MONEY SAVING BOILER CHALLENGE

MONEY SAVING BOILER CHALLENGE: SUPPORTING EVIDENCE OCTOBER 2022

About Nesta

We are Nesta, the UK's innovation agency for social good. We design, test and scale solutions to society's biggest problems. Our three missions are to give every child a fair start, help people live healthy lives and create a sustainable future where the economy works for both people and the planet.

For over 20 years, we have worked to support, encourage and inspire innovation.

We work in three roles: as an innovation partner working with frontline organisations to design and test new solutions, as a venture builder supporting new and early stage businesses and as a system shaper creating the conditions for innovation. Harnessing the rigour of science and the creativity of design, we work relentlessly to change millions of lives for the better.

Find out more at nesta.org.uk

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About the Money Saving Boiler Challenge

In 2022, Nesta launched the Money Saving Boiler Challenge. This campaign aims to help over one million households change their combi boiler settings to save energy this winter. Find out more at www.moneysavingboilerchallenge.com.

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1. Summary

This report summarises the evidence underpinning Nesta's Money Saving Boiler Challenge campaign.

In 2022, Nesta launched a campaign to help households save money by lowering the flow temperature on their condensing combi boilers to 60°C. Our evidence suggests that households could save about 9% on their total gas bill by doing this, assuming their flow temperature is currently set at 80°C.

For a medium-sized household with an annual gas consumption of 12,000 kWh, this would save 1,092 kWh of gas per year, which at current prices[1] equates to a saving of £112 per year.

We've based our stated 9% gas bill saving, and the advice to lower to 60°C, on multiple sources of evidence. Findings from real-world experiments and modelling both point toward a similar gas saving and similar impacts on room temperature.

We've chosen to recommend a flow temperature of 60°C for our campaign as our evidence suggests this temperature provides a good balance between an increase in boiler efficiency, a reasonable warm-up time and a strong chance that households are able to meet their heat demand whatever their situation or temperature preference. In our tests, lowering boiler flow temperature from 80°C to 60°C meant that the house took an extra 17 minutes to reach a comfortable temperature, and average internal temperatures was 0.5°C lower overall.

Households could make bigger savings by reducing flow temperatures even further, but in some cases, those that do so may need to readjust flow temperatures periodically in order to remain comfortable (for example, if there is a cold snap). Our campaign prompts those who are confident to do so to experiment with lower flow temperatures and see what works best for their home.

We have developed an online tool that shows people how to change their boiler settings. This has been rigorously tested with over 3,500 users. We are confident that the majority of digitally literate households will be able to successfully change their combi boiler settings with our online tool.

[1] 10.3p per kWh of gas, under the Energy Price Guarantee: Department for Business, Energy, and Industrial Strategy: Energy bills support fact sheet.

We have developed our campaign with vulnerable households in mind. We've specifically chosen a 60°C flow temperature to ensure warm-up times and room temperatures are suitable for households with vulnerable members who require warmer temperatures or more constant heating. We've also included advice in our online tool for people with vulnerabilities or those who may be helping a friend or relative with health conditions. We've suggested they try a slightly higher flow temperature to begin with, or to ensure the household knows how to adjust the flow temperature themselves in the future, should they need to.

Nesta is confident this advice will have a positive impact on households with combi boilers across the UK by helping them reduce their gas consumption and bills. It will also contribute towards lowering the UK's household carbon emissions.

2. Introduction

In 2022, Nesta launched a campaign to help one million households save money by lowering the flow temperature on their combi boilers to 60°C.

This document summarises the rationale for the campaign and the evidence that underpins it. It is aimed primarily at people and organisations that might want to advise members of the public on lowering flow temperatures, such as energy advisers, energy suppliers and gas boiler installers, as well as anyone else interested in the evidence that sits behind our campaign. It addresses common questions that advice givers raise, including:

- What's the evidence that lowering flow temperatures saves gas?
- Will this affect people's comfort in their homes?
- Can people do this themselves?
- What are the risks, and how can they be avoided or mitigated?

This document sits alongside our toolkit for advice givers, which explains what we have learned on how best to give this advice to the public, as well as the more detailed reports from the studies we have undertaken or commissioned.

3. Background

3.a What are flow temperatures?

The flow temperature is the temperature that a boiler heats water up to before it circulates around the radiators in a home. As this water circulates around the central heating system, some of its heat is transferred into rooms. When it comes back into the boiler to be reheated, this water is at a lower temperature, known as the return temperature.

It's worth noting that the flow temperature is distinct from the domestic hot water temperature (the temperature of water that comes out of the hot tap). Both the flow temperature and the hot water temperature can be changed using the buttons and/or dials on the front of the combi boiler.

3.b What's the principle behind lowering flow temperatures?

In 2005, condensing boilers were mandated in the UK. Condensing boilers are more efficient than traditional boilers because they capture and reuse energy that would otherwise be lost in gases that escape from the flue.

In order for these gases to condense, which allows the energy to be reused, the water returning to the boiler has to be below a certain temperature (around 54°C). The lower the flow temperature, the lower the return temperature will be and the more efficiently the boiler will run.

Most condensing boilers in use across the UK are set with flow temperatures of 70-80°C, which is too high for them to operate at their maximum efficiency. A boiler with a high flow temperature will also switch on and off more often when in use. This is called cycling, and increases wear and tear on the system.

3.c Why would boilers have flow temperatures that are too high?

A high flow temperature leads to burning hot radiators that can heat rooms up quickly. This is because heat transfers more quickly when there's a bigger temperature difference between the hotter body (in this case, the water in the radiator) and the cooler body (in this case, the air in the room that's being heated).

Many boiler manuals suggest using high flow temperatures on the basis that this will guarantee enough warmth and comfort regardless of property type and household preferences. Similarly, some engineers also set higher flow temperatures as they

believe it will lead to higher customer satisfaction, especially as many of us have come to expect hot radiators and quick warm-up times.

However, using a boiler in this way is not very efficient. It's a bit like driving at 70 miles per hour – you get to your destination quickly, but use a lot of fuel. Driving at 50 miles per hour takes a bit longer, but will get you to the same place on less fuel.

3.d Is this a new discovery? Why aren't we already reducing flow temperatures?

This isn't a new discovery but it has started receiving more attention in the last couple of years. This attention is largely down to efforts from people in the heating industry who have tried to bring it to wider attention. Recently, the UK government acted to ensure that all new heating systems are designed to run at flow temperatures of 55°C or below.

However, some installers, manufacturers and organisations that give energy advice have been cautious about recommending that people turn down their own boiler flow temperatures. This is because there was limited evidence about the impact of doing so in existing homes and they were concerned it could be unsafe or too hard for some people to do.

3.e Why just combi boilers?

Nesta's campaign is focusing on combi boilers that provide heating and hot water on demand, rather than boilers that have separate hot water cylinders. Combis are the most common type of boiler in the UK – there are around 15 million of them, compared to nine million boilers with separate hot water cylinders.

Households with both types of boilers can lower their flow temperature and make savings. However, where heating systems have a separate hot water cylinder, there is a risk of bacteria growing in the hot water cylinder if the householder accidentally lowers the hot water temperature rather than the flow temperature. Legionella bacteria, that can cause Legionnaires' disease, can survive and grow in warm water stored below 60°C. This is why organisations such as Which? recommend those with these types of boilers ask a heating engineer to make changes to flow temperatures. Households with separate hot water cylinders can safely lower their flow temperature to 65°C, although this means less significant savings.

As combi boilers don't store hot water and instead heat water on demand, there is no risk of legionella growing even if households lower their hot water temperatures to 60°C or below.

4. Strengthening the evidence for reducing flow temperatures

Nesta has sought to create a robust and detailed evidence base on lowering flow temperatures as an energy-saving measure. The work we have done and commissioned so far includes:

- Reviewing existing evidence on the impact of reducing flow temperatures. This work was carried out by Salford University.
- Measuring the impact of lowering flow temperatures in the Energy House at Salford University. The Energy House is a testing lab, including a traditional early 20th-century two-bedroom terraced house, set up in an environmental chamber.
- Estimating the proportion of UK homes that could successfully lower flow temperatures, based on modelling work by Cambridge Architectural Research.
- Modelling the savings and impact on room temperatures as a result of changing flow temperatures, in a range of different housing types with occupants and heating preferences. This work was carried out by Energy Systems Catapult.
- Running a trial to test the effectiveness of our online tool for lowering flow temperatures with customers of the energy saving app Loop. This work was carried out by Nesta and the Behavioural Insights Team, in partnership with Loop.

All these reports can be found on Nesta's website. There is still room to learn more, and we are continuing to do further research.

5. How much can homes save by lowering flow temperatures?

Our evidence suggests that households could reduce their total gas consumption by around 9% if they lower flow temperatures from 80°C to 60°C. Households can save more by lowering their flow temperature further. Many homes can be heated effectively with a flow temperature of 55°C or below.

5.a Energy House test results

Nesta commissioned the Salford Energy House to test how gas consumption for heating varies at flow temperatures of 80°C, 70°C, 60°C, 55°C and 50°C.

The Salford Energy House is a traditionally built, two-bedroom terraced house with solid brick walls, suspended timber floors and single-glazed windows with a conventional "wet" central heating system fired by a gas boiler. It has an energy efficiency rating of D (Energy Performance Certificate (EPC) ratings range from A (most energy efficient) to G (least energy efficient).

The Energy House is built within an environmental chamber that can simulate different temperatures and weather conditions. These tests were conducted with outdoor temperatures of 4.5°C, to simulate average UK winter temperatures. The heating was on for nine hours per day, from 07:00 to 09:00 and 16:00 to 23:00, with a thermostat set point of 21°C in the living room. Thermostatic radiator valves were used to limit the temperature to roughly 18°C in all other rooms, apart from the bathroom which was set to roughly 22°C. Further details of the methodology are included in the Salford University report.

Salford University calculated the savings in gas consumption that arose from reducing flow temperatures from a starting point of 80°C and 70°C. These savings are presented in Figure 1 below.

Figure 1 - Salford Energy House tests – gas saved at different flow temperatures of the boiler

Starting flow temperature	Reduced flow temperature	Percentage saving on gas used for heating only	Overall gas saving, assuming heating accounts for 75% of total gas use
80°C	70°C	5%	3.9%
80°C	60°C	12%	9.1%
80°C	55°C	16%	12.1%
80°C	50°C	23%	17.4%
70°C	60°C	7%	5.4%
70°C	55°C	12%	8.5%
70°C	50°C	19%	14.0%

This evidence suggests that homes that currently have their boiler flow temperatures set to 80°C could reduce gas consumption for space heating by 12% by setting their flow temperature to 60°C, or by 16% by turning down to 55°C.

We assume that homes use approximately 75% of their gas on heating[2], which means that these reductions in gas demand would result in overall gas consumption savings of 9% (for those turning down to 60°C) or 12% (for those turning down to 55°C).

5.b Other evidence

The Salford Energy House tests provide clear evidence that lowering flow temperatures reduces gas consumption. The tests were limited to one house type and one heating pattern. Nevertheless, several other sources of evidence have produced results that are broadly consistent with the Energy House findings.

Nesta commissioned Energy Systems Catapult to model the effects of lower flow temperatures on gas use across six different house archetypes and multiple occupancy profiles. The results from this modelling generally showed annual savings

[2] The Government's national statistics on energy consumption in the UK (2021 – table u3) indicate that 75% of domestic natural gas consumption goes toward space heating.

similar to, or slightly higher than, the Salford Energy House tests across different house archetypes and heating patterns (report forthcoming).

The Energy House test results are also broadly in line with Heating and Hotwater Industry Council's original calculations, which found that lowering flow temperatures could save 6-8% on total gas use over a year.

In practice, savings from reducing flow temperatures are generated partly by increasing boiler efficiency and partly from reducing heat demand (as a result of slightly longer warm-up times and, in some cases, slightly lower room temperatures). Modelling by Cambridge Architectural Research found that a medium-sized household could save approximately 3.6% on their gas bill purely through saving in boiler efficiency and a further 4.4% from the reductions in heat demand associated with turning down flow temperatures. Together, this results in a saving of 8% for a medium sized household as a result of lowering flow temperature from 75°C to 60°C.

5.c How much money will households save?

Based on the 9% saving on total gas use from reducing flow temperatures from 80°C to 60°C (reported above), we estimate that a medium-sized household with an annual gas consumption of 12,000 kWh would save 1,092 kWh of gas per year. At a price of 10.3p per kWh of gas (the Energy Price Guarantee unit rate for gas), this equates to £112 per year.

6. What happens to household comfort and room temperature when flow temperatures are reduced?

Lowering flow temperatures saves gas by improving boiler efficiency and slightly reducing the amount of heat transferred into rooms in the house. Our evidence shows that at a flow temperature of 60°C, any changes to comfort in the home are likely to be relatively small.

The changes that homes may notice as a result of lowering flow temperatures include the following:

- **Longer warm-up times** (as cooler radiators transfer less heat into the room each minute than hotter ones). The EPC D-rated Salford Energy House took

17 minutes longer to reach a comfortable temperature when the flow temperature was turned down from 80°C to 60°C.

- **Cooler room temperatures.** The Salford Energy House tests found average internal room temperatures to be about 0.5°C cooler over a 24-hour period, with a 60°C flow temperature, compared with a flow temperature of 80°C.

In our guidance we suggest that households who experience issues relating to slower warm-up times set their heating to turn on 15-30 minutes earlier than usual. Those that do so will still save energy as a result of reducing their flow temperature, but the saving will be a little less.

Modelling by Energy Systems Catapult confirms this. It suggests that the gas saving for heating from reducing flow temperatures was reduced by about 3-4 percentage points when heating time was extended by 30 minutes. For example, if a household saved 13% of its gas use by reducing flow temperature from 80°C to 60°C, putting the heating on for an extra 30 minutes would instead make this a 10% saving.

A positive change households may experience is a more consistent room temperature. At higher flow temperatures, heating systems can overshoot target temperatures, drop back below the target and overshoot again in a pattern. This happens as the room temperature is increasing so quickly that it continues to heat up even once the thermostat has signalled for the boiler to switch off. The more gradual warm-up associated with lower flow temperatures enables the heating system to more accurately maintain a temperature close to the thermostat set point. Preventing this overshoot will save energy,and could reduce any discomfort associated with overheating.

7. Can households successfully change boiler settings themselves?

Nesta has created a simple online tool to help people change their settings, based on extensive user research and testing. Our evaluation clearly shows that users are able to change their boiler settings and feel confident that they've done so correctly. Our research has included:

- Early user testing with 46 participants from Nesta and Carbon Co-op, which informed the development of a prototype online tool.
- Testing usability and comprehension with 165 participants that were broadly representative of the UK population. Qualitative and quantitative data from

this process helped us to further improve the tool. 77% of research participants said they would lower their boiler flow temperature based on the guidance.

- Field testing via a pilot randomised controlled trial where the tool was sent via email to 3,500 users of Loop, an energy-saving advice app. 34% of those who received the tool reported lowering their flow temperature two weeks later, compared to 19% in a control group. This was a statistically significant difference and suggests that the tool is effective in helping people to reduce their flow temperatures. Participants who used the tool rated the instructions 4.8 out of 5 for ease and 4.3 out of 5 for how confident they felt that they'd changed the settings correctly.
- Gathering ongoing feedback on the beta tool hosted on the Nesta website. Based on over 2,000 responses from people who have used the tool, we found that people rated ease and confidence 4.8 and 4.3 out of 5. They also rated the likelihood of sharing the tool with their friends and family 4.6 out of 5.

Given the testing we've done,and feedback we've received, we're confident that the majority of digitally literate households will be able to successfully change their boiler settings with our online tool. Nesta has also developed a printable leaflet that explains how to lower flow temperatures to help households that are digitally excluded.

8. What risks might arise and how can they be mitigated?

8.a Legionella

Legionella is a bacterium that can survive, grow and reproduce in water stored at temperatures between roughly 20°C and 50°C. Contaminated water droplets, if inhaled, can cause people to develop Legionnaires' disease. Cases are very rare in the UK. The three-year mean number of confirmed cases in England and Wales was 459 cases per year between 2017 and 2019. 40% of these cases were contracted abroad.

The risk that reducing boiler flow temperatures will encourage legionella growth, or cause Legionnaires' disease itself, is very low and we are managing this in the following ways:

- Focusing the campaign on combi boilers, which do not store hot water, and therefore don't provide a space for legionella to survive or grow. Our online

tool screens out users who have hot water cylinders (or who are not sure whether they have a hot water cylinder or not).
- Focusing on reducing radiator temperatures, rather than the temperature of the water that comes out the taps.
- Recommending flow temperatures of 60°C, so that even if a household with a hot water cylinder did take part and changed the wrong setting (reducing hot water temperature instead of flow temperature), this would still be high enough to kill off legionella bacteria.

8.b Colder homes

Many households won't notice a difference to their comfort as a result of lowering flow temperatures. The main difference people might experience is a slight increase in the time taken for the house to reach the thermostat temperature. This can be easily mitigated by setting the heating system to start 15-30 minutes earlier than usual. This will slightly lower the energy savings associated with a lower flow temperature, but it should still save energy. We've also advised households to increase their flow temperature by 5°C if their heat demand still isn't being met after increasing their heating time.

Some households may also find it harder to reach their target heating temperature at lower flow temperatures, especially if they have a poorly insulated home or prefer particularly warm rooms. The extra advice above should help those in this situation, but we've also tried to mitigate this from the start by advising a flow temperature of 60°C. This temperature is a good balance between an increase in boiler efficiency, a reasonable warm-up time and a strong chance that households are able to meet their heat demand whatever their situation or temperature preference. Nevertheless, it's important that if households are not comfortable with lower flow temperatures, they are able to readjust them.

8.c What about vulnerable households?

A Public Health England (PHE) review states that heating rooms to at least 18°C in winter poses minimal risk to health. Tests in the Salford Energy House have shown that time taken to reach 18°C is similar at flow temperatures from 55°C to 80°C.

For people over 65, or with pre-existing health conditions, PHE finds that slightly higher room temperatures may be beneficial for health. Again, the Salford Energy House tests found the average living room temperature was above 19°C at all flow temperatures except 50°C, in both the morning and evening heating period.

However, to be on the safe side, we've recommended a flow temperature of 60°C. This will ensure that the home will reach the target temperature more quickly than it would on lower flow temperatures, reducing the amount of time spent below the target temperature. It will also make it more likely that households who live in poorly insulated homes, or those who require particularly warm temperatures for their health conditions, are able to meet their heat demand.

Within our online tool we've signposted that someone using the tool to change the temperature for a household with a vulnerable member may want to start with a slightly higher flow temperature before lowering it further, or ensure the vulnerable member of the household is able to turn it back up themselves if they need to.

8.d What about households that are energy rationing?

Households that are energy rationing by heating for shorter periods of time can still benefit from lowering their flow temperatures. They could either make savings by doing so, or heat their home for a little longer for the same amount of money.

However, we wouldn't recommend that households that are currently only heating one room lower their flow temperature. This is because preliminary results from the modelling we've commissioned from Energy Systems Catapult suggest that this may actually lead to a slight increase in gas use (report forthcoming). More information about tailoring advice to households that are energy rationing is available in our toolkit for advice givers.

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