether the heating you are looking at is part of a bigger project involving the development and conservation of the building and discuss with funders who might be interested in these wider goals.*

Below: **Heating systems can vary considerably, so you want to try and identify your options and then estimate figures, considering the initial capital cost, the running costs, the maintenance, and the costs to remove at end of life. These two options have very different cost profiles; Solution 2 is more expensive upfront but costs less to run and maintain.**

	Installation cost (one-off)	Operational cost per year	Maintenance costs over lifetime of system	Expected operating life	Potential additional costs at end of life
Solution 1	£10,000	£5,000	£5,000	25 years	£5,000
Solution 2	£20,000	£3,000	£3,000	15 years	£5,000

Thinking too narrowly about the carbon costs of your heating system

It can be easy to overlook the environmental impact of your heating decision.

Heating makes up the vast majority of the energy use of your church, and most churches currently heat their church by burning oil or gas in a boiler, which emits greenhouse gasses and contributes to climate change.

(You can work out the 'footprint' of your church by using the Energy Footprint Tool each year, which is part of the online parish returns system.)

A new heating system is a key opportunity to cut the carbon footprint of your church, and help to address your church's contribution to the climate crisis. However, it can be easy to focus on the **operational carbon** represented by your use of electricity, oil or gas. It's important to think also about the **embodied carbon** in manufacturing and installing the new system; all the metals in the pipework and pew heaters, for example.

Solution*: We don't yet have any easy way to measure the carbon impact of a new heating system, but weight and cost are good proxies for how much carbon has gone into making the components required. Is there a lower cost or lower weight solution you could pursue, which is still robust enough to meet the church's needs?*

Are there elements you can reuse? For example, can you retain the radiators but replace the boiler?

Check the solution has not been over engineered: while it can be important to have backup pumps and boilers in buildings such as schools, is this really a critical requirement in every church? The risk, of course, is not installing back-ups and then being left without heating for some weeks whilst you source a part. Weighing this up should be part of the design process.

Failing to consider reuse of existing components

As mentioned above, too often components with working life still in them are simply removed and scrapped thus wasting the carbon embedded in them by virtue of their manufacture and potentially losing valuable parts of our engineering heritage.

Solution*: Existing parts of heating systems can be separated from new central plant by means of plate heat exchangers thus avoiding the risk of any damage to new central plant.*

Contracts can be written to avoid warranty claims involving the re-use of existing equipment.

Help on heritage heating systems can be sourced from the CIBSE Heritage Group.

Below: **The early and unusual radiator shown below, could be repainted, given new matching feet, better support brackets together with isolation and regulation valves and still be effectively emitting heat for decades more to come. This assumes it's not sludged-up and impossible to flush through.**

Assuming fossil fuels will remain inexpensive

For our lifetimes, we have had plentiful, cheap (subsidised) fossil fuels. As easy-to-access oil and gas becomes a thing of the past, prices will rise. In a potential future where the price is required to fully incorporate their full environmental impact, prices could rise further.

In the meantime, electricity prices are expected to level-off or fall slightly, as cheaper renewables come on-stream.

Often, the team formed to plan a heating replacement focus only on the capital outlay. It's vital to consider the running costs also, and remember that the high differential that exists now between gas and electricity is expected to narrow.

Solution: *When planning, consider the future price you are likely to pay for oil and gas and the potential for increasing carbon taxes on these fuels.*

Trying to please vocal minorities

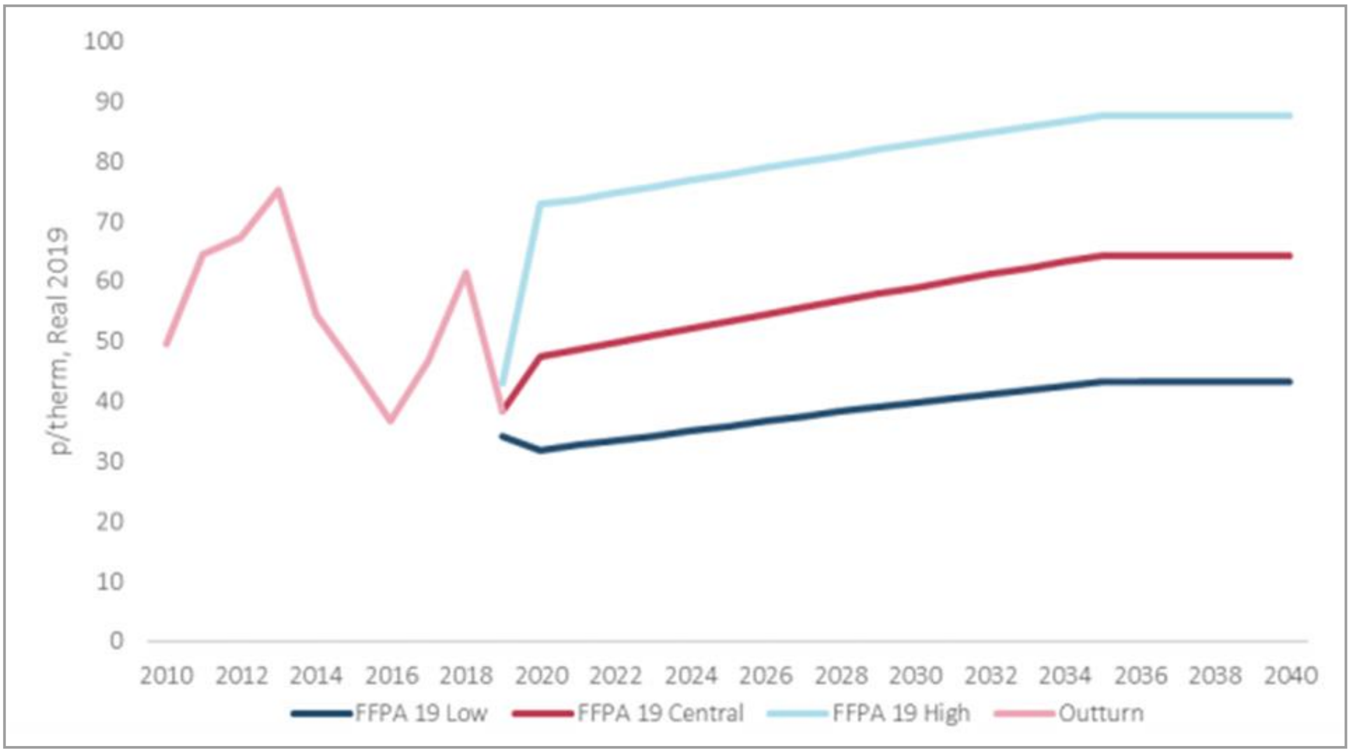
A really tricky problem to navigate is dealing with vocal minorities in the church community.

Perhaps they are the people who refuse to move to warmer spot in the church and want the heating turned up. Perhaps they are people who do not understand why environmental factors are important. Perhaps they think a particular technology is the right solution, because they have seen it elsewhere. Perhaps they complain that the church is too cold and "something needs to be done" when most people are fine with how things are.

Solution*: Let's be honest, this is a very hard one to solve. However, it can help if you consult widely through a survey, and can point to the results. It can also help if you have external advice to rely on, which supports your argument. Try and find champions for your planned approach, within the church community, and encourage them to speak up.*

Keeping everyone informed can help, so that you have general support and understanding from the church community.

Below: **This graph from the Department for Business, Energy and Industrial Strategy shows low, medium and high potential scenarios for gas prices, in today's money (i.e. adjusted for inflation). You can see the gas price is expected to gradually increase year on year.**



Choosing technology which is uncommon, so it is hard to find engineers or parts

One of the difficulties, especially if moving to relatively less common low-carbon heating solutions, is ensuring that you will be able to find an engineer and parts relatively easily, if something fails.

***Solution**: Proactively seek out reference sites when choosing a system, visit them and speak to the church warden. Before committing to a system, research how easy it is to find an engineer and spare parts.*

Below: **The church boilers pictured had a failure in their gas solenoid valves, and the church's contractor couldn't repair or source a replacement, so recommended that the boilers be totally replaced at high cost. Luckily, in this case, a church member found the parts were available online, and the boilers were able to be repaired.**

6b Conservation

In some cases, heating systems installed to make the building warmer and more welcoming can lead to costly and sometimes irreversible damage. Some examples are below, but it is important to consider these risks on a case-by-case basis. Ask yourself "what could go wrong?" Ask your church architect or DAC if your church contains precious and sensitive artefacts. Ask any conservators that you have had working for you in recent years or contact the Cathedral and Church Buildings Division.

Damage to building fabric and artefacts caused by unstable heating

Unstable air heating can cause cycles of high and low relative humidity (RH) increasing salt activity in stone and plaster, causing powdering and flaking. For timber furnishings, this same general heating and cooling can cause expansion and contraction resulting in splitting, while for sensitive artefacts such as paintings and hatchments the change in RH can cause canvas to shrink or swell causing paint to flake. Heating systems should be designed to maintain stable air temperature and slow and limited change wherever possible

Solution: *Design the heating system either for space heating that maintains a stable temperature, or to heat the people with minimal heating of the air.*

Below: **Flaking and splitting can be caused by unstable heating.**

Damage to building fabric and artefacts close to or above heaters

When heat emitters are placed close to wet building fabric the cause an acceleration in drying resulting in salt activity which can lead to powdering and flaking of stone and plaster. For timber furnishings, the heating and cooling can cause expansion and contraction resulting in splitting.

When there are sensitive artefacts close by or above heaters, such as paintings and hatchments, the change in RH can cause canvas to shrink or swell causing paint to flake. It is important, therefore, when designing a system to locate heat emitters away from sensitive fabric and if necessary, move vulnerable furnishings and artefacts.

***Solution**: Design the heating system to avoid putting emitters close to sensitive elements of the building fabric.*

Move sensitive artefacts away from existing heaters or isolate that heater (making sure that this does not affect the functioning of the rest of the system).

Dirty stains on walls directly above heaters

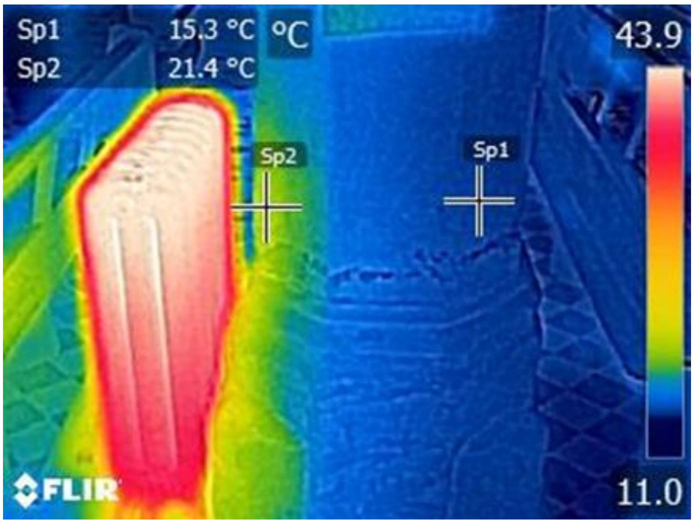
When warm dusty air rises from heaters and comes into contact with the colder walls above, it can deposit dirt onto the wall above the heater, through a process known as 'thermophoresis'. This is unsightly and can require specialist cleaning. This effect is inevitable to some extent as buoyant warm air rises across walls but there are some mitigation measures.

***Solution**: The first line of defence is to locate heaters away from walls when this might occur.*

When heaters need to be on walls, locate them away from wall surfaces which cannot easily be cleaned or redecorated (such as wall paintings).

The effect can be reduced to some extent with the use of baffles to reduce smooth air flow, and through regular cleaning of the heater; particularly the underside of radiators and air inlet grilles.

Below: **Damage and stains to the walls can be directly linked to the heat given off by radiators.**



Damaging the church organ

Unstable air heating can cause cycles of high and low RH causing expansion and contraction in timber and leather resulting in distortion and splitting of component parts of the organ.

In minor cases this can affect tuning while in more significant cases this can lead to damage requiring costly repair. The same effect can be caused by excessive heat, leading to significant drying, and by heat emitters in close proximity to the organ.

Large variations in temperature or different temperatures in different sections of the organ (if pipes are located in different parts of the church) can also have significant acoustic effects causing the organ to require retuning.

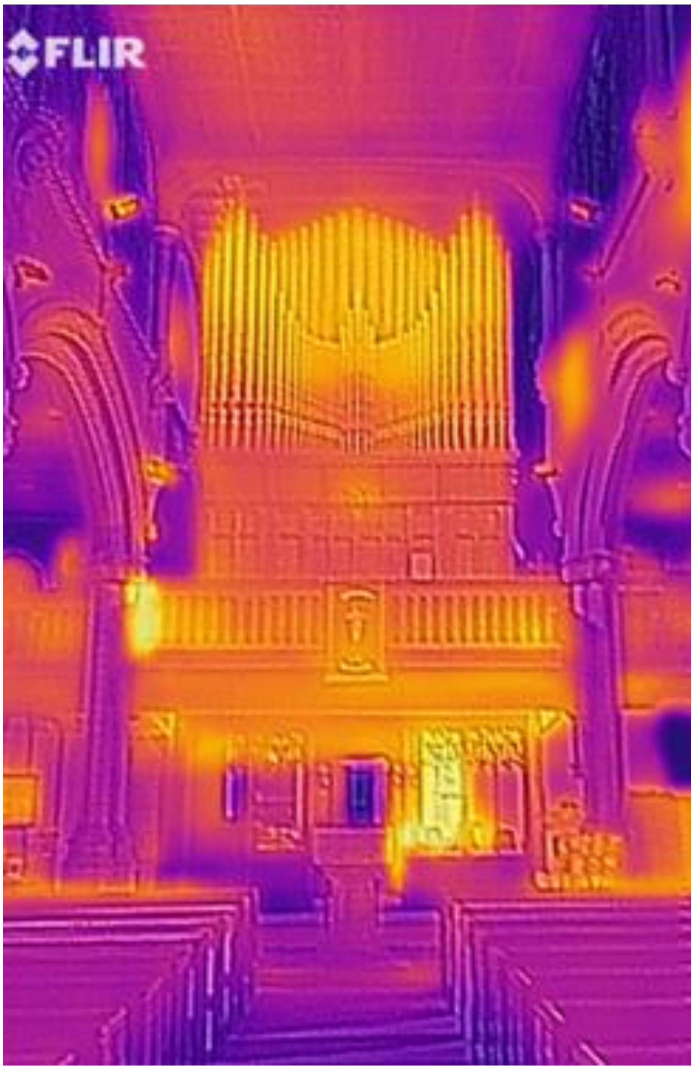
Heating systems should be designed to maintain stable and not too excessive air temperature and slow and limited change wherever possible.

***Solution**: When designing the heating system understand the effect that the temperature change will have on the different parts of the organ.*

Avoid rapidly fluctuating, unstable, and high air temperatures.

Avoid putting heat emitters or boilers next to the organ, and avoid running heating pipes through or near the organ. Particular harm to tuning happens from forced air systems that emit near the organ.

Below: **This thermal imaging photo shows how the heat from below warms the organ**.



6c Controls and settings

A good system with poor controls

So many otherwise good systems fail because of poor controls. Sometimes this is because it is too simple to be helpful, sometime too complicated to understand and sometimes just badly designed.

It is common to concentrate on energy source and heat emitters and assume that control is easy.

At one of the spectrum, some churches still have a simple on/off switch rather than a programmable thermostat. At the other, we will all have seen church installations where a keen PCC member with a technical background has commissioned a system with multiple control systems and many buttons. The control panel looks like the cockpit of a plane. Then the PCC member moves on, and the poor church warden is left baffled. Putting thought into designing controls well is worth it.

Solution: *During the design process, think carefully about what the heating is intended to do. For instance, is it intended to heat the whole building permanently at daytime or night time temperatures, or small areas of local heating at specific times, for example for a playgroup, choir group, or homeless shelter? From this, determine what heating zones and controls meet your needs, as simply as possible.*

Say to your designer "this is what we need our heating to do for us, now design a system with that outcome".

Design the heating controls so that a typical church member could understand them. Put a poster on the wall of the boiler room with the layout of the key components. Label the controls. Have buttons clearly marked, e.g., "One extra hour – nave" which are easy to understand. Keep any manuals in a ring-binder and ensure everyone knows where this is kept. Back up these instructions in electronic PDF format, file them away on all available church computers, and email copies to all interested parties.

As part of the contract require an operation and maintenance manual (an O&M manual) including a pipework diagram showing pipe sizes and layout. If the system is complicated request a short "idiot's guide" to operation. Retain this with the church's log book.

If possible, get the final design checked by your DAC Adviser before work starts.

Running the heating longer than needed

There are *some* churches where 'background heating' will work well, keeping a low level heat all the time and then boosting it when needed. These will typically be busy churches with activities happening every day and/or churches with fragile interiors where regular extreme cycles of temperature and humidity will cause harm.

For other churches, used perhaps once or twice per week, running the heat all the time is simply a waste of energy and money. An analysis of 180 church energy audits showed that reducing the *hours* and/or the *temperature* of background heating was a very common and effective recommendation.

Many churches keep the heating on until the end of the service, not realising that it may take 30-45 minutes for the radiators to cool down after the heating clicks off. This is wasting energy and money for no benefit.

Solution: *If you are currently running the heating for periods when the church is unoccupied, consider whether you can reduce or stop this without causing harm to the fabric and interiors of your church. If you have historic fabric or interiors, get advice before making changes.*

Use inexpensive data loggers for a few weeks, to work out how long it takes for the temperature in the church to drop after the heating clicks off. Then adjust your heating controls accordingly.

Thermostat not working properly

Heating problems are often caused by the thermostat; it can be turned down too low, covered up (e.g. by a curtain), placed in a recess, placed in direct sunlight, or simply faulty.

Solution: Check that the thermostat is turned to the correct temperature and working accurately.

Move items which are covering the thermostat, or get the thermostat moved to a different location where the temperature it measures is more representative of the conditions in the church as a whole.

Misunderstanding conservation heating

Some specialist heating systems are designed to be run on humidistat control to keep the relative humidity stable for the conservation of the fabric and artefacts.

This can be a very useful conservation tool (the National Trust uses it in almost all of its properties) but it can result in low temperatures. Therefore for working churches it is sometimes used in combination with thermostat control during periods of occupation, to raise the air temperature. This is not a heating approach that the general public, or most heating engineers, are familiar with and misunderstandings can lead to inappropriate changes to the settings.

Solution: *As mentioned above, as part of the contract require an operation and maintenance manual (an O&M manual) but also instruct the designer to provide a short methodology explaining how and why the system operates as it does. As with all more complicated systems request a short 'idiot's guide' to operation. Retain this with the church's log book.*

6d Problems with components

Pump issues

If the pump is not powerful enough, hot water will not circulate at the correct rate.

Multiple boilers can be installed with individual pumps rather than one larger pump.

Solution*: Commission a heating engineer to install a new pump of the correct power.*

Radiator issues

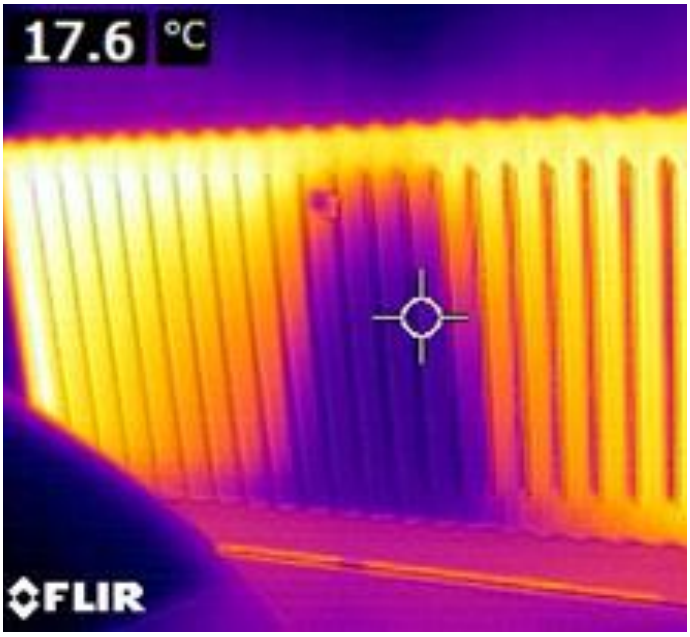
Under-performing radiators is a common problem. This can be because they are full of 'sludge', need bleeding, or are simply not turned up. If it's hot on the top edge but cold on the bottom edge its likely to be caused by sludge. If it's cold on the top edge and hot on the bottom edge, it's likely to be air.

Solution*: Bleed the radiators and ensure they are turned up.*

Ask a plumber to clear out the sludge and install a sludge filter to the system.

If the radiator has Thermostatic Radiator Valves, check that these are operational and not stuck.

Below: **Thermal image showing ludge buildup.**



Heat emitters covered up

A very common problem is heat emitters being covered up; heating grilles in the floor covered with carpeting, furniture in front of radiators, and radiators boxed in.

Solution*: Move things so that heating emitters are not covered and can work properly.*

Pipework and other elements of the system unlagged, wasting heat

The thermal imaging photo shows pipework which has been lagged, but the filter is glowing hot because it has not been lagged. This means heat is escaping in places you do not need it.

Solution*: Lag pipework.*

Below**: Thermal images of radiators covered with furniture; and a filter that has not been lagged and is wasting energy.**

Pipework scaled up and partially blocked from hard water

Pipes can get scaled up over time, and constrict the flow of hot water around the system.

Solution*: There is virtually no way of removing scale: once it's there; it's very hard. Pipes that are scaled up may need replacing.*

Install a good inhibitor, and check inhibitor levels annually.

Noisy systems which need to be turned off during services

Noise from the heating system can disturb services; this can be from the expansion and contraction of pipes, panels or radiators, gurgling water, or from fan convectors.

Solution: *Bleed air out of the system, use lagging and webbing around and between pipes to reduce noise and install pipe clips to reducing banging vibrations. Don't install a fan-based system if you are want totally quiet services.*

Below: **Scaled-up pipework.**

Radiant panel heaters mounted too low, too high, or with the wrong heating arc

Radiant panels can be very effective but the installation needs to be correct. If they are too high the radiation will not reach church users. If they are too low the radiation will only reach a few people and may be uncomfortably warm. If they are pointed in slightly the wrong direction, there will be cold spots where the radiation does not reach.

Solution*: Ensure the person who designs the installation has checked the distance the panels are effective over, and discuss with them where people will sit within the church for different activities.*

6e Aesthetic decisions

Drawing attention to things which are better hidden

In general, unless it is of particular character, heating equipment should always be installed so as to be as discreet as possible and, if practical, painted to blend in against the background surfaces upon which they are mounted.

Solution*: When planning a heating solution, consider the appearance of the heating equipment. Many installations will require faculty, and should be appropriate to the significance of the building.*

It's worth knowing that radiant panel heaters can be coated to match the colour of the wall or ceiling behind them, so that they blend in.

Below**: The heater in the top picture has been wall-mounted and painted a contrasting colour, which draws the eye. Below, they have been recessed into the wall behind the grilles. (If the grilles were painted to match the wall, they would be even more discreet.)**

Painting radiators with metallic paint

Using metallic paint on heat emitters like radiators or pipe loops will reduce the heat emission significantly, because it reduces the emissivity of the final surface compared to an ordinary non-metallic paint finish.

The reduction will vary depending on the style of radiator; for polished metal the reduction would be even greater.

Solution: *Metallic paint or polished metal finishes are best avoided.*

If radiators have been painted, then over-painting with ordinary non-metallic paint or two coats of lacquering/varnishing will restore the emissivity. The paint tone may darken, so a paint/varnish trial is recommended.

In some cases, if items like radiators pass a leak test, they may be suitable for refurbishment by specialists to strip the metallic paint off and start again with the usual primer and finishing coats. Such specialist refurbishment will also see the radiator flushed through and the valves replaced.

Inappropriate position and location and appearance of flues

It is important to consider the location and appearance of the flue, to ensure it is appropriate for the building, or they can damage the appearance of the building.

Solution*: Flues for modern condensing boilers (or 'high efficiency' boilers that operate partially in condensing mode) should ideally be arranged so that flues discharge upwards to lessen the 'steam plume' effect that can be prominent from horizontally mounted flue terminals.*

Flue terminals can sometimes be painted to match their surroundings to disguise their appearance, and a less prominent / sympathetic location chosen.

It can be possible to adapt existing redundant chimneys. A flue survey is required and it may be possible to drop a flue liner from the top and reinstate chimney pots or have a bespoke flue terminal. This would generally be the preferred option for a listed building, where possible.

Below: **Metallic paints on radiators reduce the heat emission significantly.**

Below: **A bad flue installation can look intrusive.**

6f Frost management

Many larger buildings, such as schools and offices, will have a three-stage frost management system;

Stage 1 – Outside Air – when the outside air falls below around 2°C the system will open all valves and enable the pumps so that all the water is flowing around the system. But the boiler does not fire. This is because moving water freezes well below zero (think rivers) so reduces the risk of freezing and also gets water in any cold/frost pockets out into the system.

Stage 2 – Boiler Return Temperature – when the water flowing back from the building into the boiler room falls below around 8°C then the boiler will fire. One usually chooses a temperature around 8°C as it is below the natural temperature of cold mains water (which tends to be around 12°C) but well above freezing point

Stage 3 – Inside Air Temperature – within modern buildings one tends to set the inside frost set point at 10°C as the buildings are well insulated and below 10°C is when condensation can start to cause paper to stick together in copiers and printers.

The problem with churches is there tends not to be a return temperature pipe stat or an outside air sensor. Typically, the church heating is controlled by just two internal sensors; one being the normal thermostat / set point and the other being the frost-stat / set point. This means that as soon as the temperature falls below the point on the froststat, the whole system (boiler plus pumps) fires up.

This leads to two potential pitfalls:

- if **the frost set point is set too high you often have massive energy use** when the building is empty, when the risk of freezing is almost zero. (An experienced church energy auditor states it's not unusual to find that 10-30% of a church's heating consumption is due to the boiler firing under frost conditions when the building is empty, no one is there and most people don't even know the boiler has come on.)
- if **the frost set point is set too low, you risk burst pipes** with their subsequent damage to the building fabric.

Frost-stats need to be installed in the correct place. If the main concern is stopping water pipes freezing, then locating the frost stat in the coldest part of the building, near the pipes, makes sense, or even installing a 'pipe stat' which measures the temperature of the pipe itself. If the pipes are concealed, then the frost stat may need to be installed in the boiler cupboard (which will only be cold if the boiler is not on.)

Solution: *be clear what damage you are most concerned about preventing, and then ensure the frost-stat is correctly located to prevent this damage.*

Alternatively, have a heating system that doesn't have water in it (i.e. an electric one) so there is no risk of burst pipes.

6g Health and safety

A failure to remove old redundant plant can clutter areas and create hazards.

Access for future inspection an works must always be allowed for. For example, blocking access to the fuse cupboard, as in the illustration below, creates a hazard.

Below: **Redundant plant, and blocking access to the fuse cupboard – here with cleaning supplies – creates a hazard.**

6h Final words

As you can see, there are many potential heating pitfalls.

To avoid them,

- follow the principles set out in section 1 of this suite of heating guidance notes,
- consider all the heating approaches (section 3),
- think carefully about the future (section 4),
- understand your start point (section 5), and
- carry out a full options appraisal before making changes (the next section, section 7).

Hopefully this national guidance, along with the right local advice, will help you chart a smooth and successful path forward.