ZERO WASTE SCOTLAND

Energy Efficiency Business Support

How to save money and energy on space heating

Advice and support for organisations in Scotland

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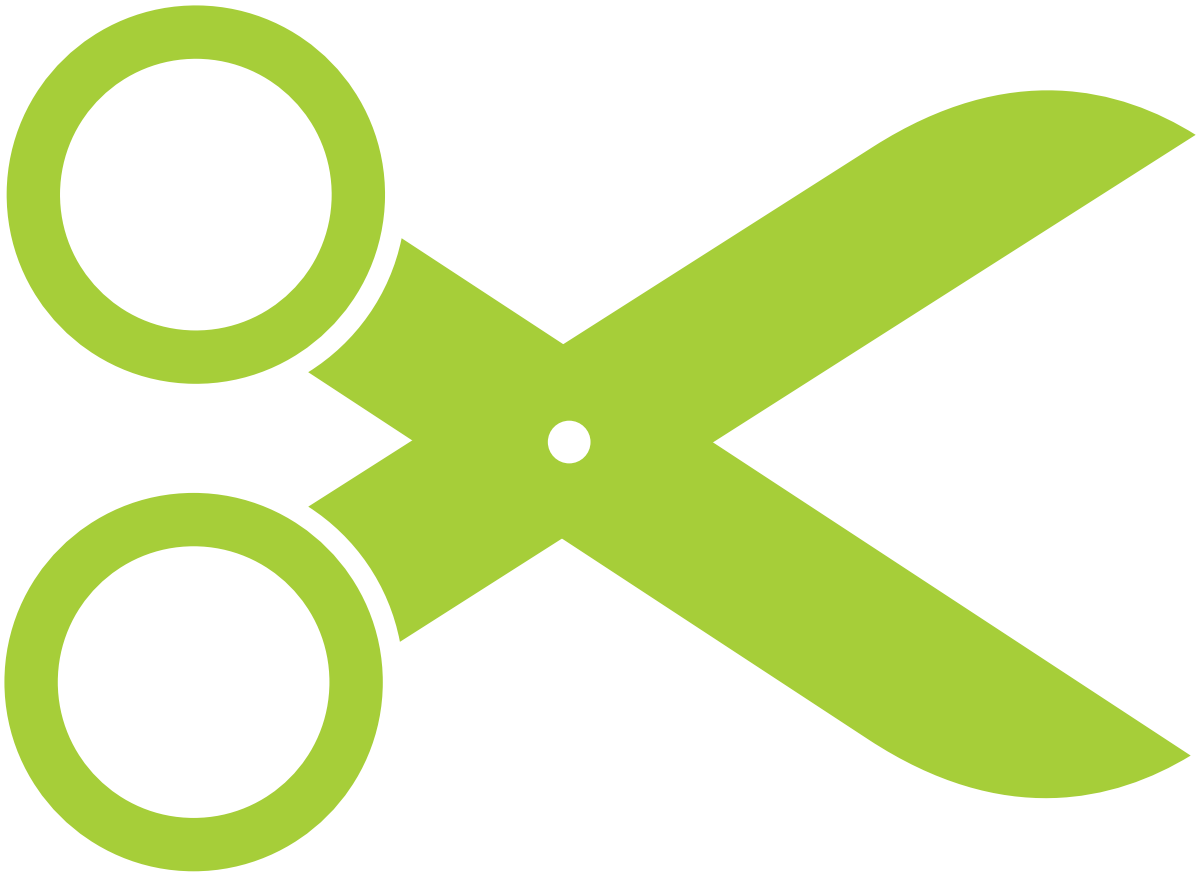
Investing in a Smart, Sustainable and Inclusive Future



Want to cut costs?

Zero Waste Scotland's Energy Efficiency Business Support Service helps businesses to cut their energy costs by an average of 24%.

Each year over 34,000 individuals from a range of organisations get in touch with us for impartial advice and free, specialist consultancy support.

We're here to help
Call us on 0808 808 2268
Email: EnergyEfficiency@zerowastescotland.org.uk
Visit: www.energy.zerowastescotland.org.uk

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Contents

We hope this guide will help you identity actions your organisation can take to become more resource efficient.

When you do take action, make sure you the get the recognition you deserve, and the organisation-wide support you need, by making a Resource Efficiency Pledge.

RESOURCE EFFICIENCY PLEDGE

Motivate your staff and senior management, and bolster their commitment to achieving your business's environmental goals.

Focus your efforts on a clear set of achievable performance improvement actions.

Get the recognition you deserve from employees, customers and wider stakeholders.

Join hundreds of organisations across Scotland that have already made a Pledge.

Make your Pledge today
https://Pledge.ZeroWasteScotland.org.uk

1. Why improving space heating is important for Scottish organisations

It's not surprising that in Scotland, where we experience the lowest temperatures in the UK, combined with the highest average wind speeds, space heating is essential.

Heating in our workplaces (offices, retails outlets and workshops) is critical for many months of the year. It provides a comfortable environment for customers and staff, and ensures that sales and productivity levels are not affected by the time of year or the temperature outside.

While heating is essential, it is also a big expense. Indeed, for many Scottish organisations, space heating can account for as much as half of total energy costs.

Since 2013, Zero Waste Scotland has been helping Scottish organisations save money and grow, by using energy, water and raw materials more efficiently.

We have helped tens of thousands of organisations to identify and implement measures that help them to use their resources more efficiently. This has resulted in savings worth millions of pounds. Space heating is an area where, time and time again, we see common, often highly costly mistakes being made and opportunities to make significant savings being overlooked.

Because space heating is such an expense, and because there are many common cost-saving opportunities to be enjoyed by most Scottish organisation, this guide is essential reading for anyone who has a role in managing energy related costs or influences those who do.

"... for many Scottish organisations, space heating can account for as much as half of total energy costs."

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2. How this guide will help you

Whether you are a business owner, facilities manager, health and safety manager, office supervisor or your organisation's nominated Green Champion, this guide will help you save energy and reduce the costs associated with heating your premises.

Written by resource efficiency and space heating experts, the guide will help you understand just how much your space heating is costing you, appraise your current performance and improve your knowledge. This will enable you to make informed decisions about how best to save money – while improving thermal comfort for your site visitors, customers and staff.

Practical advice, case study examples, and links to useful tools and further support are provided throughout to help you quickly take effective action and enjoy savings.

All organisations in Scotland, irrespective of size or sector, will find projects within this document that can deliver reductions in space heating costs. The projects recommended draw on our experience of working with hundreds of small and medium-sized enterprises (SMEs) across Scotland to help them take action to save money and energy on their space heating.

The guide includes the simple low-cost improvements you can make to your heating controls and distribution system that will deliver substantial savings. Then, the opportunities to save money by upgrading or changing your source of heat are covered. And, finally, the guide helps you understand highly effective ways to save money by improving the thermal efficiency of your premises to reduce heat losses.

Where investment is required, the guide also helps you to start thinking about setting out and evaluating your business case.

Case study
Ian Irvine Engineering

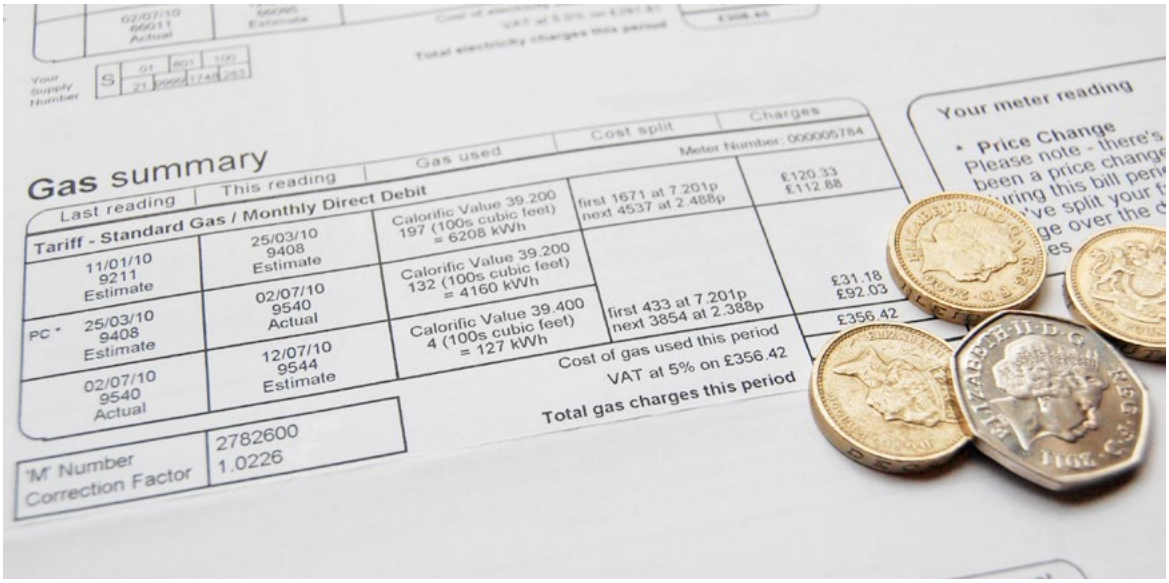
Ian Irvine Engineering is a family-run marine and general engineering business based on the island of Whalsay, in the Shetland Islands.

Before refurbishing and moving into new business premises, Ian Irvine contacted Zero Waste Scotland for energy efficiency guidance. This allowed recommended improvement measures to be factored into the refurbishment programme.

From the advice given, wall, floor and roof insulation was added to the offices on the site. An air source heat pump was also installed to replace multiple portable electric heaters that had been used on site previously. Lighting was upgraded with energy efficient lamps.

These actions have allowed Ian Irvine to create energy efficient and comfortable premises for his employees, and in doing is saving an estimated £3,000 on annual heating bills.

> **"... saving an estimated £3,000 on annual heating bills."**



3. How to understand current energy use for space heating

Most organisations are not aware of how much energy they use for space heating or what can be done to reduce consumption without affecting operations. The key to understanding energy use and, therefore, your opportunities to improve performance, is good metering and analysis of the metered data.

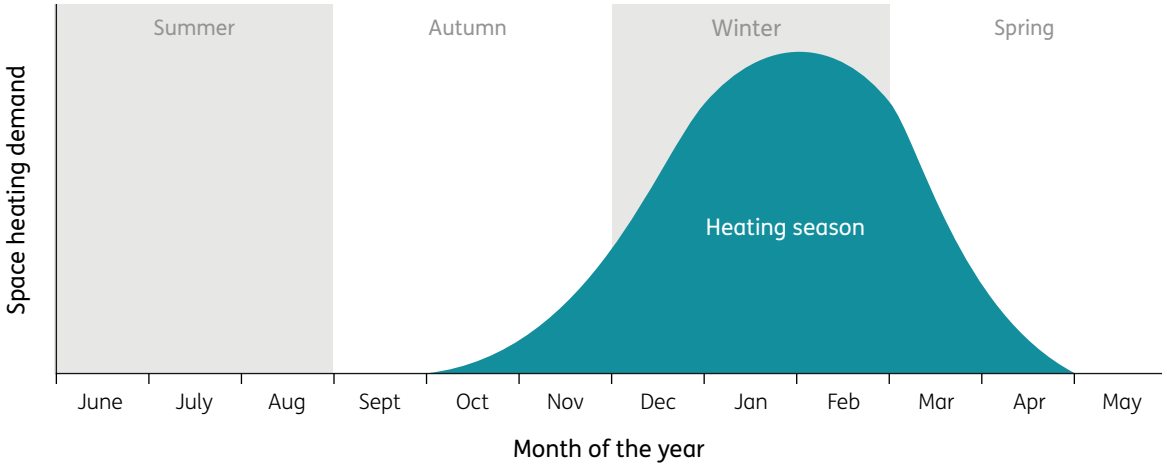
Gas and electricity are the most common heating fuels, so this guide focuses on these systems. However, the information provided here can be adapted for heating systems fuelled by oil, liquefied petroleum gas (LPG) or biomass.

3.1 Gas heating

Where heating is provided by gas, it is likely that your boiler will be the only or main user of gas. Unless you already have smart metering, you will need to refer to your gas bills to work out how much gas you are using. As shown in Figure 1, because space heating is only in use for part of the year (the 'heating season') you cannot scale-up from the latest quarterly bill, so you will need a year's worth of bills to get an accurate picture.

Figure 1 shows an organisation that has higher levels of heat demand in winter – as would be expected. Heat demand in spring is also shown to be higher than that in autumn – but this may not always be the case.

Figure 1: Example space heating over a 12-month period



Total heat demand varies from one year to the next depending on the weather. So, ideally, to get a clear picture of annual space heating demand in your organisation, you should collate and average your consumption data for the last 3 years. Otherwise, you run the risk of overestimating or underestimating costs and, therefore, misjudging your potential savings opportunities.

If your boiler also supplies 'domestic' hot water (the water used for washing and showering) in addition to your space heating, an allowance needs to be made for this. Hot water use is dependent on the type of business operation. Generally, hot water use is relatively low in SMEs and an allowance of 10% would be sufficient.

***Worked example** – Estimating the annual costs of space heating fuelled by gas*

The table below shows how to estimate the current annual average costs of gas-fired space heating where hot water is also provided by gas.

Gas use is normally measured in kilowatt-hours (kWh) and will be stated clearly on your gas bill. The impact of actions taken to reduce demand are also measured in kWh, which can then be converted to cost savings by multiplying by the unit cost of gas.

Estimating the average annual costs* of space heating fuelled by gas

Gas consumption for most recent 12 months Gas	190,000kWh
consumption for year 2	157,000kWh
Gas consumption for year 3	178,000kWh
Average annual gas consumption**	**175,000kWh**
Gas consumption for hot water (assumed to be 10%)	17,500kWh
Average annual gas consumption for heating	**157,500kWh**
Cost of gas (per kWh)	£0.04
Average annual cost of gas for space heating	**£6,300**

* This table ignores standing charges and VAT

** Note that there may be other variables apart from the weather (such as expansion or contraction of the heated area as the needs of the business change) so annual averages need to be assessed carefully.

These energy and cost estimates can then be used as the basis for estimating savings from remedial measures. If there are any supplementary forms of space heating in use (such as electric radiators, fan heaters or LPG heaters) then they also need to be taken into account when working out the total energy use and cost of space heating.

3.2 Electric heating

There are two main forms of electric heating – resistance heating and air source heat pumps (ASHP).

Electrical resistance heating (such as electric radiators, storage heaters or fan heaters) is very expensive to run, but is still used in small organisations where the cost or complexity of installing an alternative system appears prohibitive. Where it is still in use, there is a great opportunity to save running costs by fuel switching or moving to an ASHP.

ASHPs take low-grade energy from the air and convert it into higher grade energy for use in space and water heating applications. They are commonly used as the basis of heating ventilation and air-conditioning (HVAC) systems.

Where heating is provided by electricity, it is more complex to work out the costs as there will be many other uses of electricity on your premises. The best way to work out how much energy is used for space heating is to meter the circuit that provides the space heating. This can be done by installing a permanent sub-meter or by using a temporary meter that clamps around the space heating circuit wiring. In either case, a professional electrician should be consulted.

In the absence of sub-metering, the most effective approach is to estimate the proportion of electricity used for space heating.

***Worked example** – Estimating the annual costs of space heating fuelled by an electrically powered HVAC system*

Estimating the costs* of space heating fuelled by electricity

Electricity consumption for most recent 12 months	112,000kWh
Electricity consumption for year 2	97,500kWh
Electricity consumption for year 3	105,500kWh
Average annual electricity consumption**	**105,000kWh**
Estimated proportion of electricity used for space heating***	50%
Amount estimated for space heating	52,500kWh
Cost of electricity (per kWh)	£0.13
Annual cost of electricity for space heating	**£6,825**

* This table ignores standing charges and VAT

** Note that there may be other variables apart from the weather – such as expansion or contraction of the heated area as the needs of the business change – so averages need to be assessed carefully.

*** This proportion will vary widely between organisations. If there is any process energy use or significant hot water demand then the percentage used for space heating may be much lower.

3.3 Smart metering – for gas and electricity

Smart metering is due to be provided to all SMEs between 2015 and 2020. Smart meters will make it simple to track space heating energy use on a daily basis. However, many SMEs already have 'advanced meters' that have some or all of the functions of the new smart meters, including half-hourly reads and display panels.

Where detailed metering provides daily or hourly readings, data can be examined to spot any anomalies, such as heating (or other services) coming on when not required, which can then be rectified. Trends can also be analysed. For example, if performance decreases over time, this may indicate a fault with the system that then needs further investigation.

Some suppliers are now offering smart meters at low or no cost in advance of the wider roll-out. So, it may be possible to get better information at nominal cost without waiting for smart meters to be mandated.

3.3.1 Sub metering

Sub metering of space heating systems (particularly electricity) is the most accurate way to separate out space heating demand from other energy use. New non-domestic buildings (from 2002) are required to put in place metering that enables at least 90% of the estimated annual energy consumption to be assigned to the various end uses (such as heating and lighting). For existing buildings, this approach would also be considered best practice.

A comprehensive guide to strategies for and benefits of sub metering is available from CIBSE - TM 39 Building Energy Metering.

If you would like to investigate the benefits of smart metering further, please contact us on 0808 808 2268.

3.4 Analysing and using energy and cost data

3.4.1 Benchmarking

Once you know how much energy is being used for space heating, you can compare how your building performs against that for other buildings in the same sector.

To take account of variations in size, the metric most commonly used for comparison is kilowatt-hours per square metre per year (kWh/m^2/year). So, it is necessary to know the area (m^2) of your building. Dividing your average annual space heating demand in kWh by the area of your building will give you your kWh/m^2/year.

This figure can then be compared with that for other sites in your organisation or published benchmarks. A selection of benchmarks published by CIBSE (TM 46 Energy Benchmarks) is provided in Figure 2.

***Worked example** – Calculating benchmark*

In the gas-heating example on page 4, let us suppose that the heated area is 1,000m^2.

$$\frac{\text{Average annual space heating demand}}{\text{Area}} = \frac{157{,}500\text{kWh}}{1{,}000\text{m}^2} = \textbf{Benchmark } 157.5\text{kWh/m}^2\text{/year}$$

Case study
Cordiners Sawmills

Cordiners Sawmills is a family run business based in Banchory, Aberdeensire. It has over 135 years of experience in the sawmilling industry. Zero Waste Scotland has been helping Cordiners Sawmill to reduce its electricity consumption.

The business has now started an energy management system by installing metering and monitoring equipment in their electric circuits. This now allows them to track their usage and easily evaluate the improvements they are making.

They have also started fitting variable speed drives to motors and equipment within the site to further reduce electricity consumption.

James Cordiner said: 'These changes have reduced our energy usage and we have saved £2,500 since we put in the metering and monitoring software. We have also increased our throughput, so per m^3 of timber produced we are using less electricity'.

> **". . . These changes have reduced our energy usage and we have saved £2,500."**

Figure 2: A selection of space heating benchmarks

Category of building	Fossil-thermal typical benchmark (kWh/m²/year)
General office	120
Large non-food shop	170
Bar, pub	350
Hotel	330
Workshop	180
Fitness and health centre	440
Storage facility	150

If your building is performing significantly worse than the benchmark for your industry area, then this can be used as a call to action – a signal that your system or building fabric is likely to be inefficient in some way.

However, benchmarks need to be treated with great care due to variations in:

- thermal performance of building fabric (the condition of a building affects its thermal performance);
- space heating system efficiency;
- weather; and
- patterns of occupation.

3.4.2 Using your performance data

Once space heating demand is known and has been compared with any available benchmarks, targets can also be set for reductions in demand.

Having a good understanding of how much space heating costs can be very useful if you need to get senior management support for any time or financial investment required to investigate and implement cost saving actions.

Comparing your consumption with that of similar organisations and, possibly, other sites in your organisation, will help you to engage and motivate senior management in the process of reducing demand.

Your annual demand figures and benchmark comparisons will also provide the basis for estimating the potential savings available to you by implementing efficiency measures and tracking progress against those targets.

However, care should be taken when measuring short-term performance improvements as they need to take account of weather conditions that may have affected your organisation's space heating demand.

Free tool

We have produced a spreadsheet to help your organisation collate its energy meter readings and fuel purchase figures and analyse energy consumption.

Download the spreadsheet from our website

4. Heating distribution and control

It is often possible to achieve good savings in space heating energy use by making efficiency savings through improved heat distribution and control.

Heat distribution is the process of taking heat from a boiler (or other source of heat) to the point at which the heat is needed – occupied space. Distribution is via air or water in almost all cases. Water systems are used most often where there are fossil fuel boilers and air distribution is more common for HVAC systems powered by ASHPs. However, different combinations of source and distribution mechanisms are also common.

Control of space heating can be centralised at the boiler or broken down more locally at or near the point of use – or use a combination of centralised and local control. Heating systems are normally controlled by a combination of time control, system thermostats, zone controls and localised thermostats (such as thermostatic radiator valves (TRVs)).

Improving heat distribution and control is a very cost-effective way to reduce your energy use. In general, the investment required is relatively low as no major plant items need to be purchased.

4.1 Insulate pipework

Plant rooms are often very warm due to heat losses from uninsulated pipework. However, in most instances, they do not need to be heated. If you have a plant room, and it does not need to be heated, you should fully insulate pipework to reduce heat losses. Specialist products (such as easy access Velcro® wrappers) are readily available for the insulation of valves, flanges and other awkward pipe shapes.

Distribution pipes and air ducting in the heated area of the building do not always need to be insulated as they contribute to the useful heat. However, as heat losses from pipework under suspended ground floors and in the cavity above a suspended ceiling can be considerable, it is best to take the opportunity to insulate these pipes the next time that access is available.

Top Tips

Are you using supplementary heaters?

The use of local supplementary space heaters in an organisation is normally a symptom of poor, uneven heat distribution and control. As local space heaters are usually powered by electricity, they are expensive to run. In the medium term, it is usually more cost-effective to extend and improve your centralised space heating system and dispense with local space heaters completely.

4.2 Keep space around heaters clear

As businesses grow, space can be become tight. In these circumstances, it is common to find equipment, desks and other furniture being positioned in front of heaters. This should be avoided otherwise heat will not be able to circulate effectively. Discourage staff from piling up files, boxes and laptop bags in front of heaters.

4.3 Heat recovery

Heat is produced by lights, appliances and processes in buildings. This 'waste' heat can be used to contribute towards the space heating needs of a building.

Heat can also be partially recovered from contaminated or noxious warm air from kitchens or industrial processes by using a heat exchanger. This is known as mechanical ventilation and heat recovery (MVHR). MVHR is a specialist area so an expert should be consulted if you have identified an opportunity to implement this cost-saving measure. Heat recovery systems can be complex and expensive to install but can also yield significant cost savings, as demonstrated by Linn Products.

4.4 Make best use of timer controls

Buildings and their contents store heat very effectively and most buildings will stay warm for a long time after heating is switched off (see Figure 3). Yet, many organisations leave it until close of business each day to switch off their heating.

Therefore, cost savings can be made without impacting on comfort levels by switching heating off much earlier in the day. Doing this saves running costs and reduces the wear on the boiler too, so extending its life.

Similarly, there are likely to be predictable periods when your premises or areas within your premises will be unoccupied (in most cases at night and at weekends) and space heating is not be required. You should make sure that you understand these usage patterns and control your heating system accordingly. In this way, money will not being wasted by heating areas when they are not in use.

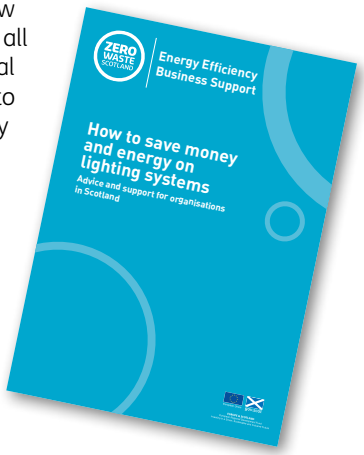
Case study
Linn Products

Linn Products design and manufacture world-leading music systems and record award-winning albums from the finest musicians, from their purpose-built factory just outside Glasgow.

They have recently fitted a heat recirculation system. The system recovers heat from the factory area of the site so that it can be used to provide space heating for offices.

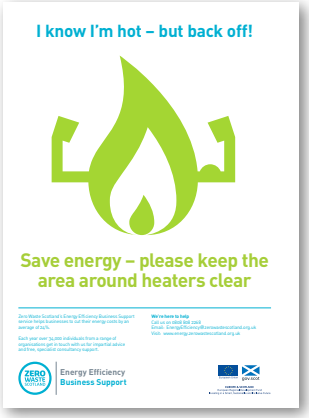
This change has reduced their energy usage and is saving them £1,130 each year.

They have now also changed all of their original light sources to high efficiency LED lighting throughout the facility, saving them a further £6,000 each year.



To find out more about saving money on lighting, download our free guide.

Free tool
Poster to encourage your staff to keep areas around heaters clear



Download this poster from our website

Top Tips
Hot-desking

If you have staff thinly spread across your site, why not try hot-desking and encourage staff to sit together? This will make your building easier to heat (people generate heat) and also allow you to switch off heating in areas that become unoccupied.

The times for heating operation shown in Figure 3 are for illustration purposes only. Each building is different and will heat up and cool down at different rates, so it may take several attempts to get the timings set exactly right (that is, to provide a consistent internal temperature and minimise wastage of heat).

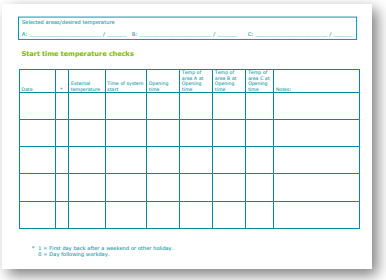
Timers are used to turn on heating prior to occupation and turn it off some time before the end of the day. A more sophisticated 7-day timer is needed to take account of weekends. It is important to recognise that a building will take longer to heat up after a weekend than after a normal weeknight. It is a common complaint that buildings are too cold on Monday mornings. To overcome this, timers need to be set to come on earlier at the start of the working week.

In all cases, a frost protection programme is needed to prevent the risk of damage occurring during longer periods of shutdown. If premises are shut down during holiday periods (such as at Christmas), then an even longer start-up period will be required on the first working day.

The most effective approach to heating timing is to install an optimum-start controller. Most optimisers use internal space and external temperature readings to detect how quickly the building reaches the set temperature. They will then 'learn' when to switch on the heating so that the building is at the correct temperature when people arrive.

Free tool

Free template for recording your heating system settings



Selected areas/desired temperature

A: _____ / _____ B: _____ / _____ C: _____ / _____

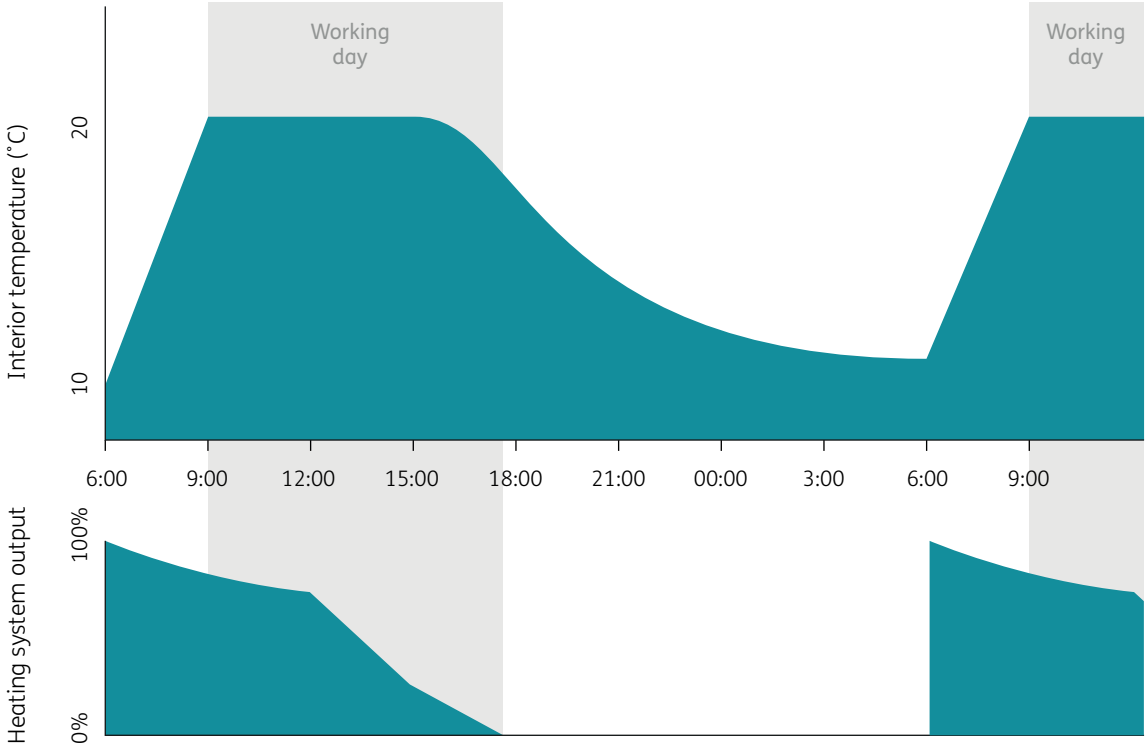
Start time temperature checks

Date	*	External temperature	Time of system start	Opening time	Temp of area A at opening time	Temp of area B at opening time	Temp of area C at opening time	Notes:

* 1 = First day back after a weekend or other holiday.
0 = Day following workday.

Download this template from our website

Figure 3: Example heating system output and building temperature



***Worked example** – Benefits of switching off* a boiler 1 hour earlier*

Project	*Set boiler to switch off 1 hour earlier*
Annual space heating cost	*£6,000*
Previous heating hours per day	*10*
New heating hours per day	*9*
Annual savings (10% x £6,000)	*£600*
Other identified benefits	*Reduced wear on boiler*

** Assuming boiler load is constant throughout the day*

4.5 Avoid overheating

Avoiding overheating will prevent heat energy being wasted, but will also reduce the energy demand for cooling – if this is in place. Described below are three things that should be considered to help prevent overheating in your buildings.

4.5.1 Set appropriate temperatures

The appropriate temperature for a workplace depends very much on the type of activity being carried out. At one end of the scale are offices where people do not tend to move around much and a relatively high temperature (normally 20°C) is required. The minimum temperature suggested by the Health and Safety Executive (HSE) is 16°C, but between 18°C and 20°C is common. If the set point exceeds 20°C, then it may be possible to turn down the heating without any objections from occupants. A 1°C reduction in set temperature is thought to save up to 8% in heating costs.

4.5.2 Locate temperature sensors effectively

The location of the temperature sensor (thermostat) is important because the internal temperature varies across a building. This variation depends on the height and elevation, and proximity to windows, doors and sources of heat. Larger buildings require zone controls and, at least, each floor to be separately controlled. For smaller buildings, it may be more effective to accommodate people who have sedentary jobs in the warmest areas.

4.5.3 Control heat gains

It is important to ensure that the space heating system responds to internal and external heat gains. Internal heat gains arise from a number of sources.

- In shops, heat gains from display lighting systems and refrigerated display equipment can be substantial.
- In offices, heat gains arise from the occupants and also from electrical equipment.
- In factories, there are often heat gains from processes such as welding or cooking.

External solar heat gains depend on the shape and orientation of the building and its windows, and whether the building can absorb and store heat. Some offices overheat from solar gains alone. While solar gains normally arise through glazing, poor insulation can result in larger heat gains. So, in addition to effectively managing your heating controls, you could also investigate opportunities to improve the thermal performance of the walls and roof (see Section 6).

Thermostatic control should enable your system to shut off as soon as heat gains arise. Bear in mind that if the heat gains are highly localised, space heating may still be needed in some areas. A saving can still be achieved if the distribution system is split into zones with local control.

If the gains are predictable and sufficient to eliminate the need for any space heating, then the timer can be used to switch off the heating at the appropriate time. Bear in mind also that buildings do not cool down quickly, so the heating can usually be set to turn off well before any solar gain takes effect.

4.6 Ensure that staff understand and can operate heating controls

If overheating occurs and it is not picked up automatically by the system, manual adjustment may be required. Employees often do not know how to turn down the heating or have concerns about using the controls.

Also, some rooms or areas, such as meeting rooms in offices, may have local controls to increase or reduce temperature as needed. If these controls are adjusted while the room is in use, they will need to be reset to avoid cooling/heating the room after it has been used and when the remainder of the office is being heated/cooled.

Therefore, it is essential that all staff know who is allowed to make alterations to the heating controls and to be trained to use the controls if appropriate. If an employee is not permitted or enabled to alter the controls, then they should know who does have the authority to do this.

As with all energy behaviour change training, the information and messages need to be reinforced at regular intervals and included for new employees as part of their induction.

Top Tips

Heat early to avoid overheating later

A common cause of overheating is that employees find the workplace too cold in the morning, so they increase the heating set-point temperature – the root cause of this problem is likely to be that the building was not brought up to temperature prior to occupation. Later in the day, this leads to overheating and waste as it is combined with solar and internal heat gains.

This problem needs to be addressed by ensuring that the timer is set to achieve the correct temperature prior to employees arriving.

Free tool

Free poster to help you stay in control of your controls

Some organisations find it helps to train key members of staff and give them responsibility for maintaining heating controls.

This free poster can be used to remind employees not to tamper with heating controls and instead to ask a trained colleague. You can add names of the trained staff to the poster template.

Download the poster from our website

Staff Engagement Toolkit

You can do a lot to reduce your organisation's energy, water and raw material costs by changing equipment and processes. However, to maximise improvements for lasting benefit, it is vital to get your colleagues on board. Our Staff Engagement Toolkit has everything you need to start engaging your staff today.

Run an effective Green Team

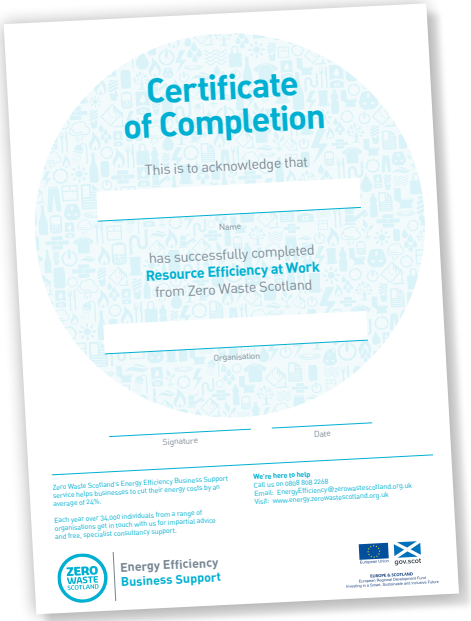
A Green Team can play a hugely powerful role in helping you to engage staff across your organisation and help you to encourage resource efficient behaviours. The toolkit includes free resources that will help you run an effective Green Team.

Train your staff

You can do a lot to reduce your organisation's energy, water and raw material costs by changing equipment and processes. However, good staff training provides the foundations to maximise improvements and create a lasting change. The toolkit includes a range of resources to help you train your staff on the importance of resource efficiency

Run campaigns to engage staff

Chances are, your staff will be happy to support your resource efficiency initiatives if you can just find ways of communicating with them effectively. Our staff engagement toolkit will help you to do just that.



Access the staff engagement toolkit on our website

4.7 Optimise HVAC controls and equipment

If your heat distribution is via warm air (convection), then it is likely to be part of a more comprehensive HVAC system. The source of heat may still be a gas boiler or an ASHP - which could also supply cooling. HVAC control is a specialist area, but it is important that at least two nominated people in your organisation understand how to operate the controls. With two trained staff, this ensures there is a back-up in place in case of absence.

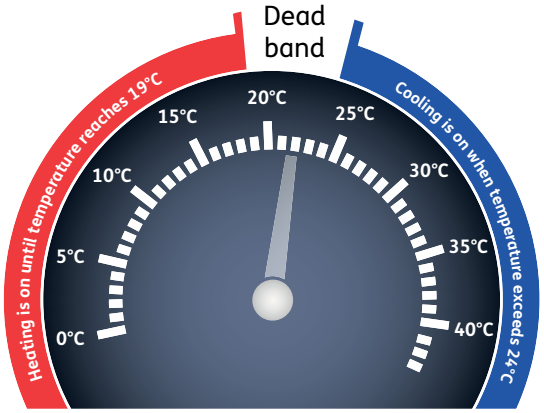
It is also important that a comprehensive record is maintained of all HVAC set points and controls. Contractors should explain and record how to use any new controls added to the HVAC system. This will enable your nominated members of staff to make adjustments as appropriate (and override temporary settings) and engineers who visit in future to understand how the system has been set up.

The most commonly used techniques for optimising energy demand from HVAC systems are set out below.

4.7.1 Maximise the dead band

This is the gap between the temperature at which heating stops and cooling starts (see Figure 4). If this is set as wide as possible (a minimum of 4°C is considered to be good practice), it will prevent the simultaneous operation of heating and cooling systems in adjacent areas and maximise the time when neither system is operating.

Figure 4: Maximising the dead band



4.7.2 Use free cooling

Free cooling can be used whenever the external air temperature is lower than the temperature of the building (or specific areas of the building) needing to be cooled.

Surprisingly, many HVAC systems do not take advantage of free cooling and the substantial savings that it offers – especially for warm locations such as server rooms and other heat-producing process areas.

If you want to investigate this further, then it is worth consulting a specialist in ventilation systems to see whether your system can be adapted cost-effectively.

4.7.3 Fit variable speed drives (VSDs)

VSDs reduce the energy required to power pumps that circulate heat. Pumps need more energy to get a circulation system moving than to keep it circulating. A VSD senses when a system has reached the correct circulation speed and reduces the power to the pump accordingly, producing a saving in electricity use.

In a gas-heated system, VSDs will not reduce gas demand, but they will reduce electricity used by the pumps. Your heating engineer should be able to tell you if VSDs have already been fitted and whether there is scope for further savings here.

4.8 Install thermostatic radiator valves in warmer areas

Most water-based heat distribution systems use radiators to deliver heat (underfloor heating and air-based distribution systems are not covered in this section).

TRVs are familiar to most people as they are used to control domestic heating systems. TRVs shut off the flow of heat to a radiator when the air temperature reaches the set level. Exactly the same applies in a commercial environment.

If you do not have TRVs, you should install them where there are large natural variations in temperature across your workspace (for example, from solar gain or internal gains from machinery). The system thermostat temperature can then be set at a relatively high temperature to heat those areas that are naturally cold and TRVs used to restrict the heat being delivered to the warmer areas of the building.

The air temperature near the base of a radiator (that is, near the location of the integral TRV) may not be a reliable indication of room temperature. Therefore, ideally, electronic TRVs should be combined with a room sensor to control their operation.

It is a common misconception that fully turning up a TRV will result in a room heating up more quickly. In reality, it does not. Unfortunately, this action often resutls in the room overheating later on in the day. A TRV's function is simply to open a valve and then close it once the desired room temperature has been reached. The use of your TRVs and the cost of misuse should be explained to staff.

Zone controls

Top Tips

Zone controls are a more sophisticated way of varying the temperature in a building. If your heating system was constructed without zoning, then some modifications to the plumbing system will be required to introduce zone controls.

Once these controls are in place, the temperature in each zone will be measured by separate sensors. This information will be used by the controller to open or shut valves to distribute heat into any areas where the temperature is below the set temperature. Once any particular zone reaches the design temperature, the valve will shut so that the boiler has less work to do, thus saving energy and money.

Zone controls should be fitted where there are variations in occupation between different areas of a building – for example, the factory may work a second or third shift whereas the administration services operate 09.00 – 17.00. This will allow occupied areas of the building to be heated while avoiding heating unoccupied areas.

5. Boiler replacement

5.1 Replace boilers with efficiencies below 80%

Many SMEs use smaller, domestic-sized boilers. The efficiency of smaller boilers of any fuel type can be determined by visiting the Product Characteristic Database (www.ncm-pcdb.org.uk/sap/pcdbsearch.jsp?pid=26).

All domestic-sized boilers sold in the UK now have to be A-rated, with efficiencies of 90% and above. Any boiler manufactured prior to 1997 is likely to be inefficient and should be replaced. Newer boilers reaching the end of their life are also likely to be less efficient. Reliability is also a cost issue for SMEs as employees need adequate heat to work efficiently. Therefore, replacing a malfunctioning boiler with a new and efficient model makes sound business sense.

Worked example – Boiler replacement

Current boiler	***New boiler***
Boiler efficiency – **80%**	*Boiler efficiency –* **92%**
Annual space heating energy use – **150,000kWh**	*Annual space heating energy use –* **130,435kWh**
Heating fuel – **Gas**	*Heating fuel –* **Gas**
Cost of fuel/kWh – **£0.04**	*Cost of fuel/kWh –* **£0.04**
Annual space heating cost – **£6,000**	*Annual space heating cost –* **£5,217**
Cost of boiler replacement – **£4,500**	*Payback period (4,500/783) –* **5.75 years**
Annual saving – **£783**	*Other identified benefits –* **Improved reliability of boiler Reduced maintenance costs**

** All costs are net of VAT*

Case study
Cardross Golf Club

Cardross Golf Club is an 18 hole, parkland course located by the river Clyde near Dumbarton. The gas boiler in the clubhouse was over 20 years old and was suffering reliability issues. An inspection from an engineer led them to believe that the boiler was operating at a very low efficiency.

We helped the Club prepare a business case for a replacement boiler unit. The boiler replacement project was funded through an SME Loan. In addition to the replacement of the boiler unit, we recommended that additional advanced controls should be installed. These included timing and zone controls the Club now has the capability to save energy by selectively heating parts of the clubhouse when the building is not fully occupied and to match heating times to clubhouse use.

The savings from installing a new gas condensing boiler are expected to be around £3,000 per year, with additional savings anticipated from the installation of the advanced control systems."

"... I would encourage all businesses to replace inefficient boilers and controls. The savings on your heating bill will justify the investment."

Graham Mill
Club Secretary

5.2 Fuel switching and the Renewable Heat Incentive

When replacing a boiler, it is also worth considering fuel switching. This provides the opportunity to move from expensive fuels, such as oil, LPG or electricity, to less expensive and more environmentally friendly forms of heating such as biomass or heat pumps.

Fuel switching is particularly relevant to SMEs that are not connected to the gas grid. Oil and LPG are expensive, and electric resistance heating is even more costly. However, there are lower cost options.

Under the non-domestic Renewable Heat Incentive (RHI), subsidies are available for ground source heat pumps (GSHP) - including water source heat pumps, ASHP (air to water systems only) and biomass boilers.

5.2.1 Ground source heat pumps

GSHPs take low-grade energy from the ground and convert it to higher grade energy for use in heating by means of a heat pump.

It is important to recognise that as the pump is powered by electricity, this is still an electrical form of heating, though much more efficient than electrical resistance heating (such as storage heaters or bar fires).

However, in addition to a higher installation cost, there are various constraints:

- GSHPs work best where there is a low-temperature distribution system, such as underfloor heating and where the building is well insulated; and
- space is required outside for a collector loop – this may be a horizontal loop or a vertical loop, depending on availability of space and ground conditions.

It is worth noting that, without taking into account any RHI subsidy, natural gas is similar in running costs and carbon emissions to that for most heat pumps.

Case study
Glengarry Castle Hotel

Glengarry Castle Hotel is a 26-bedroom hotel in the Scottish Highlands. The large, traditional stone building was built between 1866 and 1869. It was refurbished in the early to mid-1930s when the central heating and hot water systems were updated. Most of the radiators are original cast iron with some modern steel additions.

The hotel recently installed two 37kW ground source heat pumps, connected to the existing radiator and hot water systems. There are 12 boreholes of 125m depth which give Glengarry Castle Hotel a total ground loop of over 3,000m.

Glengarry Castle Hotel now has an 'always-on' heat supply which will give it a more even temperature throughout the year, while offering substantial cost savings over previous oil-fired boilers.

Glengarry Castle Hotel is part of the Green Network for Businesses.

5.2.2 Biomass boilers

Biomass boilers may be suitable if your site has a relatively high and constant heat demand. For example, older buildings in constant use, such as cottage hospitals or certain forms of agriculture (such as chicken farms). Because these have a constant demand for heat, they would justify the high installation cost of a biomass boiler. Without RHI subsidy, fuel costs are similar to those for natural gas.

However, as biomass is a renewable resource, its carbon emissions are very low, as long as the feedstock is sustainably produced and not transported a great distance.

All forms of renewable or low carbon heating can have positive corporate social responsibility (CSR) impacts and can also be used to encourage employees to become more aware of sustainability issues at work and at home.

Further support

Biomass procurement support guide

Many organisations are looking for ways to reduce their long-term energy costs, carbon footprint and exposure to fluctuations in the cost of fossil fuels. Biomass is a good way of doing this as it produces low carbon heat at a reduced cost compared with that for conventional forms of heating. However, with a host of technologies and fuel supply options to choose from, finding the solution that will work best for you can seem daunting.

If you are looking to start a biomass project or want help with one that is underway, this guide will help. It gives clear step-by-step guidance and all the information you will need.

Download this guide from our website

This will help you to avoid common pitfalls and to end up with a biomass system that best fits your organisation's needs.

6 Reduce heat losses

The most sustained and effective way to reduce the cost of space heating is to reduce heat loss. This section provides various actions you can take to save money by reducing heat loss from your premises.

6.1 Reduce uncontrolled air leakage

Air leakage can be one of the largest sources of heat loss. Many commercial buildings are not maintained effectively and suffer from draughts, which introduce cold air and drive out warm air. Draught-proofing is relatively cheap and, although it is often ignored in favour of more expensive, technological solutions, it is one of the most cost-effective ways of reducing the demand for space heating as it reduces heat loss.

6.1.1 Doors

The temperature in the area around an open door will quickly reduce. This can make the environment particularly uncomfortable for receptionists who often have to be located near external doors. Inexpensive and simple-to-fit self-closers will reduce heat losses and, thus, heating costs. It will also make the environment more acceptable to staff working in these areas.

Doors commonly suffer from draughts under the bottom rail – usually because the door has been set or undercut to allow clearance for floor coverings. This can be remedied by fitting a brush strip.

A top-down flow of air (known as an air curtain) can be used in certain circumstances to reduce heat loss at doorways as it provides a separation between heated and unheated space. However, a door is a much more effective air seal and air curtains themselves use electrical energy, so good control is needed to ensure that they only operate when necessary and when doors are open.

If you have a warehouse with roller doors, automatic fast-closing mechanisms can be fitted to stop heat loss by ensuring the doors are only open for as long as they need to be. The doors can be controlled remotely or automatically by sensors. These will detect when a vehicle, such as a forklift truck, approaches the door and then trigger the door-opening mechanism. The door will close again when the area is detected as being clear for a pre-set length of time.

6.1.2 Windows

Most windows can be draught-proofed quickly using adhesive foam tape. This is a simple and cost-effective way to reduce draughts and improve the comfort of building users.

Sash windows can also be draught-proofed very effectively. However, this is a specialist job as the sliding sashes have to be removed and brush strips routed into the frame and the sashes.

6.1.3 Other draughts

Draughts also arise from other areas of a building including floors (especially where old butt-jointed floorboards form suspended floors), the floor/wall junction, services entrance points and chimneys.

Flexible sealants are particularly effective around frames and at other junctions between materials where there is likely to be movement in the future (for example, where skirting boards meet the floor).

All these routes for air ingress provide ‘natural’ ventilation, so when sealing up the building it is very important to ensure that sufficient ventilation is still provided. This is covered by the Building Regulations (Approved Document F). Failure to provide ventilation will result in poor indoor air quality and may even cause damp and associated mould growth.

6.2 Improve the thermal performance of building fabric

Compared to many other techniques, adding insulation to the building fabric produces the greatest and most enduring savings in energy use and costs. However, this strategy is often low on the priority list of projects because some measures can require considerable investment and payback periods can exceed 10 years. Indeed, where SMEs lease their premises, it is unlikely that they will be able to justify any investments in improving the thermal performance of the building fabric unless the majority of the cost is borne by the landlord.

When insulating and draught-proofing a building, the savings achieved will vary depending on whether the building was underheated in some way prior to the measure being installed. This is known as the 'comfort factor' or take-back – and recognises that the benefits from improvements to the building fabric will be improved conditions for occupants and/or reduced energy bills.

6.2.1 Roof

It is not unusual for commercial buildings to have completely uninsulated roofs. Sometimes, insulation may be present at rafter level and the loft space is ventilated – which defeats the object.

Therefore, it is important to understand where the insulated shell of your building (the 'thermal envelope') lies. If there is an opportunity to add insulation to an uninsulated flat ceiling and there is reasonable access, this is likely to pay back the investment within 5 years.

6.2.2 Walls

If cavity walls are present, then they can be filled with insulation. This measure is common in domestic buildings and there is no reason why it should not be applied to all cavity-wall buildings. Evidence from the domestic sector indicates that the cost of installing cavity-wall insulation will have a payback period of around 7 years.

For solid-walled buildings, insulation can be applied internally or externally and paybacks can exceed 10 years. Both strategies are expensive and have technical challenges depending on the complexity of the building. Solid wall insulation (SWI) is not possible in all cases due to a range of risk factors. Buildings with any kind of heritage value (including most traditionally constructed buildings) are unlikely to be appropriate for the retrofit of SWI and, at the very least, this should be approached with great care and in consultation with relevant experts. Visit www.stbauk.org for more information.

***Worked example** – Cavity wall insulation*

Current walls	***Insulated walls***
% of heat loss through walls – **25%**	*% of heat loss through walls –* **12.5%** *(50% reduction)*
Annual space heating energy use – **150,000kWh**	*Annual space heating energy use –* **131,250kWh**
Heating fuel – **Gas**	*Heating fuel –* **Gas**
Cost of fuel/kWh – **£0.04**	*Cost of fuel/kWh –* **£0.04**
Annual space heating cost – **£6,000**	*Annual space heating cost –* **£5,250**
Cost of cavity wall insulation – **£3,500**	*Payback period (3,500/750) –* **4.7 years**
Annual savings – **£750**	*Other identified benefits –* **Improved thermal comfort**

** All costs are net of VAT*

*** Assumes heating controls are responsive to reduced heat demand to deliver savings*

Case study
Colintraive Village Hall

Colintraive Village Hall is situated in Argyll. As it was becoming too expensive to heat the hall to a comfortable temperature, cavity wall insulation was fitted, along with a number of energy efficiency improvements and the installation of three air-to-air heat pumps.

These improvements reduced Colintraive Village Hall's annual energy bills by over half, including all heating and electricity, from £944 to £410. This process has taken them from an energy efficiency performance rating of G to D, and also reduced their annual CO_2 footprint from 4.39 to 1.46 tonnes of CO_2.

Colintraive Village Hall is part of the Green Network for Businesses.

6.2.3 Windows

In addition to draught-proofing windows, there are further savings to be achieved from window (and door) replacement. Savings will be greatest where windows are single glazed and in poor condition.

The savings available from replacing even early double-glazed units are unlikely to justify the investment, although there may be other benefits in terms of appearance or acoustic performance.

The majority of the savings to be gained from window replacement can also be achieved by a combination of secondary glazing and the use of blinds, curtains or shutters. Secondary glazing is a particularly cost-effective way of reducing heat losses as glazing technology has developed recently and removable panels have also become more common.

6.2.4 Floors

Retrofitting insulation to floors is a costly and disruptive exercise. If the floor is suspended, then it is possible to add insulation beneath the existing floor surface. This can be achieved by taking it up and relaying it or from below if there is suitable access. Solid floors can have insulation added on top, but this raises the finished floor level and gives rise to issues at doorways. Because heat rises, the heat loss through floors is less than that lost through roof, walls and windows, so it is unlikely that a rapid payback will be achieved if floor insulation is fitted.

It is important to review heating controls whenever building fabric is upgraded in any way as heat demand will have fallen, but not uniformly throughout the building. Unless the system can respond to these reductions in demand, areas of the building may become overheated and the full potential savings will not be achieved. See Section 4 on heating distribution and controls. Ventilation should also be reviewed when making alterations to heating systems and to building fabric.

7 Making the case for measures to reduce energy use for space heating

This guide has outlined a range of opportunities to save energy and money on space heating. Most organisations in Scotland will be able to benefit from one or more of these opportunities.

Some measures (such as making alterations to heating set points) are free, some are low cost and others will require considerable investment.

Whether your organisation will be prepared to make these investments depends on the availability of capital. It will also depend on your investment horizons. For example, improvement measures with longer term payback may only be attractive if your organisation owns the building or has a long lease.

This section provides some simple advice that will help you make the case for measures to reduce space heating costs in your organisation.

7.1 Ensure that costs are realistic

First, it is essential to get realistic project costs when preparing a business case. This is best done by getting estimates from contractors. However, it is essential to set out clearly what you require so that all contractors can estimate from the same basis. Contractors usually know more than the clients about the complexities and pitfalls of particular jobs, so they will often advise you of the best ways to set out your requirements.

The costs for relatively simple tasks, such as adding improved controls to a heating system, can usually be estimated without any further work needing to be done. However, more complex jobs, such as boiler replacement or upgrades to building fabric, will require a specification that sets out the exact extent of the work to be carried out.

In the case of fabric alterations, this may include changes to services and usually requires redecorating. It is also important to allow for associated works to ventilation systems or to heating controls following fabric measures.

7.2 Ensure that estimated savings are transparent

The estimated savings from space heating efficiency measures should also be as accurate as possible. However, calculating accurate savings from space heating improvements is a complex task.

There are a number of reasons for this, including:

- the building may be heated to a higher temperature after the upgrade measure has been installed (the 'comfort factor');
- measures interact – for example, if a control improvement measure is introduced then the savings from boiler replacement would be reduced;
- modelling cannot be relied upon to give accurate results – most models overestimate the energy used for space heating and the cost savings to be achieved from remedial measures;
- buildings are not homogenous – they have often been added to over time, so the fabric and heating systems may not be the same in all parts of the building; and
- there are many other variables in terms of how buildings are used and these can change in the future.

For all these reasons, published data on energy savings arising from improvement measures are hard to find. In addition, as buildings and the way they are used vary so much, the savings achieved by one organisation may not be replicable in another. Therefore, even published data cannot usually be used as the basis for your own calculations.

The best way to proceed is to be transparent and to set out all assumptions being made in your calculations.

7.3 Identify any non-energy costs and benefits

Measures to reduce the energy used for space heating can have other costs and benefits, so it is important to identify these and bring them into the overall assessment of a project.

For example, reducing draughts and raising comfort levels may result in improved productivity and a healthier and more enjoyable environment for employees and visitors. Improvements to windows can deliver reductions in noise levels as well as reducing heat loss.

Similarly, there can be costs associated with efficiency measures where there is disruption to the working environment. For example, a door is fitted in a corridor where there was no door before, thus slowing people down. Of course, by consulting with employees at an early stage, these issues can often be identified. Careful management of the process can then control these costs or introduce other measures to avoid them altogether.

Once any additional costs and benefits have been identified, these can be included in your overall business case.

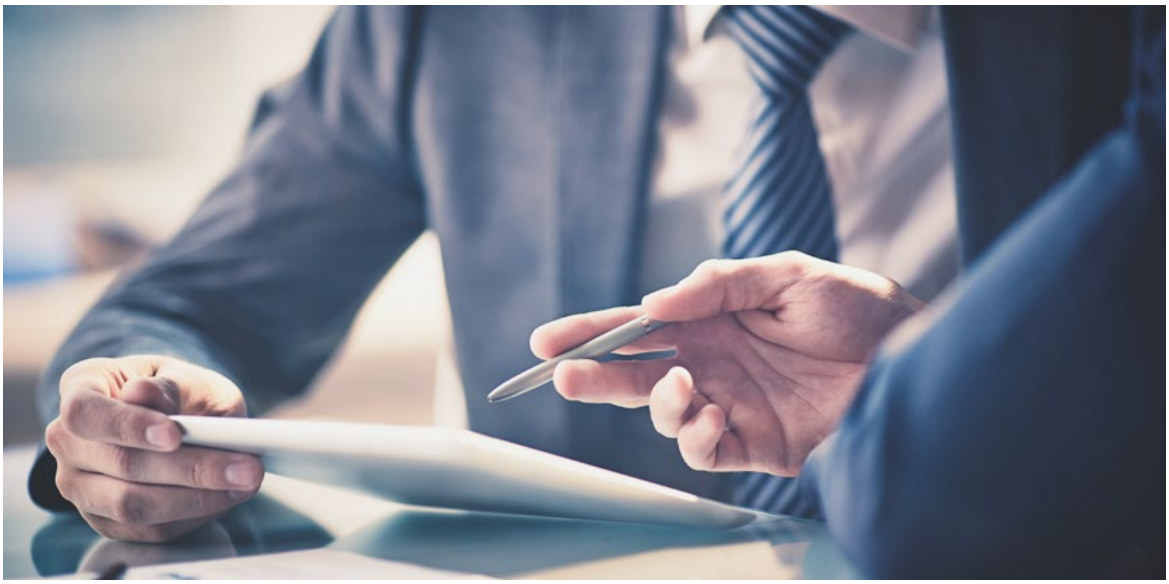
7.4 Present the business case clearly

The business case needs to be presented in a way that is accessible to managers and to the finance department, and speaks the language of the decision-makers.

Estimated costs of a proposed installation should be backed up by cost estimates from contractors. Potential measures should have estimated energy and cost savings clearly set out alongside all the relevant assumptions made. The payback period can then be calculated. Any associated costs and benefits (often non-monetary) should also be included at this point, including any marketing or CSR benefits that could arise.

Further support

If you wish to improve the space heating in your organisation by implementing some of the measures outlined in this guide, it is likely you will need to access finance. Whether the finance is from internal or external sources, Zero Waste Scotland's guide 'Developing a business case for your energy efficiency projects' will help you. It will show you how to prepare a robust business case to support your proposed investment and how to present a case for investment to your senior management or external lenders. You can download the guide from our website.



8. Make the savings with free one-to-one advice and support

Our team of experienced advisors has helped hundreds of organisations across Scotland improve their space heating and reduce associated energy costs.

We understand that it can take time and experience to implement the types of projects outlined in this guide. That is why we can provide you with specialist advice; access to funding and suppliers; and in-person, on-site support to help you save money on energy, water and raw materials.

If you would like help finding savings or implementing projects that you have already identified, please contact the team on 0808 808 2268 or email EnergyEfficiency@zerowastescotland.org.uk.

The Green Network for Businesses

Learn from neighbouring organisations that have already taken action to improve their space heating.

The Green Network for Businesses gives you the opportunity to visit a green business in your area to help you learn how they have cut energy, water, waste or raw material costs.

A range of businesses that have made changes to save money and resources are members of the network. This means that whatever saving measures you're interested in – and wherever you're based – we can arrange for you to connect with a network member in your local business community.

Find out more at: https://greennetwork.zerowastescotland.org.uk

Save money on your organisation's energy costs

Zero Waste Scotland's Energy Efficiency Business Support Service helps Scottish businesses to cut their energy costs by an average of 24%. Each year over 34,000 individuals from a range of organisations get in touch with us for impartial advice and free, specialist consultancy support.

Supporting Scottish organisations to be more energy efficient and reduce their carbon footprint will make a significant contribution to addressing the climate emergency and helping achieve the Scottish Government's strategic economic objectives as well as climate change and energy efficiency targets.

Funded by the Scottish Government and the European Regional Development Fund, the service offers free advice and technical support as well as sharing best practices and new technologies.

Our **free** advice and support is available to every organisation in Scotland. **How much could you save by . . .**

- installing new, high-efficiency lighting
- upgrading your heating system
- encouraging staff to be resource efficient
- insulating your premises
- improving processes
- using renewable energy

We're here to help

Call us on 0808 808 2268
Email: EnergyEfficiency@zerowastescotland.org.uk
Visit: www.energy.zerowastescotland.org.uk

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