SUSTAINABLE ENERGY ASSOCIATION

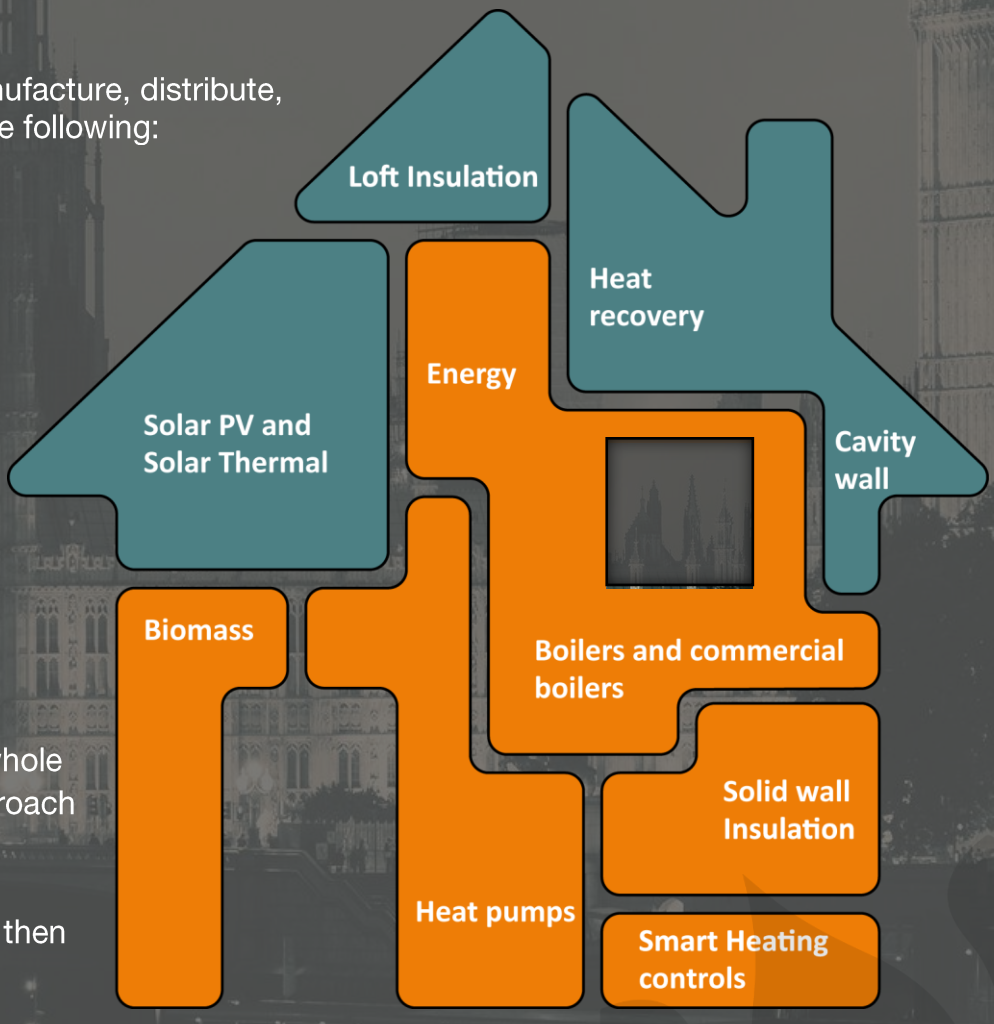
Sustainable Energy Association

Heating System Plus Policy Position Paper

The Sustainable Energy Association

The Sustainable Energy Association (SEA) is a member based industry body offering innovative policy solutions that link up building-level technologies and the wider energy system to achieve a low carbon, secure energy future for the UK, benefits for UK consumers, and commercial growth for businesses working in the sector. Our membership is comprised of a wide range of organisations that engage to develop our policy positions, establishing member-led working groups and a governing body of members to discuss and authorise policy positions that have real commercial impacts.

SEA members manufacture, distribute, retail or regulate the following:



The SEA takes a whole house holistic approach starting with the building fabric. We champion “wrap it then heat it”.

Summary

The SEA supports "Heating System Plus" a progressive, pathway approach to improve heating system efficiency through a series of staged improvements in installation practices. The four stages proposed by the SEA have the ability to provide substantial additional benefits, whilst still being readily achievable and consistent with other policy areas. This upgrading of domestic heating can be considered a pathway with gradual improvements made over time which will provide much needed direction and stability for the industry.

Stage 1

Require all boiler installations to include a boiler with minimum ErP space heating efficiency of 92% and:

- modulating heating controls in line with relevant ErP classifications, for example through weather compensation control or a modulating room thermostat with load compensation (ErP Class II or V respectively) in order to achieve a minimum ErP package value of 95% **or**
- weather compensation plus at least one additional measure from the following: smart heating controls, TPI, FGHR or TRVs in all rooms except room with thermostat.

Require all heating systems to be hydraulically balanced.

Stage 2

In new build installations, *require* return temperatures to be less than 55°C rather than "preferable" as currently stated in the Domestic Building Services Compliance Guide (DBSCG)[1]. This will involve requiring the assessment of radiators/heat emitters to ensure optimum sizing and water temperature in line with current established design guidance.

Stage 3

Apply requirements of Stage 2 to retrofit. If necessary the radiators/heat emitters should be changed to comply with the above need for the return temperature to be less than 55°C, where cost effective.

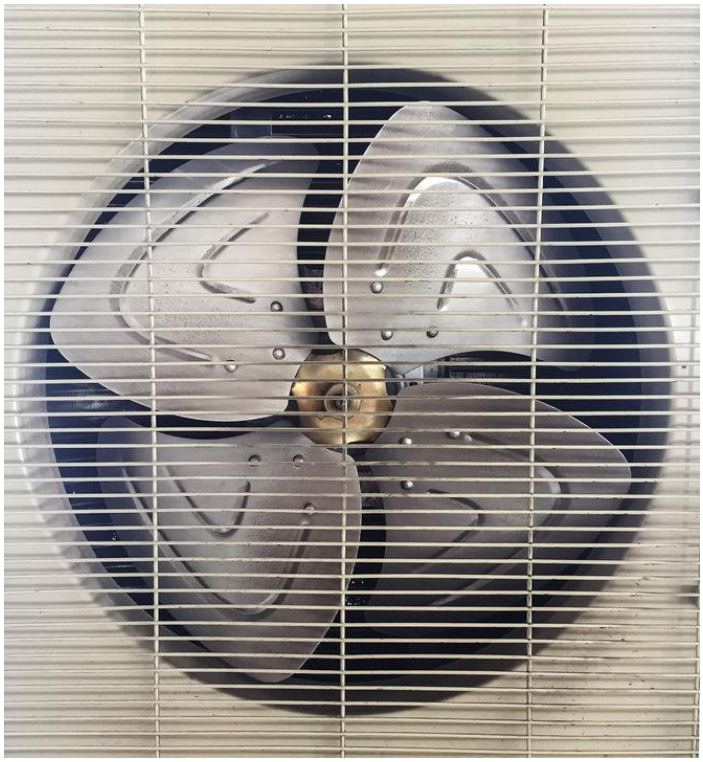
Stage 4

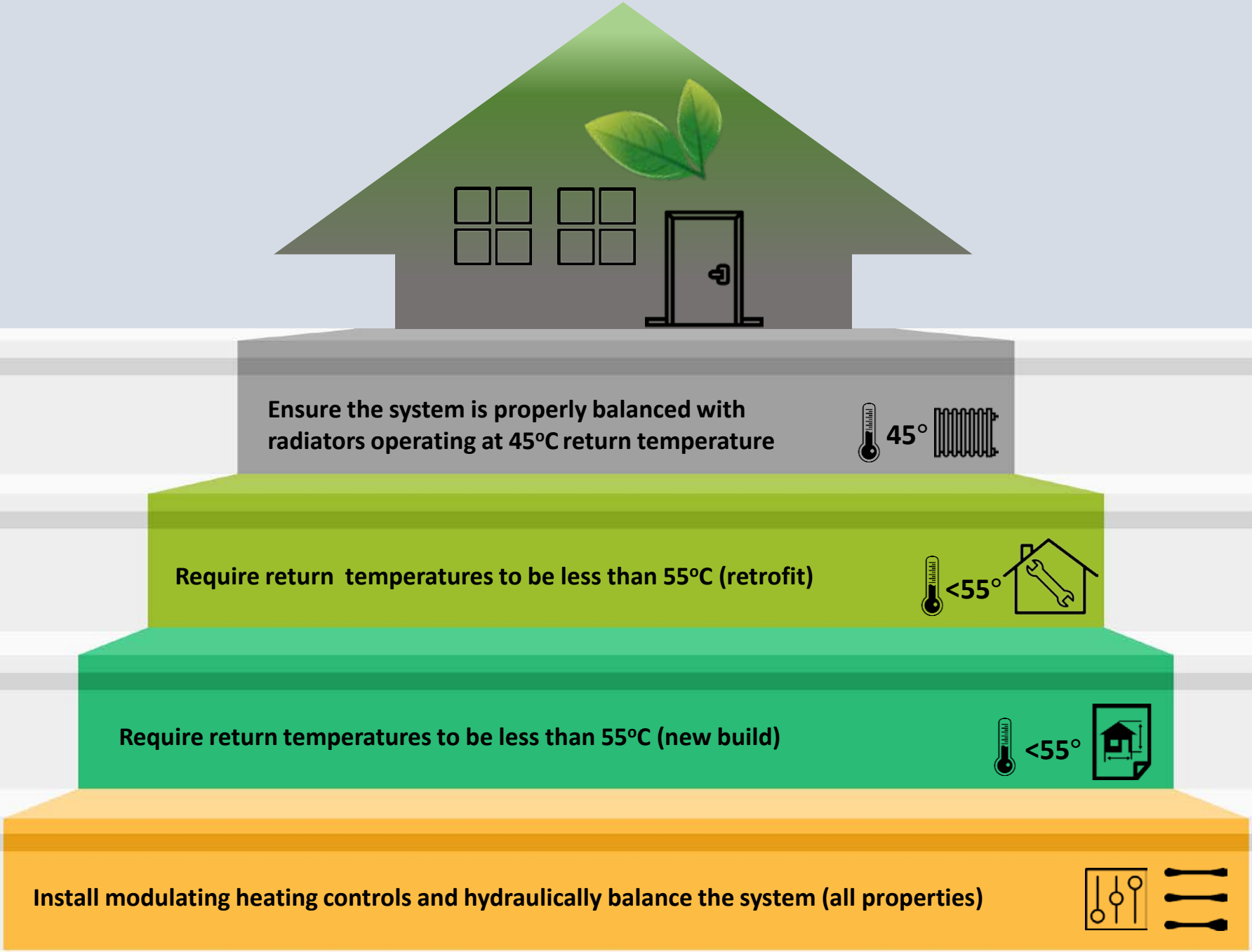
Where radiators have to be changed to allow a properly balanced system to operate to a return temperature of under 55°C recommend radiators be fitted that are sized to operate at 45°C return temperature.

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/453968/domestic_building_services_compliance_guide.pdf

This staged approach provides a stable and substantial regulation timetable, which maps out the strengthening of efficiency requirements for residential boilers as technology improves, and supports the deployment of future-proof heating infrastructure making it “renewables ready”. The clear setting out of a pathway to improve heating system efficiency will allow industry and installers to prepare and innovate for forthcoming changes to regulation.

The paper also outlines the consumer, installer and industry journeys throughout the proposed timeline. Boilers are often retrofitted in the case of boiler breakdown and therefore the consumer will already face some disruption but the addition of these extra stages should not lead to significant disruption. A long-term policy signal creates the certainty and consistency required by the private sector to invest and deliver the technologies that will help drive down energy bills and carbon emissions. The products captured throughout the SEA’s proposal are readily available to the mass-market therefore none of the technologies require significant innovation, increases in production capacity or learning. Installers should already be familiar with the technologies and installation best practice.




Ensure the system is properly balanced with radiators operating at 45°C return temperature
45°
Require return temperatures to be less than 55°C (retrofit)
<55°
Require return temperatures to be less than 55°C (new build)
<55°
Install modulating heating controls and hydraulically balance the system (all properties)

Heating System Plus background

The action to set higher standards for boiler efficiency within Building Regulations was very successful in 2005 and was the driver for the mass roll out of condensing boilers. However, more than ten years later technology has progressed but standards remain the same. In addition, there is no legal requirement for heating systems to be modified and balanced as appropriate to ensure boilers perform to optimum efficiency when in situ. This means that there is a lost opportunity as customers investing in new heating systems may not achieve optimum fuel bill and carbon savings. To install a new heating appliance and then not optimise the overall system operation is wasteful in terms of both energy and carbon and the consumer is unlikely to be aware that the operation of the new system is not optimised.

SEA supports "Heating System Plus" a progressive, pathway approach to improve overall heating system efficiency through a series of staged improvements in installation practices that will ultimately pave the pathway for future low carbon heating systems. The underlying principle behind Heating System Plus is that heating systems should be made "low carbon technology ready" whenever this is possible and cost effective. Key to this is to use the disruption afforded by the need to install a new boiler to make other changes to the heating system to ensure the high efficiency capabilities of modern boiler technology is fully exploited.

Heating systems in buildings will only be installed around once every 10-15 years so the opportunity to make the system as efficient as possible must be taken otherwise the opportunity will normally be lost for at least another decade. In new-build the opportunity is even more apparent as the cost of implementing these measures when a property is constructed will be less than for retrofit and the opportunity to install at the time of build will be lost for many decades if not taken.

What should the Heating System Plus policy achieve

The Government now has the opportunity to develop a regulation roadmap, reducing consumer's energy bills and carbon emissions and leaving a legacy of more efficiently heated homes.

Given the significance of climate change and fuel poverty it is clear that any policy that can act to reduce the impact of these hazards, should do so to the greatest extent possible. This is the concept of policy **additionality;** any government intervention should seek to have the greatest positive impact on the targeted public, and mitigate any unwanted negative impacts. In this sense the Heating System Plus policy should seek to improve system efficiency and lower fuel bills and carbon emissions as much as possible.

This can be achieved by a stable and substantial regulation timetable, which maps out the incremental strengthening of minimum requirements for heating system installations as technology develops, and supports the deployment of future-proof heating infrastructure.

Given cost implications and the need for consumer acceptance, the stages in this roadmap should be considered and gradual. It is important to develop the Heating System Plus policy with a good understanding of what is **achievable**. These proposals take account of the consumer, installer and industry *journeys* and provide considered stages which can be achieved cost-effectively by each actor.

Finally, the policy should be **consistent** with other Government schemes and objectives. In particular the development of able-to-pay and less-able-to-pay energy efficiency policy, the roll-out of smart meters and the strategic vision for the role of low-carbon heat in helping the UK lower average energy bills and emissions.

The key to developing a successful Heating System Plus policy, is to simultaneously promote regulation that provides substantial **additional** benefits in the form of reduced energy bills and emissions, whilst still crucially being readily **achievable** and **consistent** with other policy areas. Heating System Plus can achieve these objectives.

The need for Heating System Plus

The Department of Energy and Climate Change (now part of Business, Energy and Industrial Strategy) produced a departmental plan for 2015 to 2020 which cites keeping household bills low as one of the 4 core objectives of energy policy. Indeed high energy bills seen in the UK have had an adverse impact on householders struggling to power and heat their homes. With high bills comes a higher threat of fuel poverty, and with it a greater exposure to ill health as a result of poorly heated properties. Age UK estimate that illnesses caused by cold homes costs the NHS in excess of £1.36 billion a year in hospital and primary care[2]. It is estimated that there were 2.3 million households in fuel poverty in England alone[3] and 43,900 excess winter deaths occurring in England and Wales in 2014/15, the highest number since 1999/00, of which the majority occurred among those aged 75 and above[4].

Fuel poverty can be tackled by helping households lower their energy bills. The installation of measures that enable heating systems to operate efficiently, creates a significant opportunity to reduce the amount of energy needed to heat homes. The lower the consumption, the lower the fuel bill, which provides substantial benefits to UK householders. Lower residential heating demand also benefits the UK through reduced energy imports and thus greater security. Currently the UK imports nearly half of the total energy consumed[5]. Ensuring that our heating systems are operating efficiently lowers the country's exposure to and demand for foreign imports that could vary in price and availability in the future and be subject to currency risk. This reduction in risk is valuable in itself. In addition to affordability and security benefits, the UK is legally bound to achieve its 2050 target of reducing carbon emissions by 80% - compared to 1990 levels. Building emissions, primarily those from heating, accounted for 18% of all emissions produced by the UK in 2015[6]. The independent Committee on Climate Change (CCC) is mandated to set a number of stepping-stone carbon budgets to help the UK reach its target cost-effectively.

The CCC is concerned that the progress on reducing the emissions from buildings has continued to stagnate into 2015 and therefore has recommended that standards are introduced to ensure that new build properties are highly energy efficient. Moreover, they advocate a stronger policy framework to drive residential energy efficiency by addressing policy gaps as shown Figure 1. The CCC predict that given their assessment of current and planned policies, the UK will miss its 4th carbon budget which runs up until 2027.

[2] Age UK (2012) The Cost of Cold: Why we need to protect the health of older people in winter.
[3] DECC (2015) Annual Fuel Poverty Statistics Report
[4] Office for National Statistics (2015) Excess Winter Mortality in England and Wales : 2014/15 (Provisional) and 2013/14 (Final)

[5] Net imports at 45% and UK production at 55%. Source: DECC (2015) https://www.gov.uk/
[6] Committee on Climate Change (2016) Progress Report

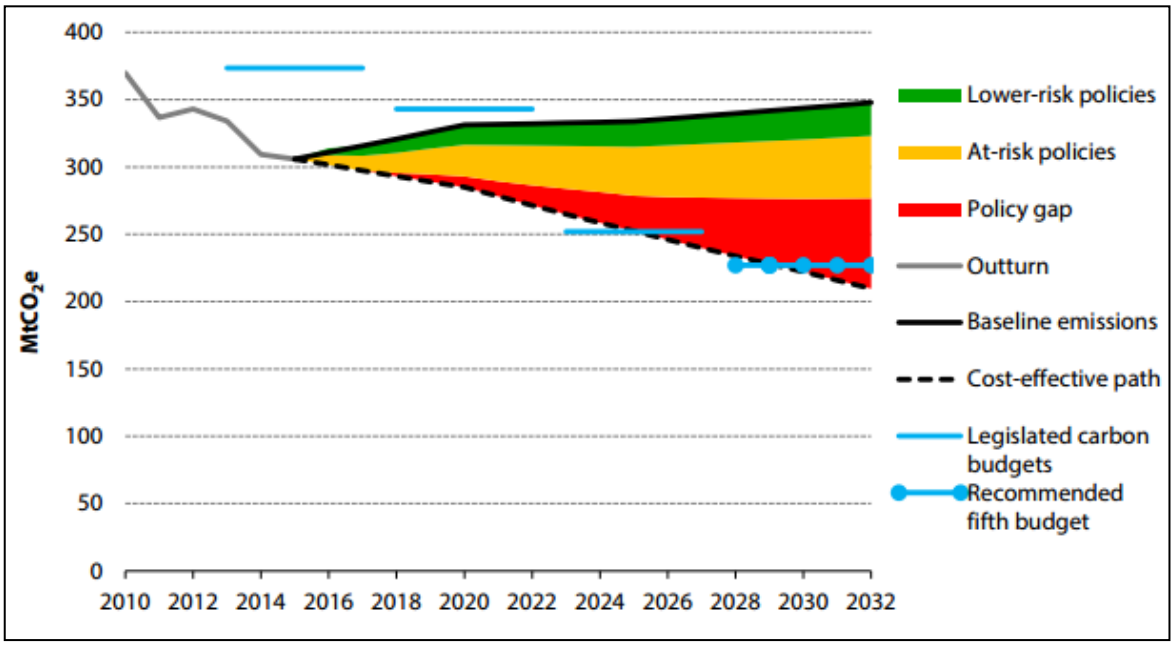


Figure 1 - Assessment of current & planned policies against future targets (non-traded sector) (Committee on Climate Change, 2016[7])

Source: DECC (2015) Updated energy and emission projections 2015; CCC analysis

As box 1 shows despite clear rationale for many households to invest to improve or replace their inefficient heating system, a number of financial and non-financial barriers can prevent this from happening. The Government thus has a clear mandate to address these market failures, improving heating system efficiencies, protecting consumers, reducing the UK's energy consumption, carbon emissions and helping to lower householder's bills. These barriers must be acknowledged and addressed in order to maximise the benefit derived from the Heating System Plus policy. In general end-users are unaware of the energy saving potential of their heating systems as they are often only concerned about system performance which suggests that as long as the system realises the desired indoor temperature, the end-user is not concerned about optimisation measures[8].

[7] Committee on Climate Change (2016) Meeting Carbon Budgets – 2016 Progress Report to Parliament
[8] Ahern and Norton (2015) Energy savings across EU domestic building stock by optimising hydraulic distribution in domestic space heating systems.

Inclusion of Private Rented Sector

It is vital that Heating System Plus includes the private rented sector. In 2012, there were 4.2 million private rented sector (PRS) residential properties in England and Wales alone, representing 18% of the housing stock[9]. In Scotland the share of PRS as a proportion of the Scottish housing stock has more than doubled in the last decade to 11% with 273,000 PRS properties in 2010[10]. These properties have significant potential for energy efficiency improvements as illustrated by Figure 2 which shows that the PRS has the highest proportion of households in EPC bands F and G compared to other tenure categories.

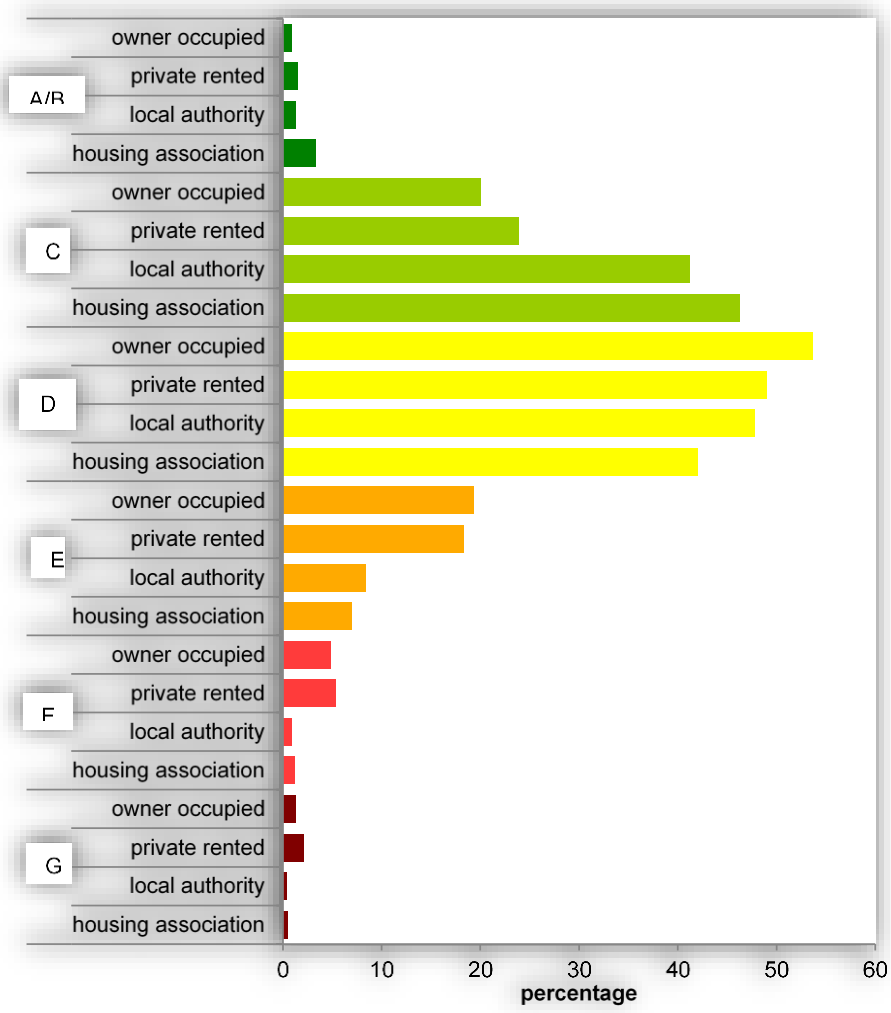


Figure 2 - Energy Performance Certificate Bands by Tenure (Source: DCLG, 2014[11])

Private landlords are less motivated to invest in energy efficiency measures as they incur the cost but the benefit in terms of bill savings and/or comfort will accrue to the tenant (spilt incentives). The benefits in terms of reduced carbon emissions and energy security accrue more broadly to society Government has a role to play in tackling this market failure of under consumption of energy saving measures in this sector.

Requiring landlords to adhere to the modest regulations set out in Stage 1 is both an effective and appropriate intervention to ensure tenants are protected from high energy prices due to inefficient heating systems.

[9] DECC (2015) Domestic Stakeholder Briefing – Private Rented Sector: Energy Efficiency Improvements to the Private Rented Sector

[10] Scottish Government (2014) Report of the Review of the Private Rented Sector Tenancy Regime: Final Report

[11] DCLG (2014) English Housing Survey: Headline Report 2014-15

Heating System Plus in practice

Many technologies with improved system efficiencies already exist and others are being developed however, the deployment gap needs to be bridged. The industry needs a clear signal of policy direction over the next 10 to 15 years to provide stability and enable adequate planning and investment. The SEA therefore calls on the Government to implement a policy that delivers credible, staged improvements to efficiency standards included in building regulations and sets out clear direction for the industry and its supply chain.

The following section provides detailed descriptions of the four stages of Heating System Plus and highlights how these proposals provide substantial **additional benefits**, whilst still being readily **achievable** and **consistent** with other policy areas. This upgrading of domestic heating can be considered a pathway with gradual improvements made over time with a clear, defined and realistic approach laid out by Government, as with the CCC's carbon budgets. This approach will provide much needed direction and stability for the industry.

Stage 1 - Making good boilers work optimally

Proposal

Stage 1, requires regulation that ensures that – at a minimum - every boiler installed is rated at 92% space heating efficiency in accordance with the Energy Related Products Directive (ErP), has modern heating controls and/or add-ons and is hydraulically balanced to ensure that the boiler performs optimally. Throughout the recommended policy stages outlined in this document, lowering the return temperatures of heating systems facilitates the improvement in efficiency. Stage 1 can be structured to achieve this in a number of ways, there are two main options in this regard:

1. Using ErP efficiency class values of heating controls, mandate a minimum package value which requires the installation of both a minimum boiler efficiency of 92% and modulating heating control in line with relevant ErP provisions, for example through a weather compensator control or a modulating room thermostat with load compensation (ErP Class II or V respectively) to achieve a minimum 95% ErP package efficiency

Or;

2. Mandate that each condensing boiler (minimum 92% efficiency) need be installed with weather compensation, basic time and temperature control together with at least one additional measure either smart heating controls, TPI, FGHR or TRVs in all rooms except room with thermostat.

Table 1 - Options for Stage 1 regulation

Objective	Policy target	Strengths	Weaknesses
(i) Improved efficiency	**ErP package value of whole system**	• Recognised European Methodology • Potential for more installer choice and competition • Provides framework that easily allows for future tightening	• More complicated than mandating technology solutions • ErP values not trusted by all • Some options do not have an ErP value e.g. FGHR and hydraulic balancing therefore this option will limit development of these and other products • Will be difficult to add technologies to ErP
(ii) Improved efficiency	**Technical solution – technology regulated**	• Simple policy to understand and administer • Easy to understand the costs and benefits • List of technologies can easily be revisited by UK policy makers	• May stifle some competition and create incentives for least cost technical solution, regardless of suitability

ErP is a useful tool that captures much of the technologies covered in Stage 1 and allows for flexibility when designing a total system solution. Of course buildings, geographies and consumers are heterogeneous and policy if possible should allow for different solutions to be used where most suitable. ErP allows for different combinations of measures and add-ons to be utilised in different circumstances. However, the value and ranking of technologies within ErP is not trusted by all and some options such as FGHR and hydraulic balancing do not have ErP values.

Efficient boilers and renewable heating technologies

There have been 9.3 million energy efficient boilers installed in the UK since 2007,[12] delivering both energy bill and carbon emission savings. The installation of a new condensing boiler over a non-condensing alternative is likely to increase heating system efficiency by around 13%.[13] In monetary terms, the Energy Saving Trust[14] estimates that replacing an old gas boiler with new A-rated condensing boiler fitted with a programmer, TRVs and room thermostat could save a detached house up to £350 a year (see table 2).

Table 2 - Savings per year associated with upgrading an old gas boiler with a new condensing boiler plus programmer and room thermostat. Estimated figures will depend on size and thermal efficiency of the property. Figures are based on fuel prices as of March 2016 (Source: Energy Saving Trust, 2016)

Old boiler rating	Semi-detached	Detached house	Detached bungalow	Mid terrace house	Mid floor flat
G (<70%)	£215	£350	£180	£175	£95
F (70-74%)	£145	£240	£125	£120	£65
E (74-78%	£115	£190	£95	£95	£50
D (78-82%)	£85	£140	£70	£70	£35

Given the typical gas consumption of a semi-detached house, this saving on energy usage could net a family £75 per annum in reduced operating costs and £900 over a typical 12 year lifetime. In terms of carbon emissions, this equates to 4 tonnes of CO_2 saved per household over this time period. Aggregated across the number of household's in the UK operating non-condensing boilers, the total carbon emission saving from the switch to condensing systems, is substantial and testament to effective policy supporting the market in delivering societal goals of more affordable and efficient energy.

However it needs to be recognised that all heat sources, whilst capable of achieving efficient operating standards, may not all actually do so in practice because of poorly calibrated systems, installed without the controls that allow for optimum performance. Ultimately, the operation of the heating system as a whole is of greatest importance, with lower return temperatures signifying greater efficiency, lower energy consumption and emissions. Installing better equipment in the form of more

[12] CCC (2015) *Reducing emissions and preparing for climate change: 2015 Progress Report to Parliament*. Available from: https://www.theccc.org.uk/

[13] BRE (2012) *The Government's Standard Assessment Procedure for Energy Rating of Dwellings*. Available from: https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf

[14] Energy Saving Trust (2016) *Boiler Replacement* Available from: http://www.energysavingtrust.org.uk/home-energy-efficiency/boiler-replacement

efficient boilers is part of this, but the system needs to be both calibrated to run optimally, and twinned with modulating controls that can help adjust output to maintain comfortable temperatures at lowest energy input. The recommendations outlined in this paper are also relevant to renewable heating systems. The move towards heating systems with a low return temperature will allow consumers to more easily and cheaply move to a number of renewable heating technologies in the future. The controls summarised on the next page can be used in conjunction with renewable technologies as well as conventional systems to improve system efficiency, reduce waste and drive down costs for the consumer.

Heating System Controls

Current building regulations support the provision of basic room thermostats and programmable timers. These basic models typically use simple mechanisms to regulate whether the boiler is firing on or turned off in response to the timer and/or ambient air temperature picked up by the thermostat. In practice this means that as long as room temperature remains below the set-point, the boiler is firing. In practice this causes the boiler to "over-shoot" the set-point, with actual room temperature fluctuating above and below the comfortable level.

Time Proportional and Integral (TPI)

These controls utilise more complex algorithms to allow the system to learn how to adjust output gradually as the room nears the target temperature. Instead of fluctuating widely above and below, the set-point is neared with more precision, comfort and efficiency, with the boiler firing for shorter periods as the room temperature nears. *Modulating room thermostats* perform a similar function and allow for incremental modulation of boiler output in response to the room's temperature in a more efficient way than TPI. These controls help the heating system reach its target temperature with less energy input.

Weather compensation

A weather compensated system uses an outdoor temperature reading to adjust the heating system to compensate for changes in outdoor air temperature. As such, when the weather gets colder the system produces more heat compared to a warmer day, and will run at a lower temperature on warmer days. The consumer will benefit from a consistent response which will increase levels of comfort and reduce fuel consumption over the year. Weather compensation allows the system to run more consistently thus improving energy efficiency and reducing energy bills.

Smart thermostats

These thermostats are a relatively new technological development which allow individuals greater operability and control over heating. These controls are "smart" as in many instances they learn the behaviours of users and take advantage of opportunities to lower temperatures when for example they leave the home. More advanced smart controls incorporate modulating functionality to offer similar benefits to compensating control.

Hydraulic balancing

Stage 1, proposes that every new system is properly balanced by the installer. Balancing the heating system, so that each radiator receives a consistent amount of heat, can increase the operational efficiency of a heating system by at least 10%. It reduces temperature imbalances between different emitters on the system. This is recommended best practice currently and should be common procedure for all installers

There is a lack of awareness among consumers of the benefits of hydraulic balancing[15] and they often assume that uneven radiator heating (one radiator being hotter than another) is caused by a problem with the boiler rather than an unbalanced system.

When a system hasn't been hydraulically balanced the householder is likely to increase the output of the boiler in order to heat all rooms to a minimum temperature – including those furthest away from source - which is inefficient. A properly balanced system would enable each room to receive an equal amount of heat, increasing comfort and reducing the need to increase whole system return temperature. Thereby saving energy and money.

It is not straightforward to quantify the costs and benefits of hydraulic balancing due to the range of factors such as house-size, technology used and assumed counterfactual that change from one situation to another. The potential costs to installers who do not already undertake hydraulic balancing and expected benefits of the procedure are summarised below.

Costs for the installer

- Extra time on a job performing the balancing
- Extra time and potential cost of additional training (if needed) for an installer
- Cost of capital of equipment needed to carry out balancing (if the installer does not already have access to it)

[15] Ahern and Norton (2015) Energy savings across EU domestic building stock by optimising hydraulic distribution in domestic space heating systems.

The cost associated with extra time taken on the job is a function of time taken and the wage rate of the installer and/or the forgone revenue from working on another job. The time taken on a job varies given the balancing technology and method used, and the size of the property. The larger the house, the more radiators to balance the longer the procedure may take.

Equally there is a difference between methods for carrying out the balancing process. Using clip-on thermostatic readers which are placed on the incoming and outgoing radiator pipes is a more manual, labour intensive and time consuming procedure. More accurate electronic readers that interact with computer software allow an engineer to more quickly adjust radiator valves appropriately to balance the system.

The quicker methods performed on smaller households may take an installer 30 minutes or less to carry out, this is the lower bound for the analysis. Equally a manual procedure carried out on a large house may take half a day to perform, so 4 hours is the upper bound for time taken. Similarly the hourly wage rate of an installer can vary considerably therefore, a midpoint wage rate of £60/hour was used.

Hydraulic balancing is taught as part of Level 3 NVQ Diploma in Domestic Heating - a qualification which is needed to become a qualified plumber and heating system installer. This means that all qualified installers will be able to carry out hydraulic balancing. Nonetheless for those not currently adhering to best practice there may be some additional training needed to refresh these skills. This could be done via electronic videos sent out to installers or through more traditional training courses.

The cost of capital is variable based on the type of technology used to carry out the hydraulic balancing. At its simplest, the thermostatic clamp-on readers cost around £80. SEA's market research suggests that a digital unit using computer software and/or an app, typically costs in the region of £500. The use of this technology would allow the installer to carry out balancing far more quickly and accurately, saving the installer time on a job and therefore money. This capital cost should be offset by the installer over the number of jobs the technology is used to complete. Thus over time they become relatively small on a per job basis.

Based on the assumptions outlined the total cost, which varies depending on the installer wage rate, the need for additional training, and the technology used, is between £30 and £240 per job. As balancing becomes a requirement, installers will either invest in better equipment and/or become quicker and more skilled through learning by doing, reducing time taken on average and costs. Therefore it is likely that these costs will reduce over time.

Cost for the consumer

A study by Ahern and Norton into the Energy savings across EU domestic building stock by optimizing hydraulic distribution (hydraulic balancing) in domestic space heating systems[16] suggest that the average cost for a 120m^2 family dwelling would be in the region of €438 given investment costs ranging between €2 and €7 per square meter depending on the number of thermostatic valves required and whether a new variable speed pump is installed.

Benefits

- *Increased efficiency of heating systems that would have performed sub-optimally if not balanced (consumer benefit). This is evident in energy bill savings over the system's lifetime.*

SEA research shows that most quoted energy efficiency savings from hydraulic balancing are between 10-25% for new buildings, with one source claiming energy consumption can be cut as much as 40% (see Table 3). Ahern and Norton's research paper states that the energy savings potential of heating system optimisation in post 1980 properties ranges from 1% to 19% (conservative estimate). It should be noted that savings are dependent on the type of balancing undertaken (static or dynamic) as well as the energy performance of the building, age, location and initial energy consumption. Hydraulic balancing is most effective in newer buildings given that Ahern and Norton found no apparent savings from the hydraulic balancing in pre-1980 buildings.

Typical amortisation times of three to four years can be achieved[17]. Heating system balancing has been considered ***best practice*** for many years. Mandating system balancing, as is the case in Germany (see Box 2), is an opportunity to ensure that good quality equipment is performing optimally, protecting consumers from poorly operating systems and high fuel bills, and helping the country achieve its carbon objectives.

Table 3 - Quoted energy savings from hydraulic balancing

Energy savings (%)	Source
5-10%	http://www.hydronic-balancing.info/hydronic-balancing-en.html
8-10%	http://heating.danfoss.com/PCMPDF/CSPC_Product_Leaflet_HBC_VBA6R102.pdf
10.5%	http://www.stelrad.com/wp-content/uploads/2014/10/Radical-Technical-Specification-Brochure.pdf
10-20%	https://books.google.co.uk/books?isbn=3955531430
21%	http://www.stelrad.com/wp-content/uploads/2014/10/Radical-Technical-Specification-Brochure.pdf
25%	http://www.imi-hydronic.com/en/afc-technology/end-user/hydraulic-balancing-pays-off/
40%	http://www.construction.co.uk/c/98579/ta-hydronics

[16] Ahern and Norton (2015) *Energy savings across EU domestic building stock by optimising hydraulic distribution in domestic space heating systems*. Available from: http://dx.doi.org/10.1016/j.enbuild.2015.01.014

[17] http://www.stelrad.com/wp-content/uploads/2014/10/Radical-Technical-Specification-Brochure.pdf

Box 2: Germany – hydraulic balancing case study

Total domestic energy bills in Germany are often lower than the average in other Western countries (Energy Transition, 2015) despite having very high unit prices for energy. This is because of the efficient properties of homes, including their heating systems fabric which has helped lower householder demand for energy. This is illustrated in the graph shown below.

In Germany it is a legal requirement to hydraulically balance a heating system. This boosts the system efficiency and lowers energy consumption. The *German Energy Saving Ordinance (EnEV)* introduced in 2004 stipulates that the heating load, pipe network and heating surfaces must be calculated before a system is installed, as well balancing to meet this heat demand adequately for each room.

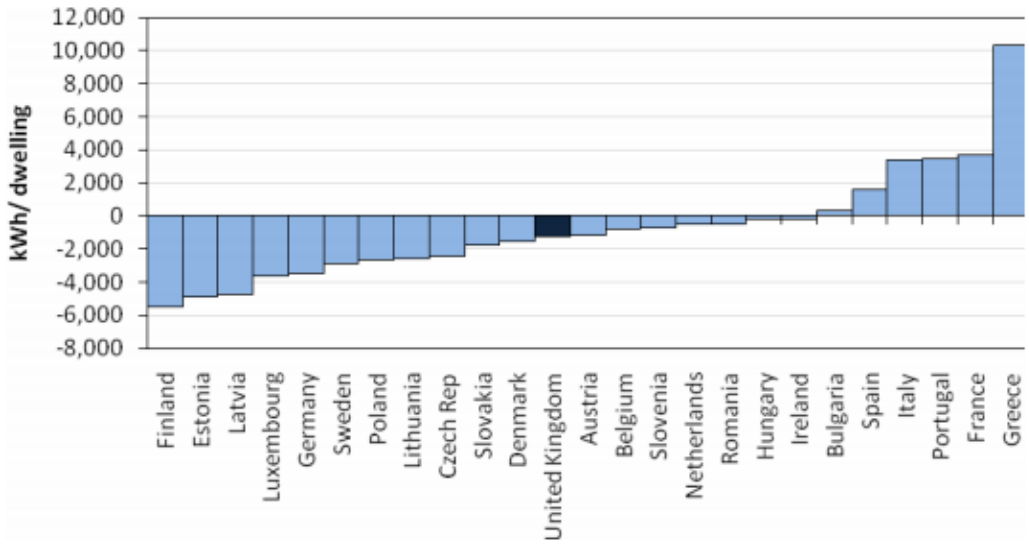


Figure 3 - Difference in household energy consumption per dwelling between normal and average EU climate by country for space heating. Source: DECC (2011).

System balancing is best practice and should become an essential element of each installation. Monitoring is a challenge, but using and modifying existing standards and paperwork generated by an installer on each job is a viable option. This solution would make it clear to both the installer and customer that hydraulic balancing is an integral element to any new system installation, and provide incentives for the installer to carry out the procedure. Introducing a checklist which requires installers to confirm they have hydraulically balanced the system could provide a means to regulating this practice.

Add-ons

Controls reduce the amount of energy needed to maintain a comfortable temperature, and will save families money through reduced energy bills over time. Stage 1 of Heating System Plus policy should therefore mandate other low cost solutions that similarly reduce the energy consumption of gas, oil and LPG boilers. In particular – though not suitable for all installations – flue gas heat recovery (FGHR) utilises waste heat in a way which can improve total efficiency and lower energy bills.

Achievement of Objectives

Heating System Plus Stage 1 is readily **achievable**. The technologies, supply chains and knowledge already exist and are ready to be unlocked by legislation that mandates the installation of more efficient boilers, controls and the use of hydraulic balancing.

The CCC estimate that 9.3 million high efficiency boilers have been installed since 2007. The following analysis assumes that half of the boiler stock in use in the UK are condensing, and the other half non-condensing. Field trial results suggest that a typical condensing regular gas boiler in situ operates at an overall efficiency of 80% (with all system losses included), and a condensing combi gas boiler at 83%[18] whereas non-condensing boilers are assumed to operate at 75% efficiency.

Given this and assuming Stage 1 regulation ensures that efficient heating systems are installed, Figure 4 details operating cost calculations made using current gas prices for retrofit system changes. Stage 1 legislation – though liable to have some additional upfront cost above the less efficient boiler counterfactual – ensures yearly bill savings in excess of £100.

[18] Energy Saving Trust (2009) Final Report: In-situ monitoring of efficiencies of condensing boilers and use of secondary heating

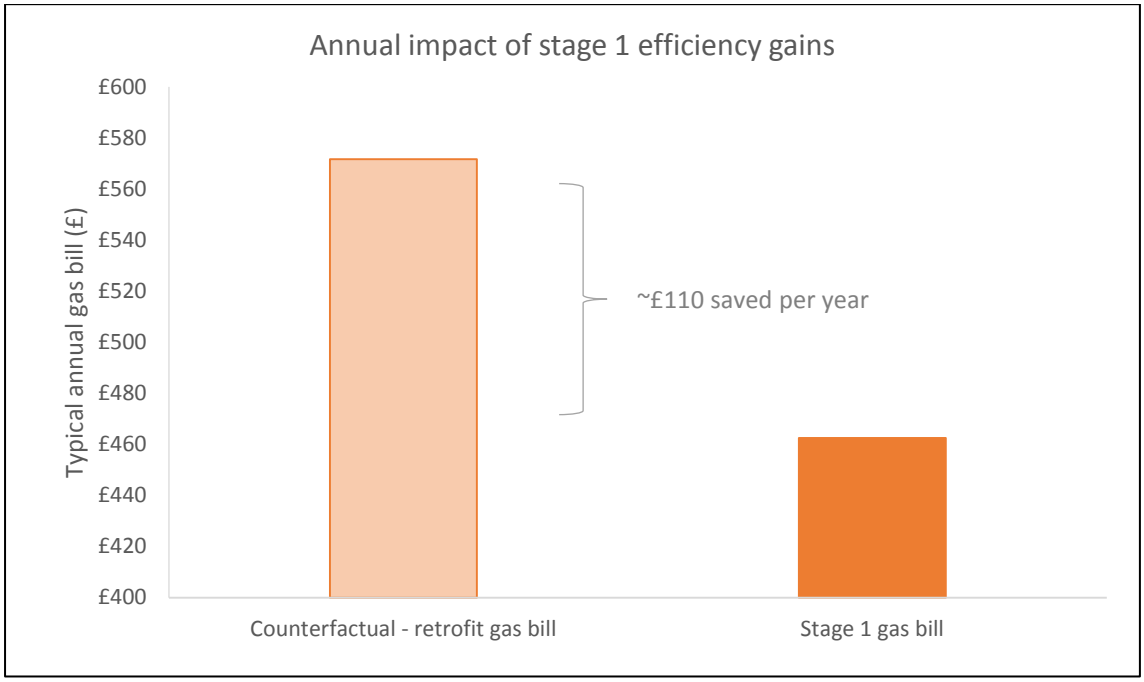


Figure 4 - Stage 1 yearly gas bill saving for retrofit

Each year approximately 1.6 million gas boilers are installed – 150,000 in new build and the remaining majority in existing properties. Figure 4 aggregates the carbon savings made through the installation of 92% efficient condensing gas boilers, and controls/add-ons that increase energy efficiency by a further 3%. Over 7 years of cumulative deployment of heating systems that operate to the standard expressed in Stage 1, the UK will have saved 4.5 million tonnes CO_2.

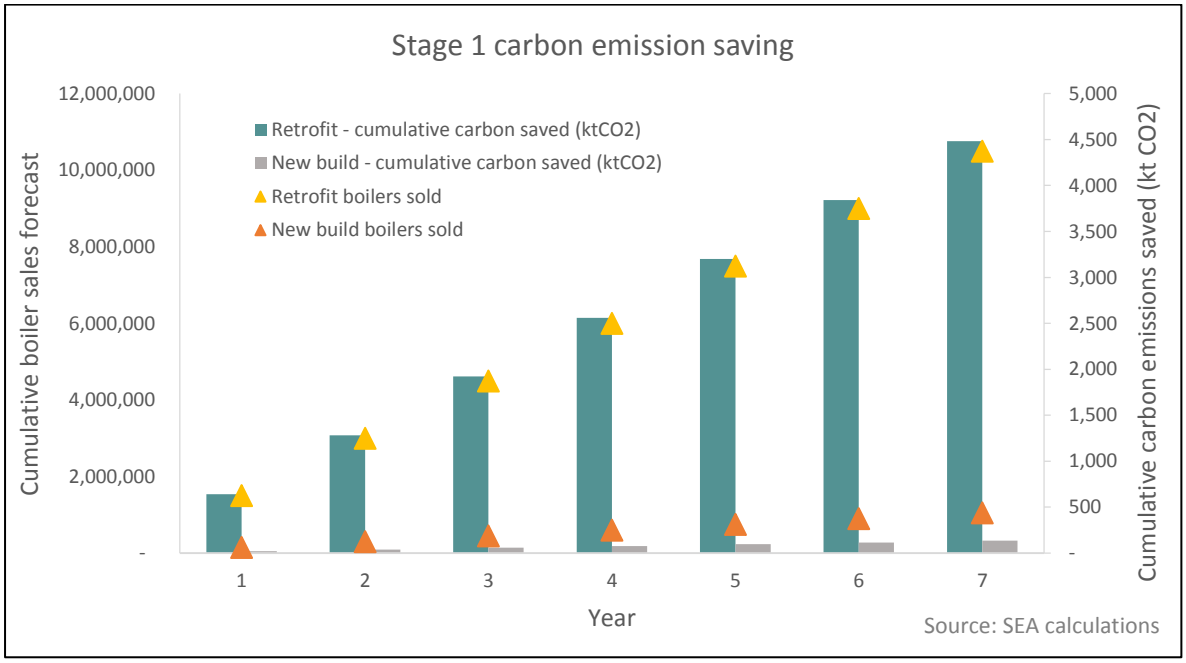


Figure 5 - Stage 1 potential carbon emission saving

In summary, Stage 1 will save householders money on their energy bills, improve security of supply and help contribute towards the UK meeting its carbon targets.

Figure 6 considers the policy from a cost effectiveness perspective. The diagram shows the abatement cost which is the net of additional capital cost and energy bill savings divided by carbon emissions saved. Figure 6 below shows that Stage 1 applied to retrofit properties is the most cost effective carbon abatement solution compared to draught proofing, Stage 1 in new build properties and smart electricity meters. The abatement cost for a tonne of CO_2 when applying Stage 1 to retrofit properties is -£77.71 and for new builds the abatement cost is £202.63.

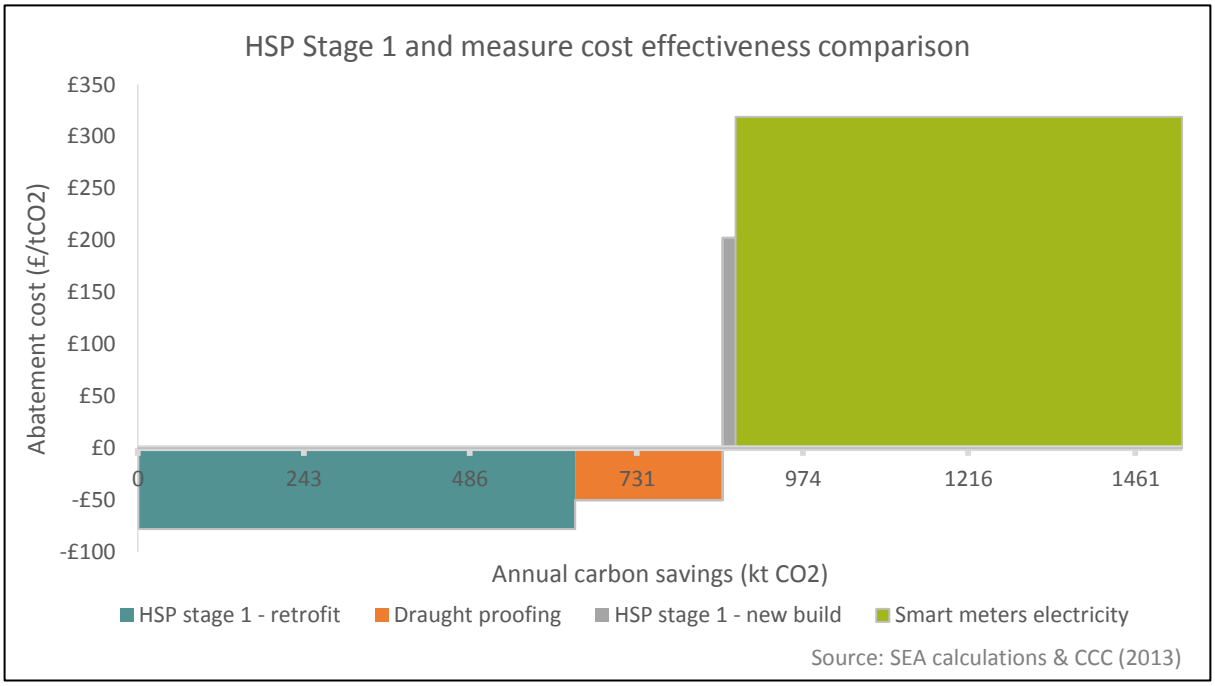


Figure 6 - Cost of carbon saved of SEA Stage 1 proposal & measure comparison

By installing an efficient boiler with heating controls and ensuring that the system is hydraulically balanced, the consumer will realise energy and cost savings. The consumer will no longer have to increase the output of the boiler in order to heat all rooms to a minimum temperature because a properly balanced system will be able to provide each room with the same amount of heat. This will reduce the risk of the consumer having one room that is too warm and another that is cold room thus providing substantial **additional benefits** by increasing comfort and reducing the need to increase whole system temperatures which reduces energy demand.

Stage 1 is **consistent** with other government objectives such as the roll-out of smart meters, and improvements to the energy efficiency of domestic buildings, which would enhance the effectiveness of Heating System Plus policies.

Stage 2 - Future-proofing heating infrastructure in new builds

Stage 1 sets out an intervention that helps to ensure condensing boilers operate to optimum efficiency in situ when twinned with controls, add-ons and system balancing. This is a good first step, but in order to meet the country's carbon targets and generate greater efficiencies that save householders money, additional savings have to and can be found.

The key metric to target when regulating an improvement to heating system efficiency is the return temperature. When low, this indicates that the system is operating efficiently with minimal fuel input required for the desired comfort level - thereby minimising carbon emissions and saving householders money.

Stage 2 of Heating System Plus proposes that the government regulates a target return temperature for new build properties. This would provide a clear signal to industry to innovate and produce cost effective solutions that ensure that the heating systems operate to this standard. New build properties are key to regulate today, as the infrastructure developed in the homes being built now will impact the ease of transition to a low carbon heating scenario in the future.

Proposal

The SEA recommends that all new build properties be (i) designed to operate at 55°C or less return temperature today, and (ii) built to a standard which ensures that the heating system infrastructure is suitable for low-carbon systems, installed if not today - then tomorrow.

Given that many new build homes will be built to similar specifications and purchases are usually bulk, this should not be a costly process and will ensure that the heat emitters and infrastructure installed allow the system to operate at a maximum return temperature of 55°C.

Stage 2 builds upon Stage 1 and the requirements of Stage 1 still apply - so a condensing boiler should be twinned with controls that help its efficient operation. In addition, hydraulic balancing is also a requirement. In addition, Stage 2 proposes that each new build property be designed to ensure optimum overall system efficiency. This will bring lower fuel bills to homeowners, lower energy consumption and lower carbon emissions for the country also.

The second part of the proposal recommends that new build properties have future-proof heating infrastructure, which will not have to be retrofitted in the future if the homeowner wishes to install a renewable system. This is prudent and, given the tightening of carbon budgets as the UK pushes forward with meeting it's legally binding 2050 emission target, also a sensible and cost-effective step to take in the new build sector.

The CCC and BEIS (formerly DECC) have both identified the important role that heat pumps could play in the decarbonisation of heat. Where low-cost, efficient, and consistent with condensing boiler operation, heat pump-ready infrastructure should be mandated in new build properties today where cost effective. This allows for the efficient operation of existing condensing boiler technologies today, whilst reducing the cost of heat pump installation at any date in the future

The ancillary measures to be covered by this change in the building regulations include:

- Heat emitters that are suitably sized
- Heat pump ready piping
- Low loss headers
- Hot water cylinders

This is not expensive, and requires the installation of suitable heat emitters and larger piping and the completion of heat loss calculations. These measures and procedures will support the efficient running of condensing boilers in situ, and also substantially lower the costs of any later retrofit to a heat pump based system.

When installed in a retrofit property, the average total cost of an air-source heat pump is approximately £8,500 - £9,500[19]. The figure below is informed by SEA members and heat pump manufacturers. It breaks this cost down into a number of elements including the cost of installation, the heat pump and also ancillary measures and demonstrates that a significant proportion of the total cost (41%) is attributable to heat emitters and thermal stores.

[19] DECC (2016) *The Renewable Heat Incentive: A reformed and refocused scheme consultation*. Available from: https://www.gov.uk/

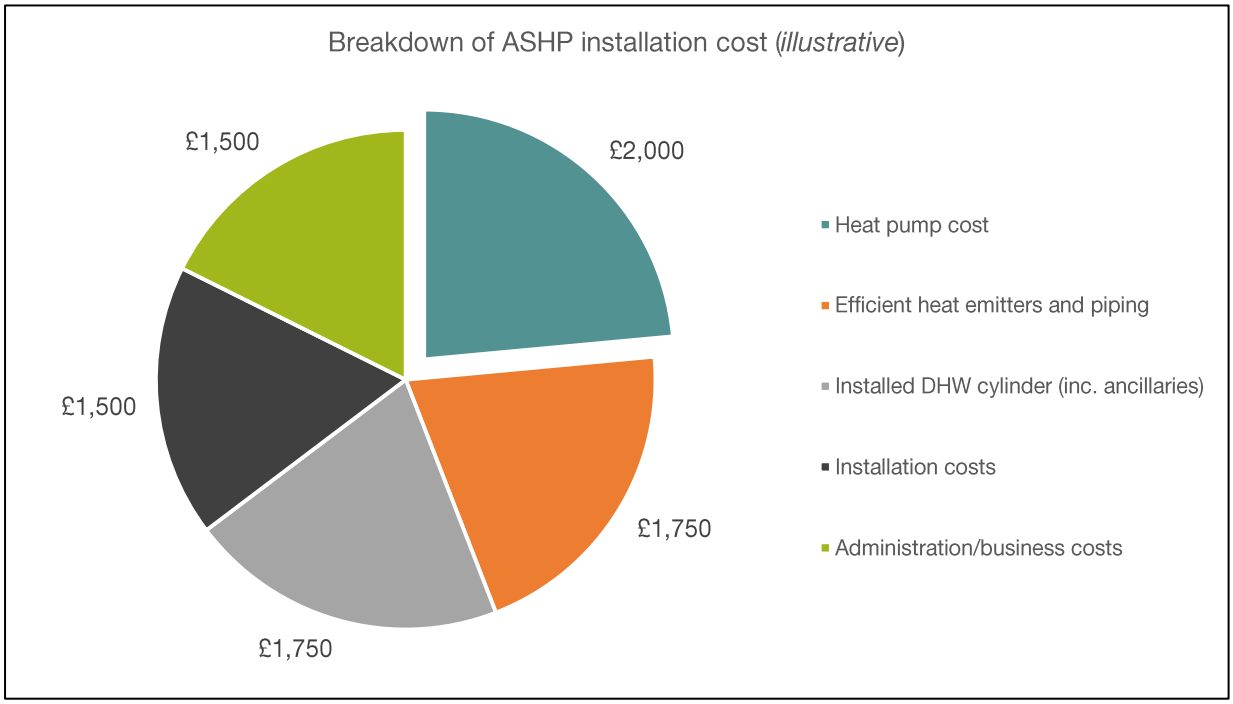


Figure 7 - Illustrative example of the costs associated with installing a heat pump and ancillary measures (Source: SEA)

Stage 2 proposes that these ancillary measures should be installed as standard in new build properties, reducing the cost of installing renewable heating infrastructure in the future. There is a very marginal increase in cost for the new build property when installing larger heat emitters, but a significant saving when highly efficient heating systems are installed in the future.

Box 3: Sweden – low temperature regulation

Before 1980, radiator systems in Sweden used high temperature, typically 80/60 with supply temperatures of 80°C and return temperatures of 60°C at the Dimensioning Outdoor Temperature (DOT). In 1984 new building regulations were implemented in order to reduce energy consumption. It was prescribed that hydronic heating systems must be designed so that the supply temperatures at the DOT does not exceed 55°C.

Many of the old systems could be adjusted to these new set temperature levels, because they were oversized. Furthermore, extra insulation of the house could also decrease temperature levels. Common temperature levels today are 55-45°C at the DOT.

Floor heating systems are popular in Sweden, with approximately 70% of wet systems using this technology (this is primarily due to comfort and aesthetic considerations). These systems use low temperatures around 28-35°C at the DOT and are thus ideally suited for heat pump technology.

Achievement of Objectives

The proposal to require heating systems operating to a maximum return temperature of 55°C in new build is easily **achievable** with all of the technologies and know-how available today. The consumer will receive **additional benefits** in the form of reduced energy bills and emissions and will more easily and cheaply be able to move to a low temperature renewable heating system in the future thus further reducing emissions. In addition as explored in this section, improving new build heating infrastructure standards should not hinder house building – a core objective of the government, and will bolster other policy aims such as increasing energy efficiency and security, and lowering both bills and emissions. Thus the Stage 2 proposal is **consistent** with other government policies.

Stage 3 - improving retrofit heating infrastructure

The SEA recommends that following a consultation and evidence gathering exercise, the Government applies the requirements outlined in Stage 1 and Stage 2 to retrofit properties where cost effective.

Stage 2, proposes that the government regulates a target return temperature for new build properties. This would provide a clear signal to industry to innovate and produce cost effective solutions that ensure that the heating systems operate to this standard. Extending this to retrofit properties would further drive industrial and technological innovation to produce cost effective options for these properties.

There are over 27 million households across the UK, a large proportion of which date back to the Victorian era[20]. Despite Building Regulations being introduced in 1965, many of these properties are still considered thermally inefficient. There are 9.2 million properties that are deemed 'hard to treat' across England[21]. There are four dwelling characteristics that are considered hard to treat; solid walls, off the gas grid, no loft, and high-rise flats. Post-1990 properties only represent 12.2% of the housing mix whereas over 50% of houses are pre 1965 of which 37% are pre-1919[22]. Moreover, approximately 80% of the homes we live in today will still be in use by 2050[23]. This demonstrates the size and diversity of the retrofit market in comparison to the new build market and the longevity of these buildings. Therefore measures should be taken to improve heating system efficiency in our current housing stock.

During a boiler replacement or property retrofit, it should be mandated that condensing boilers are installed alongside heating controls and that the system is hydraulically balanced.

Finally, the SEA proposes that heating systems are future-proofed to reduce the need for retrofit in the future if the homeowner wishes to install a renewable system.

Achievement of Objectives

The proposals discussed in Stage 1 and 2 are **achievable** with current technologies and understanding, yet innovation could be used to improve the techniques or solutions to reduce costs or improve efficiencies. As highlighted in the above stages the consumer will receive **additional benefits** in the form of reduced energy bills and emissions and will more easily and cheaply be able to move to a low return temperature renewable heating system in the future. This move will contribute towards achieving other policy aims such as increasing energy efficiency and security, and lowering bills. With 23% of the UKs energy demand coming from the domestic sector[24] and the ability of these proposals to reduce carbon emissions in the current housing stock, Stage 3 is **consistent** with other government policies.

[20] DECC, 2013. The Future of Heating: Meeting the challenge
[21] BRE (2008) A Study of Hard to Treat Homes using the English housing survey
[22] DCLG, 2010. English Housing Survey Housing stock report 2008
[23] Construction Industry Council (2013) APPG for EBE – Inquiry into Sustainable Construction and the Green Deal
[24] DECC, 2013. The Future of Heating: Meeting the challenge

Stage 4 - ensuring whole system efficiency

Proposal

It is recommended that following further evidence gathering and evaluation, the Government introduces a policy to ensure that the whole heating system is running efficiently. Where radiators have to be changed to allow a properly balanced system to operate to a return temperature of under 55°C, we recommend that the radiators fitted that operate at 45°C.

Achievement of Objectives

Stage 4 is an obvious next step towards improving the whole heating system, an evidence gathering session will be required to assess the number of properties for which low return temperature radiators are feasible. However, the proposal is **achievable** with current technologies and installers are easily able to perform the installation as well as balancing tasks. The consumer will notice **additional benefits** in the form of reduced energy demand thus lower bills and also increased comfort levels as each room receives an equal amount of heat. The transition to low return temperature systems and radiators will allow the consumer to move to a low temperature renewable system in the future if desired. Stage 4 contributes towards Government policy objectives such as decarbonisation and energy efficiency targets and increased deployment of heat pumps. It will also improve energy security as household energy demand is reduced. Stage 4 is **consistent** with other Government aims and objectives.

Impact on consumers, installers and industry

Consumer journey

The measures outlined in this proposal will ensure that the heating system is operating in situ at optimum efficiency which will give the customer optimal rates of return on their investment in a new heating system. The proposals should allow consumers to benefit from more efficient systems and thus face lower energy bills through reduced energy consumption. In addition, carbon emissions should also be reduced. Consumers will be able to more readily transition to a renewable heating system in the future.

The consumer will benefit from a correctly balanced system, more efficient radiators and lower return temperatures which will reduce the household's energy consumption and ensure that the rooms are sufficiently heated. A properly balanced system ensures that each room receives an equal amount of heat, increasing comfort and reducing the need to increase whole system return temperatures.

Stage 1

The determining factor in the uptake of efficiency upgrades in the heating sector is the relationship between the installer and the customer and it is often left to the installer to promote energy efficiency measures. Many heating system replacements are distress purchases i.e. purchases made because the existing boiler has broken or is beyond economic repair so this is an appropriate place to start the consumer journey. A local installer is called out and advises that the old gas boiler needs to be replaced with a new condensing gas boiler. When the consumer agrees, the installer makes the replacement and then takes some additional time to balance the system, ensuring that the radiators in different rooms heat each to similarly comfortable levels. Hydraulic balancing can be delivered in a number of ways which vary in cost, labour intensity and time requirement however, all methods, if carried out correctly offer energy saving potential. Hydraulic balancing can therefore take as little as 30 minutes and up to 4 hours. Once a system has been hydraulically balanced, the radiators will not need additional balancing unless different equipment such as a new radiator is added.

The installer advises the consumer that controls or a boiler add-on will be needed to complement the new system. The qualifying solutions will be calculated by the installer and the options will be presented to the consumer. Table 2 below provides some indicative costs and benefits of the controls and add-ons that could be available to consumers under Stage 1.

Yearly gas bill savings of between £13 and £217 could be achieved which means that a small upfront investment can be easily recouped over the lifetime of the system. The boiler fitted will be at least 92% efficient and the consumer will have choice and flexibility of other add-ons specific to circumstances.

Table 4 - Indicative costs and benefits associated with the installation of heating controls and add-ons for the consumer

Measure	Installed cost		Consumption saving		Energy bill saving		Payback period (years)		Rate of return	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
TPI controls	£30	£100	2%	2%	£18	£18	1.8	5.7	17%	59%
Weather comp controls	£50	£120	2%	7%	£13	£58	0.9	9.0	9%	116%
Smart thermostats	£150	£350	10%	30%	£36	£217	1.6	4.2	24%	62%
FGHRS	£200	£1,050	10%	20%	£27	£48	4.15	#N/A	-6%	24%

Stage 2

Stage 2 of the proposal focusses on new build properties and therefore the consumer will experience no or very limited disruption and inconvenience. The consumer will not be exposed to any hassle factor as they will not be inhabiting the building prior or during installation. Stage 2 will ensure that the new occupants will have a condensing boiler operating at optimum efficiency and the additional features will ensure they have a heating system that does not waste energy. At most, the additional cost of bigger heat emitters, differently sized piping will slightly increase house prices, but by a very small figure – indeed in likelihood much less than £500. This additional cost could be passed on to consumers through higher house prices, but the impact would be very small.

Stage 3

Given that Stage 3 targets retrofit, the consumer will feel more disruption than in the new build market segment. As discussed in Stage 1, hydraulic balancing and installing heating controls are relatively simple and are not overly invasive. Thus consumers will not be significantly inconvenienced especially as boilers are often retrofitted in the case of boiler breakdown and therefore the consumer will already face some disruption.

Older heating systems are relatively easy to adjust to lower set temperature levels as they are often oversized for the property. Furthermore, the addition of insulation could also be used as a means to decrease temperature levels although this may not be a simple solution in some 'hard to treat' properties. The level of disruption and cost is therefore dependent on the size of heating system and energy efficiency measures present.

The consumer will also be required to install future-proof heating infrastructure where cost effective to do so which may be a disruptive procedure depending on the house type, property age and heat system. This will make in the move to renewables easier which could lead to increased deployment into older properties as they will be 'renewables ready'.

Future proofing should mean that the homeowner will face lower costs when installing a renewable system in the future. However, it should be noted that the beneficiary may not always be the person who has faced the capital outlay i.e. if the homeowner moves.

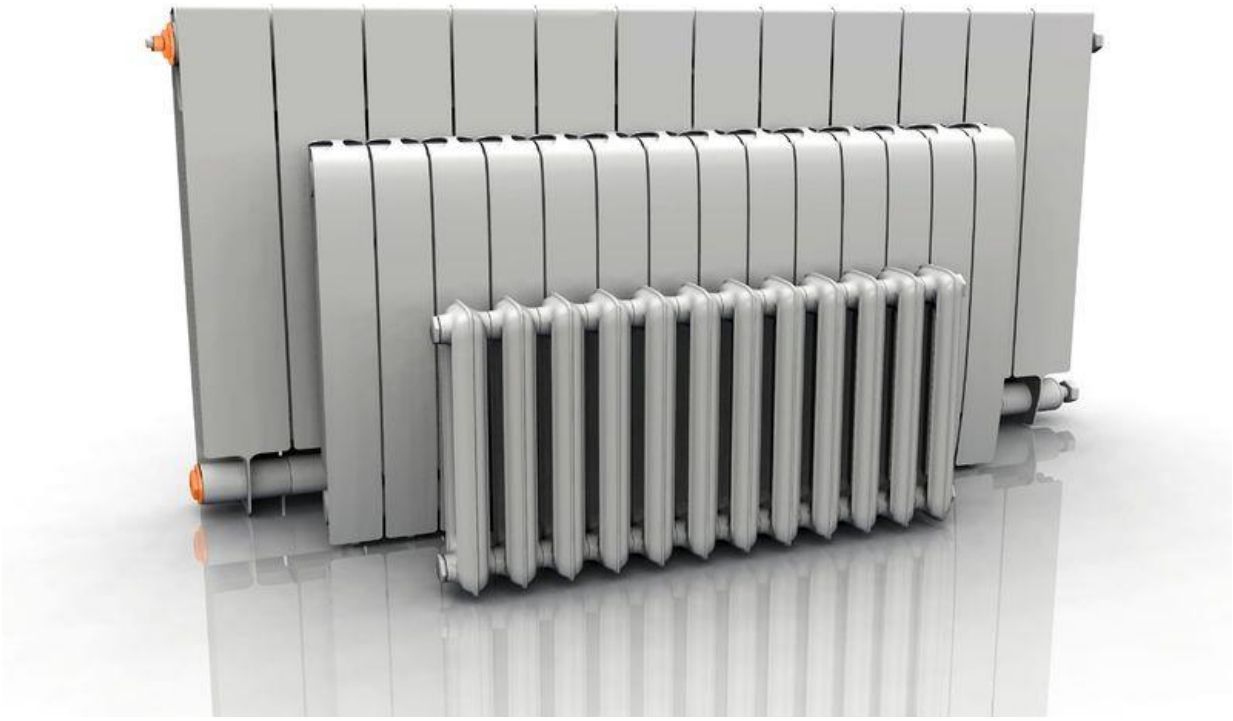
Installing future proof infrastructure will not only make the transition to renewables easier in the future for whoever the homeowner is at the time when the boiler is in need of replacing, but should also improve system efficiency for the current household. If this practice is becomes widespread, homeowners should benefit from it even if they opt to move house.

Stage 4

Radiator replacements can occur for a number of reasons. When a new boiler is installed, it may be necessary to replace the radiators if the new heat source is not compatible with the old radiators

Generally, the replacement of existing radiators should not involve significant investment or disruption. Radiator technology has improved significantly over recent years with regard to performance which means that switching from old radiators to new, more efficient ones could be a simple means to cutting energy wastage particularly in older properties.

The suitability of low temperature return systems depend on the property's heat loss value and space. If a building has significant heat loss that cannot be corrected then it may not be practical and economical to switch to lower temperature heating. In addition, low temperature systems require more surface area to work effectively which means that space is a limiting factor.



Installer journey

Heating System Plus is a staged approach to deliver heating system efficiencies with Stage 1 of the proposal causing a change in the actions of some installers. The installer is now required to both balance the heating system following the installation of a new gas (or oil/LPG) boiler, and also to offer the heating controls that will improve its operation.

Hydraulic balancing is a process that can take between 30 minutes and four hours in a typical house depending on the technology used. This process requires basic training which is part of the Level 3 NVQ Diploma in Domestic Heating - a qualification which is needed to become a qualified plumber and heating system installer. This means that all qualified installers should be able to carry out hydraulic balancing. It is relatively straightforward to perform, but will increase the time taken and cost of each job if the installer is not already doing this. However, the installer can invest in electronic equipment to speed this process up and reduce the time he takes balancing a system on each job to as little as 30 minutes. Indeed this training and know-how is available via online courses.

Installers and/or housing developers will be required to deliver new build properties that have heating systems operating at a maximum of 55°C return temperature. Once this has been achieved, the role of the installer is much the same in the instances of system replacement and retrofit in the future. Consumers may be more likely to consider other low temperature heating systems as their total install cost falls in relation to current counterfactuals – with some of the ancillary measures needed for these highly efficient systems already in place at no additional cost. This means that installers of low return temperature products may be in greater demand thus increasing competition and driving down costs.

To ensure that boilers operate at optimum efficiency, the installer will need to employ appropriate heat loss calculations for each property and for individual rooms. This will allow the installer to configure the boiler correctly to deliver a heating system that is operating at a maximum of 55°C return temperature.

Traditionally, radiators fed by central heating systems operate at temperatures of 60-80°C, however lower temperature radiators are becoming more common. Replacing radiators is a relatively simple task and ensuring the system is correctly balanced should not add a significant amount of time onto the job (4 hours maximum depending on equipment used). This means that installers should easily be able to replace radiators whilst ensuring that the system is properly balanced.

Industry journey

The SEA proposes a staged approach to deliver improved heating system efficiencies which sets out a reasonable timetable for industry to adjust, invest and innovate. A long-term policy signal creates the certainty and consistency required by the private sector to invest and deliver the technologies that will help drive down energy bills and carbon emissions.

The products captured throughout the Heating System Plus proposal are readily available to the mass-market therefore none of the technologies require significant innovation, increases in production capacity or learning. However, some scaling of production, of FGHRs for example, may be needed to match additional demand, but the facilities, know-how and supply chains are already formed allowing for industry to quickly deliver these technologies at low cost. A clear and early signal from Government to industry notifying of any changes to building regulations ensures that production and supply chains can respond accordingly.

The staged approach recommended sends a clear message to industry that the development of innovative heating systems will be supported by the Government. This signal will help incentivise manufacturers to produce heating systems which integrate with controls and add-ons. Due to the flexible nature of Stage 1, industry will be incentivised to develop new products which fit within the broad categories of efficient boilers, heating controls, and add-ons and develop innovative methods to hydraulically balance the system. By not being specific about which technologies are needed, Government will be able to establish a level playing field which will foster research and development to produce more efficient and/or simple technologies.

There may be increased demand for energy efficiency measures such as insulation in order for low temperature radiators to be used in thermally inefficient properties. In addition in the future there may be increased demand for renewable technology such as heat pumps. Innovation may be driven by the policy signal towards low temperature radiators which could encourage the development of radiators which are able to operate at even lower temperatures thus further improving efficiencies.

Property developers and house builders are an industry that could be impacted by Stage 2 proposals. In 2014, UK house prices were the second highest in the world per square meter[25]. Supply constraints and planning restrictions are the main cause of high house prices, especially in areas of the country where demand remains highest. Therefore it is important to consider whether additional building regulations could restrict home-building and supply further, and exacerbate the affordability crises.

[25] Centre for Economic Performance (2015) http://cep.lse.ac.uk/pubs/download/ea033.pdf

It is clear that the improved heating standards proposed in this paper will not prevent properties being built, and will not contribute to the housing crisis. Firstly, the proposals in Stage 2 involve small incremental changes to heating system infrastructure that – though marginally more expensive today – are unlikely to deter house building. Figure 6 shows that at times when building regulations have been tightened, the rate of residential building applications being granted in the UK has not slowed. The proposals outlined in Stage 2 are far less demanding than those highlighted in Figure 6. Therefore, there is little to suggest that any of the improved heating system standards advocated in Stage 2 of this policy would slow the rate of new build properties being developed.

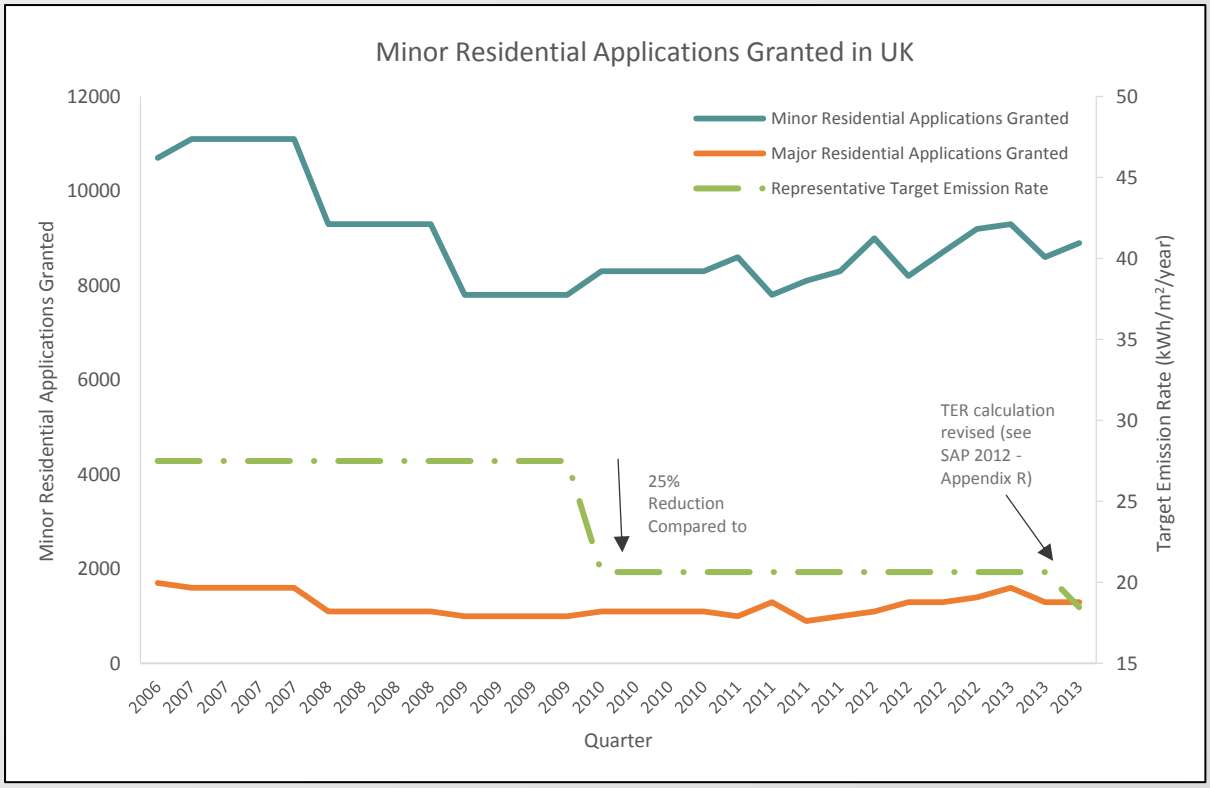


Figure 8 - Tightening building regulations and housebuilding application numbers, UK

Since a large proportion of the current housing stock are classed as 'hard to treat' or were built pre-1965 some of the solutions which apply to new build may not be appropriate or may need to be adjusted for retrofit. For example, reducing return temperatures can be challenging in thermally inefficient properties as it can lead to rooms being heating ineffectively. Installing insulation and other energy efficiency technologies will allow installers to reduce the return temperatures by a greater degree however, in some properties increasing thermal efficiency can be difficult given the building type. The signals delivered to industry from these policy proposals should incentivise innovation in this area to make it easier to deliver improvements in heating system efficiency in 'hard to treat' or old properties.

Conclusion

This paper has outlined the motivations behind a Heating System Plus policy and the barriers faced by consumers when they are given the opportunity to improve system efficiency. The four stages discussed in the paper provide necessary steps towards strengthening efficiency requirements for heating systems in new build and retrofit. The proposals put forward in this paper support the deployment of renewable heating systems in the future whilst improving current system efficiency which will provide additional benefits to the consumer through reduced household bills and improved comfort levels. Moreover, society will notice additional benefits in the form of increased energy security and reduced carbon emissions. Thus the Heating System Plus policy has the ability to address a number of key Government policy areas; fuel poverty, climate change and energy security. The policy will also support the development of able-to-pay and less-able-to-pay energy efficiency policy, the roll-out of smart meters and the strategic vision for the role of low-carbon heat as households will be 'renewables ready'.

The clear pathway set out by the paper will provide a predictable direction for industry and installers to prepare for upcoming changes to regulation. By assessing the consumer, installer, and industry journey, the paper has demonstrated that these proposals should not cause significant disruption or lead to consumers or installers incurring substantial costs. The staged approach provides long-term certainty to allow the private sector to invest in new technologies and provides ample time for the purchase of relevant technical equipment or to attend training courses. The proposals are achievable as they utilise readily available and economically viable technologies which are easily deployed by installers.

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