‘Title: Domestic Heating Replacement Regulations **IA No: BEIS010(F)-17-HBE** **RPC Reference No:** (TBC) **Lead department or agency:** Department of Business, Energy and Industrial Strategy	Impact Assessment (IA)
	Date: 6th July 2017
	Stage: Final
	Source of intervention: Domestic
	Type of measure: Secondary legislation
	Contact for enquiries: Marten Ford

Summary: Intervention and Options	**RPC Opinion:** RPC Opinion Status

Cost of Preferred (or more likely) Option

Total Net Present Value	Business Net Present Value	Net cost to business per year	In scope of One-In, Three-Out?	Measure qualifies as
+£483m	-£80m	£3.7m	Yes	IN

What is the problem under consideration? Why is government intervention necessary?

We want to help households reduce energy bills and cut carbon. The deployment of technologies in the new and replacement boiler market that could deliver potentially cost effective energy savings, is low for a number of reasons including the bounded rationality of consumer decisions and undervaluation of potential bill savings. Existing regulation delivers significant energy and carbon abatement, but could deliver further savings on consumer bills, with additional government intervention. Additional technology installed at the point of boiler replacement presents an opportunity to deliver bill and carbon savings, at low cost to consumers and in a way which minimises hassle and maximises the quality of installation.

What are the policy objectives and the intended effects?

The policy objectives are to deliver additional energy and carbon savings from the domestic heating sector in England by lowering overall gas demand from domestic properties, thereby reducing fuel bills for these properties and contributing towards meeting the UK’s legally binding carbon budgets. It aims to do this by increasing the deployment of devices which increase the efficiency of domestic heating systems, through controls and measures to make gas boilers heat homes more efficiently.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

The final policy design will require existing households in England to install an additional energy saving measure from a choice list at the point of installing a new or replacement combi gas boiler: load compensators, specified smart controls, flue gas heat recovery and weather compensators. Installations in domestic Private Rented Sector buildings will also be required to comply with the regulations. The new standards will be published in October 2017. Timers and thermostats will also be mandated in all households replacing their gas boiler and the boiler efficiency metric will be updated. The option delivers bill and carbon savings and allows householders to better control their heating. The design has been updated following consultation responses and new evidence.
Non-regulatory methods have been trialled in this area in the past and not delivered the potential which exists. Historically there has been low uptake from non-regulatory interventions.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date: 10 /** 2020

Does implementation go beyond minimum EU requirements?		**N/A**		
Are any of these organisations in scope?	**Micro:** Yes	**Small:** Yes	**Medium:** Yes	**Large:** Yes
What is the CO2 equivalent change in greenhouse gas emissions? (Million tonnes CO2 equivalent)		**Traded:** 0	**Non-traded:** -2.0 Mt in CB4	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible Minister: .... Date: 27/09/2017

Summary: Analysis & Evidence

Description: When installing a new or replacement combi gas boiler in an existing dwelling in England, householders (including the Private Rented Sector) must also install an energy saving technology from a list of available measures to improve the whole system performance thereby reducing the carbon emissions associated with their heating and yielding additional bill savings.

FULL ECONOMIC ASSESSMENT

Price Base Year 2016	PV Base Year 2017	Time Period Years 30	Net Benefit (Present Value (PV)) (£m)		
			Low:-£632m	High: +£829m	Best Estimate: +£483m

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low				£1,830m
High				£790m
Best Estimate				**£987m**

Description and scale of key monetised costs by 'main affected groups'

The costs considered in this policy are the additional capital costs of installing heating measures by approximately 910,000 householders in England, at the point of boiler replacement. There may be a small element of profit for manufacturers and installers of additional components, slightly over-estimating resource costs.
Training and familiarisation costs have also been included for the businesses considered in scope for this policy, considered here to be installers and the Private Rented Sector.

Other key non-monetised costs by 'main affected groups'

This Impact Assessment does not attempt to monetise the hassle costs which might be associated with some of the measures considered.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low				£1,198m
High				£1,619m
Best Estimate				**£1,469m**

Description and scale of key monetised benefits by 'main affected groups'

The monetised benefits are the energy savings as a result of the policy, the air quality impacts and the carbon emissions reduction. There is some residual, unresolvable uncertainty about these benefits which is explored in more detail in Section B of this Impact Assessment.

Other key non-monetised benefits by 'main affected groups'

Non-monetised benefits include the benefits of allowing households to better control their heating and optimise comfort and efficiency in their home. In addition this policy could have positive health impacts through householders being able to heat their homes more effectively.

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

The key assumptions for this analysis are the cost and performance of the measures considered. These are highly uncertain and discussed at length in the Impact Assessment. For example there is little in-situ evidence as to how load compensators might perform, or how householders' behaviour might change. We used the consultation period to improve our evidence base. This Impact Assessment looks to communicate these uncertainties through sensitivity and threshold analysis.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m: £18.5	
Costs:£3.7m	Benefits: £0m	Net: -£3.7m		

Contents

Section A

Rationale for Intervention

1. The Climate Change Act 2008 established a target for the UK to reduce its emissions by at least 80% from 1990 levels by 2050. To successfully deliver this, significant carbon reduction is required from the heat sector which accounts for around 45% of UK energy demand[1] and 19% of final UK greenhouse gas emissions[2].

2. With around 1.2 million gas boilers replaced each year in England[3] a sizable opportunity exists to reduce emissions from this sector in a way which is more cost effective than many other types of action and more affordable than longer term efforts to displace fossil fuels. Minimum standards already apply when consumers choose to install new or replacement boilers.

3. The following market and behavioural barriers were identified in the Consultation IA[4] and prevent the uptake of more efficient heating systems: carbon externality, bounded rationality and valuation of bill savings.

4. To address these the Government consulted on a number of intervention options and factored in evidence from a wide range of sources. Given these considerations and as a regulatory framework governing the performance of domestic heating systems already exists, the Government have determined that a regulatory approach would be the most effective in delivering benefits to consumers and society.

5. Non-regulatory options, outlined in the Consultation IA, were considered however would not likely deliver the additional carbon and energy saving abatement required to make a contribution to the Government's legally binding carbon budgets. Research has shown that advice-based interventions may not produce benefits[5]. This is compared to the effectiveness of previous regulatory approaches from 2005 onwards.

[1] Energy Consumption in the UK (2015)
[2] UK Greenhouse Gas Emissions (2015)
[3] Commercial sales data indicates there are approximately1.5m replacement boilers installed each year in the UK, 96% are gas boilers and 86% of gas connections are in England (2014 Subnational statistics) this gives approximately 1.2m boiler replacements in England per year
[4] https://www.gov.uk/government/consultations/heat-in-buildings-the-future-of-heat
[5] Benefits include reductions in fuel use and thus carbon emissions savings. For example the Newcastle trial evaluation: https://www.gov.uk/government/publications/advice-on-how-to-use-heating-controls-evaluation-of-a-trial-in-newcastle.

Policy Objective and Final Policy Design

6. The overall objectives of the final policy are to **lower fuel bills for consumers** through reduced gas consumption and **reduce carbon emissions from heat in domestic buildings**, contributing towards legally binding carbon budgets. The aim is to do this without necessarily triggering high-cost technology changes for consumers whilst providing them with greater control of their heating systems to optimise comfort.

Scope of Regulation

7. The regulation will improve on minimum standards set out in Building Regulations and have the following scope:

   a. **Sector:** Domestic households

   b. **Geographical region:** England only

   c. **Population:** All households replacing a boiler including Privately Rented Sector

   d. **Boiler types:** Gas (mains and LPG) and Oil

   e. **Minimum standards publication date:** October 2017

Final Policy Design

8. The final policy design is a simplification of the policy design consulted on and has three components:

   a. Setting the mandatory performance for gas boilers at 92% ErP, compared to the current regulatory requirement[6]. This will clarify the regulatory requirement for compliance with one boiler efficiency standard.

   b. Mandate the installation of timer and temperature controls with all gas and oil boiler installations (unless present already). This will clarify the requirements for installations in line with current practices.

   c. Mandate the installation of an additional measure selected from a list (unless present already), with combination gas boiler installations only. This includes: specified smart controls, load compensation, flue gas heat recovery (FGHR) or weather compensation. Details of these technology options can be found in Annex 2. This will provide further opportunities for consumers to improve the energy efficiency of their systems as well as to benefit society through carbon savings.

Full details of the policy design can be found in the Government Response.

[6] ErP refers to the calculation methodology manufacturers use to assess and label products' performance as determined in the Energy related Products directive. The current minimum performance standard is set at 88% on SEDBUK 2009 scale.

Rationale for Policy Design Changes

9. **Technologies in scope:** Following feedback from the consultation regarding technical suitability factors, the mandatory installation of weather compensators was removed[7]. Including weather compensators as a choice will instead give consumers more flexibility to select a product most suited to their property and energy needs.

10. TRVs[8] have been removed as they already have high coverage across the housing stock[9] and therefore offer limited scope for additional benefits. TPIs[8] were also removed as evidence indicated that the technology may not deliver significant savings. Load compensators now feature in the list in response to feedback in the consultation.

11. **PRS inclusion:** The Private Rented Sector (PRS) constitutes approximately 20% of households in England[10] and therefore including them adds a significant proportion of carbon savings and the potential for bill savings by tenants.

12. **Additional controls for some boilers:** BEIS's initial aim was to broaden the scope of the policy to mandate controls for non-combination gas boilers (system and regular) and oil boilers. Research conducted by BEIS indicated a lack of controls on the market, or compatibility issues, reducing the options available and flexibility for consumers. Therefore, the additional measure requirement only applies to combination gas boilers.

[7] factors include building characteristics or heating schedules that limit scope for reducing water flow temperature; where an external weather sensor cannot be suitability sited or, for internet enabled systems, where there is no access to accurate weather station data.
[8] Thermostatic Radiator Valves (TRVs); Time Proportional Integral (TPIs). More detail can be found in the Consultation IA.
[9] TRVs have 76% coverage in households (English Household Survey 2015 to 2016) and market intelligence suggests high levels of uptake at the point of boiler replacement.
[10] English Household Survey 2015 to 2016.

Section B

Evidence Updates and Remaining Uncertainty

13. The evidence collected to support this final IA has been acquired from a wide range of sources spanning industry, academic papers, field trials, consumer surveys, commissioned reports and consultation responses.

14. Like the Consultation IA, evidence sources have been considered alongside one another to construct our assumptions (detailed in Annex 2). The consultation and research undertaken since the Consultation IA helped refine our understanding of the technologies. There is however some residual, unresolvable uncertainty around many of the assumptions which lie behind this assessment.

Evidence Changes

15. Since the Consultation IA we have commissioned reports (both technical and relating to consumer consideration of the measures), undertaken a government consultation and continued engagement with industry to increase the provision of good evidence underpinning this policy.

    a. **Products:** Better understanding of product variation in the market, leading us to re-assess costs of householders complying with regulations and how those costs may reduce over time. This has provided for a more realistic approach to costs, which were otherwise static throughout the appraisal, and lowered Net Present Value (NPV). A new technology (load compensators) has also been added to the list providing consumers with a lower cost option.

    b. **Performance:** Additional evidence about performance of products which we have considered in making judgements about energy savings. This has refined the assumptions underpinning the benefits to consumers and society.

    c. **Costs to Business:** Engagement with industry regarding familiarisation and training required for landlords and installers to comply with the regulations. This has added a small cost to the NPV (£9m) and been factored into the EANDCB.

    d. **Consumer decision-making:** The consultation and our additional consumer panel commission did not provide further evidence to justify how consumers would select measures and how they may interact with them. However, we do have a better understanding of the circumstances in which technologies would be better suited to different households.

    e. **Energy costs:** Since publishing the Consultation IA BEIS has updated the projections of energy prices in the Green Book Supplementary Guidance. This has lowered NPV in terms of monetised energy savings (using long run marginal costs) and consumer metrics such as bill savings (through retail gas prices) and pay back.

16. These additional evidence sources have allowed the policy design and analysis to be refined. However there remain uncertainties focused around consumer choice and the performance of these products. We conduct threshold and sensitivity analysis in this Impact Assessment to test the magnitude of the effects these uncertainties may have.

Technology Costs and Benefits

17. The key suite of assumptions in this IA are the cost and performance of the various technologies which are in scope of this regulatory change.

18. These have been refined and improved since the Consultation IA based on additional evidence sought and assessed from industry and research. Table B1 provides a summary of the updated costs and impacts of the measures that householders can install to meet the requirements of this regulation. Further details about the updated assumptions and the sources of evidence used can be found in Annex 2.

19. The evidence base for specified smart controls is limited and the definition is wide. BEIS has evidence on learning thermostats however so we assume consumers meet the regulatory requirements for specified smart controls through installation of these.

Table B1 Measure Impact and Cost Summary

	Impact		***Cost*** *(product and installation, excl. VAT)*		
	Current	***Previous***	***Current Year 1***	***Current Year 2 onward*** *(with mass production)*	***Previous***
Learning Thermostat (specified smart controls)	0% - 5.8% reduction in gas demand Central: 3.8% reduction (in addition to Smart Meter benefits)	2.9% net reduction in gas demand after deduction of weather compensator impact	£150 - £230 Central: £190	£130 - £230 Central: £150	£130 net after integrated weather compensator cost deducted
Load Compensator	0% - 1.8% improvement on boiler efficiency Central: 0.7% improvement	*Was not previously considered*	£25 - £150 Central: £50	£15 - £110 Central: £30	*Was not previously considered*
FGHR	Dependent on hot water demand: 3.1% (weighted average)	*Same as current assumption*	£300 - £800 Central: £460	£130 - £530 Central: £200	*Same as current assumption*
Weather Compensator	0% - 1.8% improvement on boiler efficiency Central: 0.7% improvement	0% - 2.2% reduction in heat demand Central: 1.1% reduction	£90 - £150 Central: £130	£60 - £140 Central: £100	£40-£115 Central: £80

20. As discussed in the Consultation IA, the lower bound for many of these measures is zero impact which can occur if, for example, householders use them to increase comfort rather than reduce bills. In these cases the carbon emission abatement delivered by these measures could be zero (or possibly negative). While this is

unlikely on a large scale given the consultation responses, this represents a plausible lower bound impact.

21. For this IA, future cost assumptions have been developed for all technologies as a result of evidence collected during the consultation[11]. We now assume cost reductions are effective from year 2 onwards where measures are deployed widely. These cost reductions are highly uncertain and will depend on market conditions. If significant innovation in product design and delivery occurs then cost reductions could be greater. For example following the 2005 regulation change and the mass deployment of condensing gas boilers, there were significant cost reductions for this product.

22. For context, the average cost of boiler replacement[12] is between £1,900 and £2,900.

Analytical Approach

23. This IA assesses the impact of these proposals on consumers, the business sector (landlords and installers) and society, by looking at the financial impacts and carbon abatement. Given the uncertainty highlighted in the evidence, it also considers what performance and/or costs might have to be to achieve certain outcomes, such as achieving simple payback for consumers within 5 years.

24. The planned publication date for this policy is October 2017 with the regulations coming into force in April 2018 (appraisal start date).

25. Heating controls are expected to have a lifetime of 15 years so this policy covers one replacement cycle of the English household stock. The benefits are continued to be collected for a further period of 15 years from the last year of installations. Therefore the cost benefit analysis is conducted over a 30 year appraisal period.

26. The policy applies to England only as this is an area of devolved responsibility. Other elements of the policy scope are summarised with the earlier policy design section.

27. As in the Consultation IA all impacts stem from the third element of the policy only i.e. the requirement for households to install an additional measure from the list.

28. The update of gas boiler standard from 88% SEDBUK (2009) to 92% ErP will not change the performance or cost of boilers offered to consumers. This is because gas boilers being manufactured are already broadly compliant with the new standard, according to the BEIS's understanding of the metrics. In addition, market intelligence indicates that the new standard is approximately equivalent to the average standard of boilers currently being installed into households. Timers and thermostats currently

[11] See Annex 2 for more detail on sources of evidence used to determine current and future cost assumptions
[12] Including installation, according to market intelligence by Delta-EE

have high coverage across the housing stock[13] with sales data indicating that these are installed when boilers are replaced.

Modelling Approach

29. The impacts of this regulation change are considered in terms of how costs and benefits will accrue in the case that all households make the same technology choice e.g. the installation of load compensators.

30. The modelling approach builds on the approach used in the Consultation IA, with adjustments and refinements detailed below:

    a. **Policy design:** The policy has been simplified compared to the consultation proposals and implementation dates have been refined. There is a new, inexpensive technology (load compensators) that has been added to the list that households can choose from and as a result overall costs of compliance are lower compared to the Consultation IA. PRS landlords are now treated the same as other consumers.

    b. **Smart Meters:** The modelling has been updated to better reflect the interactions of smart meters and particularly those with learning thermostats. This has explicitly removed any smart meter gas demand reduction ahead of modelling the impacts of this policy.

31. Annex 3 illustrates how the NPV has changed as a result of key assumption and modelling changes since the Consultation IA.

Counterfactual

32. Changes to the policy design have meant changes to the construction of the counterfactual position since the Consultation IA.

    a. **Number of installations:** Market data available to BEIS maintains that there are approximately 1.2m gas boiler replacements in England per year and that this will remain static. Policy design changes have narrowed the scope down to combination boilers only, which constitute 77% of all gas boilers[14]. Therefore we estimate that there will be 910,000 yearly boiler replacements to which this IA applies.

    b. **Heating control choice:** Previously the counterfactual was determined by the high prevalence of TRVs, which have now been removed from the policy.

    Limited research suggests the current prevalence of heating measures included in the choice list is very low and could be between less than 1%[15] and 2%[16]. This IA

[13] 99% of gas-fuelled homes in England have a timer; 85% have room thermostat. 99% of oil-fuelled homes also have a timer and 81% have a room thermostat (English Household Survey 2015-2016)

[14] The remaining 23% are system and regular gas boilers, according to market intelligence

[15] Taken from smart controls market data shared with BEIS. FGHR prevalence is assumed to be from installation to new build properties.

[16] Compensation control coverage: BRE (2017) *Heating Controls Evidence Gathering Report*

assumes a central figure of 1% coverage across households under the counterfactual in light of the limited evidence base. We therefore expect the majority of households to take action when the regulation comes into force.

Consumer panel findings outlined in the Consultation IA showed that over half of consumers were less willing to pay an additional cost for a learning thermostat. In reality however, there may be an increased uptake of so-called ‘smart’ controls given the extensive marketing that has been undertaken by leading manufacturers.

33. The appraisal maintains the assumption that the in-situ (installed) boiler efficiency remains the same in the counterfactual and policy scenarios.

Central Scenario for Policy Assessment

34. There is significant uncertainty about how consumers may choose the option which is best for them. Their choice is likely to be influenced by a range of factors including their installer and personal circumstance, but they could be driven by two distinct motives:

    a. **Cost minimisation** – consumers who prefer to focus on reducing upfront cost, accepting lower benefits yet still maximising utility, would choose the lowest cost product i.e. load compensators.

    b. **Benefit maximisation** – consumers who focus on optimising over the lifetime of the technology select a measure that has a higher upfront cost (where they can afford to) to maximise their annual benefits in the form of bill savings. The highest performing technology of our choice list is the learning thermostat.

35. Using this method of consumer assessment, we narrow consumer choice down to two plausible options: load compensation and learning thermostat (£50 and £190 year 1 central costs respectively). These measures have few known technical compatibility issues meaning they can be installed into most households.

36. How much of each is likely to be taken up is uncertain and difficult to estimate. Consequently, the central case assumes equal take up of these two technologies.

37. The NPV and carbon savings on the front pages of this IA will reflect these values. For completeness this IA reports analysis on FGHR and weather compensation though we expect much lower uptake[17].

[17] As outlined in the Government Response, FGHR and weather compensation are on the list to provide consumers with greater choice

Section C

Impact Appraisal - Societal Cost Benefit Analysis

38. The minimum standards proposed in this consultation will promote the installation of a greater number of heating measures. However as noted in Section B there is still some uncertainty surrounding the impact of these measures on actual energy demand and hence the benefits outlined in this IA.

39. The appraisal conducted, was derived using the methodology outlined in the Analytical Approach section. It looks at four strands of analysis:

    a. **Consumer proposition:** what the offer is to consumers;

    b. **NPV analysis:** central assessment for appraisal purposes;

    c. **Threshold analysis:** what we have to achieve to make technologies payback in certain timeframes;

    d. **Sensitivity analysis:** impact of changes away from the central assessment.

40. For each of these, we consider how different groups are impacted by the regulation. The associated costs and benefits are summarised in Table C1. More detail about each can be found in the Consultation IA.

Table C1 Costs and Benefits

Affected Group		Costs	Benefits
Society as a whole		Additional upfront capital costs	Net energy savings Carbon savings Air quality improvements
Owner Occupiers		Additional upfront capital costs Other costs	Net bill savings Non monetised benefits
Social Housing Sector	Landlords	Additional upfront capital costs	Non monetised benefits from tenants
	Tenants	None	Net bill savings
Private Rented Sector	Landlords	Additional upfront capital costs Compliance costs	Non monetised benefits from tenants
	Tenants	Passed on costs from landlords	Net bill savings
Supply Chain	Manufacturers	Costs of producing products	Increased sales
	Installers	Costs of retraining	Additional trade

Central Assessment of Appraisal: Offer to the Consumer

41. The consumer offer is considered in a deliberately simple way based on three key metrics: average cost of compliance, average energy bill savings achievable in the first

and second years of operation and finally, implied payback period. This, taken together, gives an impression of how the offer to consumers would change.

Table C2 Offer to the consumer

Offer to the consumer - Central case			
Measure installed in all households:	**Additional Upfront Costs (£ 2016)**	**Yearly bill saving in 2018 (£ 2016)**	**Payback period (years)**
Learning Thermostats (specified smart control)	**Year 1: £190 Year 2 onward: £150**	**£17**	**At year 1 cost: 11 At year 2 cost: 9**
Load Compensators	**Year 1: £50 Year 2 onward: £30**	**£4**	**At year 1 cost: 13 At year 2 cost: 8**
Central scenario (equal split of learning thermostats and load compensators)	**Year 1: £120 Year 2 onward: £90**	**£11**	**At year 1 cost: 11 At year 2 cost: 9**
FGHR	*Year 1: £460 Year 2 onward: £200*	*£15*	*At year 1 cost: 14 At year 2 cost: 11*
Weather Compensators	*Year 1: £130 Year 2 onward: £100*	*£4*	*At year 1 cost: 35 At year 2 cost: 27 (Unlikely to pay back over lifetime)*

42. The results show that learning thermostats and load compensators pay back within the technology lifetimes (15 years), even at the higher year 1 cost. For those consumers who value lowering their upfront cost, bill savings will be significantly smaller compared to those who seek to maximise bill savings over the longer term.

43. Weather compensators and FGHR will likely not be attractive offers to the majority of consumers due to the high upfront costs or long payback periods. For some circumstances however these technologies will be beneficial e.g. households with high hot water demands who can benefit from higher than average performance from FGHR and associated bill savings.

Central Assessment of Appraisal: NPV Analysis

44. This IA now considers the policy in terms of impacts to society as a whole in the form of NPV analysis. The NPV weighs up the upfront costs and costs to business against key benefits of monetised energy and carbon savings and air quality improvements.

45. Table C3 illustrates the results of the NPV analysis for each technical measure. The negative figures represent a cost to society; the positive figures indicate a benefit. Figures may not add up due to rounding.

Table C3 Cost-Benefit analysis (2018 to 2048, Discounted at Government rate, all costs in £2016m)[18]

Measure installed by all households:	Additional Upfront Costs	Monetised Energy Savings[19]	Air Quality Savings	Monetised Carbon savings	Additional Business Compliance Costs	Net Present Value (NPV)
Learning Thermostats (specified smart controls)	**-£1,622**	**£1,287**	**£37**	**£1,091**	**-£9**	**£784**
Load Compensators	**-£333**	**£278**	**£8**	**£236**	**-£9**	**£181**
Central scenario (50:50 split of learning thermostats and load compensators)	**-£978**	**£783**	**£23**	**£664**	**-£9**	**£483**
FGHR	*-£2,304*	*£1,213*	*£33*	*£973*	*-£9*	*-£94*
Weather Compensators	*-£1,083*	*£278*	*£8*	*£236*	*-£9*	*-£570*

46. The analysis illustrates there is significant variation in the NPV of the policy depending on the measure chosen. As there is considerable uncertainty around the impact particularly of the various heating controls and their attributed costs, this assessment should be considered alongside the sensitivity and threshold analysis.

47. The option with the greatest NPV is the installation of learning thermostats where the high relative performance in the central case offsets the additional upfront costs. Compared to FGHR which gives the same region of monetised energy and carbon savings, the cost is relatively lower making it an attractive proposal for those households.

48. With the same measure performance as weather compensators but much lower costs, load compensators also have a positive NPV. In this case the same monetised energy and carbon savings are outweighed by much lower upfront costs.

Central Assessment of Appraisal: Societal Impacts – Carbon Savings

49. In addition to the NPV analysis it is important to consider the achievable non-traded carbon savings[20] as benefits to society. This is summarised in Table C4.

[18] As outlined in the Green Book, societal costs and benefits are discounted at a rate of 3.5%: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf
[19] Valued at the long run variable cost of gas
[20] All savings from this policy are in the non-traded sector as domestic gas use is counted in this sector.

Table C4 Non-traded carbon savings of the policy in Carbon Budget periods 4 and 5

Measure installed in all households:	Carbon Savings ($MtCO_2e$)	
	CB4	CB5
Learning Thermostats (specified smart controls)	**3.2**	**5.2**
Load Compensators	**0.7**	**1.1**
Central scenario (equal split of learning thermostats and load compensators)	**2.0**	**3.2**
FGHR	*2.9*	*4.7*
Weather Compensators	*0.7*	*1.1*

50. The table shows that those technologies with lower performance i.e. compensation controls, do not provide as great a benefit to society in terms of carbon savings as better performing technologies like learning thermostats.

51. In the case of the learning thermostat, the carbon savings rely on consumer interaction. Where measures have a behavioural element carbon abatement will likely be more variable, meaning savings could be higher where consumers actively engage with the controls, though potentially lower (including negligible).

52. In the case of compensation control (load or weather) the level of sophistication of the product will also make a difference to the savings, with upper cost range measures having higher benefits to society. This is because these products have a thermostat included, aiding effectiveness.

53. Analysis indicates that the central scenario has a non-traded carbon cost effectiveness of approximately £15/tCO_2e.

Threshold Analysis

54. Given the uncertainties in the evidence base, threshold analysis has been conducted to illustrate "what you have to believe" to generate various simple payback periods from the energy savings products under consideration in this IA.

55. Tables C5 and C6 summarise the minimum performance and costs required to achieve five and ten year payback periods. These periods have been selected as insight from consumer panels and stakeholders indicate that consumers welcome payback before the lifetime of the technology, here assumed to be 15 years.

Table C5 Threshold analysis – Performance required to achieve payback

Technology	Assumptions used in modelling		Performance required to achieve:	
	Measure performance	Measure cost	Payback within 5 years	Payback within 10 years
Learning Thermostats (specified smart controls)	**3.8% (0% - 5.8%) gas demand reduction**	**Current cost: £190**	**8.5%**	**4.2%**
		Future cost: £150	**6.7%**	**3.3%**
Load Compensators	**0.7% (0% - 1.8%) improvement on boiler efficiency**	**Current cost: £50**	**1.9%**	**0.9%**
		Future cost: £30	**1.1%**	**0.6%**
FGHR	*3.1% improvement on boiler efficiency (2.3% - 3.8%) (All weighted averages)*	*Current cost: £460*	*21.3%*	*9.5%*
		Future cost: £200	*8.1%*	*3.9%*
Weather Compensators	*0.7% (0% - 1.8%) improvement on boiler efficiency*	*Current cost: £130*	*5.1%*	*2.5%*
		Future cost: £100	*3.9%*	*1.9%*

Table C6 Threshold analysis – Costs required to achieve payback

Technology	Assumptions used in modelling		Additional cost chargeable to achieve:	
	Measure cost	Measure performance	Payback within 5 years	Payback within 10 years
Learning Thermostats (specified smart controls)	**Current: £190 (£150 - £230)** **Future: £150 (£130 - £230)**	**3.8% gas demand reduction**	**£87**	**£173**
Load Compensators	**Current: £50 (£25 - £150)** **Future: £30 (£15 - £110)**	**0.7% improvement on boiler efficiency**	**£19**	**£38**
FGHR	*Current: £460 (£300 - £800)* *Future: £200 (£130 - £350)*	*3.1% (weighted average) improvement on boiler efficiency*	*£80*	*£160*
Weather Compensators	*Current: £130 (£90 - £150)* *Future: £100 (£60 - £140)*	*0.7% improvement on boiler efficiency*	*£19*	*£38*

56. The threshold analysis shows that although shorter payback periods are generally preferred by consumers, ten year paybacks are achievable for learning thermostats and load compensators and within the cost and performance ranges specified in this appraisal. With further diversity in the technology market, cost reduction or higher performance from innovation or behaviour change five year paybacks could be achieved, making an attractive offer to the consumer.

Learning Thermostats

57. The functionalities of specified smart controls (learning, automation and optimisation) are developing quickly with new products being introduced. As the market matures, manufacturers may reduce costs through mass deployment or be more creative with their price structures to remain competitive, lowering cost and reducing payback periods. With product development there may also be a growth in older models remaining on the market, widening the spread of costs. Whilst product costs may become less expensive, installation cost may not fall as time will still be required to fix and activate these controls.

Load compensators

58. Whilst load compensation controls are not necessarily the most sophisticated products on the market, they show the greatest promise for cost reduction due to their technical simplicity. Accordingly, the threshold analysis illustrates that load compensation can realistically achieve the 10 year payback with cost and performance within the range of current assumptions.

59. The challenge is whether this will continue to be the case as smart technology takes off, absorbing this technology into a higher cost product and diminishing the market for the simpler but cheaper, effective controls.

FGHR and weather compensators

60. FGHR and weather compensators show less potential for being cost effective within the range of costs and performance assumptions determined for this appraisal. More drastic improvements to cost or performance would be required for these products to become cost effective.

Sensitivity Analysis

61. There is a significant degree of uncertainty in many of the assumptions used in this appraisal. This section therefore looks to illustrate the sensitivity of the NPV to changes to the key assumptions.

62. The following sensitivities have been conducted on load compensation and learning thermostats separately as they represent the most likely choices for consumers. These are standalone sensitivities where variations are made from the central assessment.

    a. **S1: Technology costs –** Upfront costs have a large impact on the NPV and there are wide ranges of current and future cost due to the diversity of products on the market. This IA therefore tests the lower and upper ranges, though noting that higher cost technologies may have greater associated benefits.

b. **S2: Future cost reduction –** Future cost reductions will be based on a multitude of factors including consumer preferences and innovation and are therefore hard to predict. This IA therefore removes cost reduction assumptions to assess impacts from static costs as a worst case.

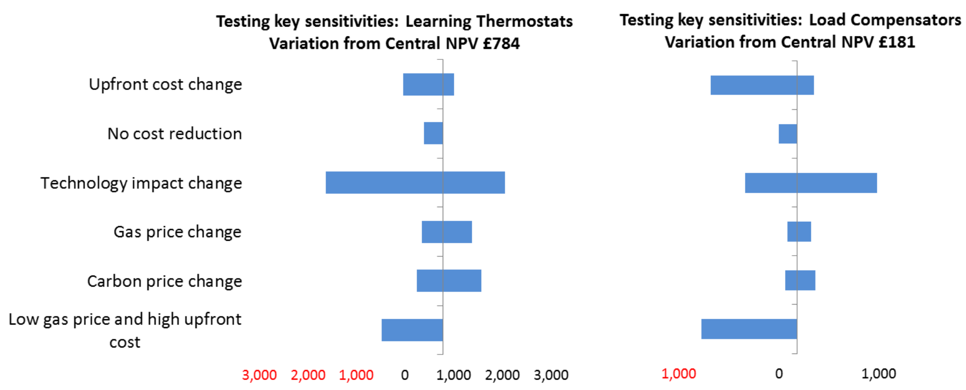
c. **S3: Technology impacts –** Performance of the technology has a large impact on aspects of societal and consumer benefit. This IA therefore tests the low and high ends of the range, though noting that higher performances may require higher upfront cost to achieve this.

d. **S4: Energy prices –** Gas prices (both faced by the consumer and society through the Long Run Variable Cost, used for assessing the NPV of the policy) are highly variable. This IA therefore tests the impact of the NPV under Government low and high gas price assumptions. Energy prices are assumed not to affect the demand or how households may choose to comply.

e. **S5: Carbon valuation –** This IA tests the impact of the NPV under high and low carbon price forecasts, as featured in Green Book standard assumptions.

f. **S6: Energy price and technology cost** – This IA tests low energy price in addition to high upfront cost to determine the impact on the NPV. This sensitivity is used for the front summary pages, assuming an equal split over the technologies.

Graph C1 NPV sensitivity of load compensation and learning thermostats



63. The sensitivity analysis shows that societal benefit is highly dependent on the technology offering by manufacturers and choices that consumers make as well as market forces which impact energy and carbon prices. Variation of technology performance has the greatest impact on the NPV of the policy, particularly for learning thermostats at the lower end where the household experiences no gas demand reduction but all the cost. This may occur where, for example, households seek to maximise comfort rather than reduce bill savings.

64. These sensitivities are tolerable for the most part as the consumer will be able to select the most appropriate technology for their individual circumstances, considering products offered on the market and retail gas prices. Therefore if these vary from our central assessment, consumers will have the flexibility to opt for a different technology.

65. A further sensitivity has been conducted on the central scenario of assuming an equal split of learning thermostats and load compensators by considering alternative take-up profiles and their impact on the NPV and carbon savings. This is shown in Table C7.

Table C7 Sensitivity analysis – Variation from central 50-50 split

Split of learning thermostats (LT) and load compensators (LC)	Social NPV (discounted, £ 2016)	CB4 Carbon Savings ($MtCO_2e$)	CB5 Carbon Savings ($MtCO_2e$)
50% LT – 50% LC (central scenario)	+£483m (from Table C3)	2.0 (from Table C4)	3.2 (from Table C4)
25% LT – 75% LC (lower bound take-up scenario)	+£332m	1.3	2.2
75% LT – 25% LC (upper bound take-up scenario)	+£633m	2.6	4.2

66. The results show that this policy would still have a positive NPV and achieve carbon savings even if, in the lower take-up scenario, a greater proportion of consumers opt for lower upfront costs (load compensators) than longer term bill savings (learning thermostats).

Costs to Business

67. This section of the IA considers the direct costs and benefits to businesses to assess the net regulatory impact for one in, three out purposes.

Direct Costs and Benefits

68. There are two types of businesses directly affected by this regulatory change:

    a. **Installers:** Individual and organisations who install boilers and heating controls in households. They will face some familiarisation and training costs.

    b. **Private Sector Landlords:** The proposed requirements affect all domestic landlords in England who own approximately 20% of properties[21]. As a result of this regulation they will face familiarisation costs as well the product costs.

For the purposes of this IA social landlords are not assumed to be businesses.

[21] English Household Survey 2015-2016

Installers

69. Installers will likely face some one-off familiarisation and training costs to comply with the new technical standards. They will likely also benefit from additional trade, although this is considered an indirect benefit.

70. Installers already receive training in the regulatory standards and installation of other technologies from a number of sources including media, manufacturers and building control compliance and enforcement. Publication of the new requirements will be followed by a familiarisation period of 6 months to allow industry to prepare for changes before the requirements come into force.

71. Based on consultation responses and engagement with industry the average additional time required by installers is estimated to be approximately 2 hours[22]. Their time is costed based on the Annual Survey of Hours and Earnings.

Table C8 Impacts to Installers

Installer Impacts (transition)		
Installers impacted[23]	Opportunity cost of time (£ 2016 per hr)[24]	Additional time required for familiarisation and training
105,000	12.50	2 hours

Private Landlords

72. In the majority of cases the landlord is responsible for the replacement of the boiler and the general physical condition of the dwelling. The tenant is responsible for the energy bills. While there are other contractual arrangements which may exist, for simplicity it is assumed that all landlords are affected by this regulation, but receive none of the benefits.

73. PRS Landlords will also face a small familiarisation cost of the regulation through access to resources currently at their disposal such as landlord associations, online forums, other specialist publications or through discussion with their installer at the point of boiler replacement.

74. Table C9 shows the assumptions used to assess costs to PRS landlords.

[22] FGHR and basic load compensators are unlikely to require installation training. This is as FGHR is built into the boiler and basic load compensators can be installed in the same way as room thermostats. Basic weather compensators are generally sold with easy to follow installation guidance for installers to refer to (as seen in this example). More advanced compensation products are usually smart thermostats. These and learning thermostats may require further time however at zero or low cost e.g. online guidance and free training offered by manufacturers (at the time of writing). Therefore only the cost of installers' time may be relevant here. Some installers will already be skilled in installation practices, have pre-existing arrangements in place for installation or choose not to offer products to customers. Where that is the case, no additional training is required. Familiarisation of the policy will be undertaken through training or annual continual professional development time required by all installers.

[23] Gas Safe installers apportioned by number of gas-fuelled households in England (approximately 85%)

[24] Weighted average hourly wage of Skilled Trade Occupations from the Annual Survey of Hours and Earnings 2015, adjusted for 2016 price base (Green Book deflator series)

Table C9 Impacts to PRS Landlords

<table>
<tr><th rowspan="3">Technology installed:</th><th colspan="5">Landlord Impacts (yearly cost)</th></tr>
<tr><th rowspan="2">Landlords impacted per year[25]</th><th rowspan="2">Additional time to familiarise with regulation[26]</th><th rowspan="2">Opportunity cost of time (£ 2016 per hr)[27]</th><th colspan="2">Cost of compliance (£ 2016)</th></tr>
<tr><th>Current</th><th>Future</th></tr>
<tr><td>Learning Thermostats (specified smart controls)</td><td rowspan="2">Year 1: 135,000
Year 2 onward: 180,000</td><td rowspan="2">15 mins</td><td rowspan="2">£11.50</td><td>£190
(£150 - £230)</td><td>£150
(£130 - £230)</td></tr>
<tr><td>Load Compensators</td><td>£50
(£25 - £150)</td><td>£30
(£15 - £110)</td></tr>
</table>

75. In the case where landlords have live-in tenants, landlords may also benefit from energy bill savings. We do not have data on this although we might expect these cases to be a smaller proportion and generate smaller savings due to being shared with the tenant.

76. In some cases landlords may benefit from improved system performance as a result of the measures, potentially delaying boiler failures and reducing maintenance cost.

Total Cost to Business (EANDCB)

77. The total cost to business will highly depend on the technology choice favoured by PRS landlords as upfront technology cost is the greatest contribution to the EANDCB as shown in Table C10.

78. PRS landlords who we consider to be microbusinesses[28] may well be more likely to choose load compensators to minimise their costs. We therefore assume that all landlords with fewer than five properties i.e. 95% of all landlords[29] would select load compensators and the remaining 5% select an equal split of learning thermostats and load compensators[30]. With rounding this gives a 98-2 split between load compensators and learning thermostats for PRS landlords.

[25] 20% PRS landlords of assumed annual boiler replacements within scope of the policy (year 1: 685,000 and year 2 onwards: 910,000). Year 1 has lower uptake as replacements start in April rather than January.
[26] Based on judgement and evidence collected as part of the PRS energy performance standards regulation
[27] Hourly wage of Estate Agent from the Annual Survey of Hours and Earnings 2015, adjusted for 2016 price base (Green Book deflator)
[28] Businesses employing up to 10 employees
[29] DCLG Private Rented Sector Landlords' Survey 2010
[30] This does not impact our overall central scenario of equal split across the two technologies

Table C10 EANDCB

<table>
<tr><th colspan="2">Cost to business</th><th>Load Compensators</th><th>Learning Thermostats (specified smart controls)</th><th>PRS Uptake Scenario (98% learning thermostats and 2% load compensators)</th></tr>
<tr><td colspan="2">Installer familiarisation and training (transition, £ 2016 undiscounted)</td><td colspan="2">£2.6m</td><td>£2.6m</td></tr>
<tr><td rowspan="2">Landlord</td><td>Familiarisation (yearly, £ 2016 undiscounted)</td><td colspan="2">£0.5m</td><td>£0.5m</td></tr>
<tr><td>Measure purchase[31] (rounded yearly, £ 2016 undiscounted)</td><td>Year 1: £7m
Year 2 onward: £5m</td><td>Year 1: £26m
Year 2 onward: £27m</td><td>Year 1: £7m
Year 2 onward: £6m</td></tr>
<tr><td colspan="2">EANDCB (£ 2014, discounted over 30 years[32])</td><td>£3.5m</td><td>£15.4m</td><td>£3.7m</td></tr>
</table>

Small and Micro Business Assessment

79. This section considers the specific impacts on small and micro businesses, in addition to the general impacts on business.

Installers

80. The boiler installation sector is dominated by small businesses; there are over 60,000 registered Gas Safe businesses[33], comprising of over 120,000 registered Gas Safe installers in the UK[34]. Around 70% of registered businesses have 10 employees or less[35].

81. Given the high proportion of installers that operate as micro businesses, excluding such businesses from the policy would remove a significant proportion of intended benefits as consumers heavily rely on installers to guide them in decision-making.

82. Training can be accessed at relatively low cost, and at times outside the peak boiler installation periods so installers can be flexible as to how and when they choose to undertake training within the coming into force period.

Private Rented Sector

83. Based on the Private Rented Sector Landlords' Survey 2010, 78% of landlords own only one property [36] and only 2% own more than 10 properties. As per the Final IA for the PRS Regulations published in 2015, all landlords are assumed to be small or micro businesses[37].

[31] 25% reduction for Year 1 as replacements are assumed to start in April rather than January.
[32] Yearly costs are incurred for 15 years, as per methodology specified in Analytical Approach section
[33] Statistic provided by Gas Safe.
[34] https://www.gassaferegister.co.uk/who-we-are/
[35] Statistic corroborated by Gas Safe.
[36] DCLG Private Rented Sector Landlords' Survey 2010
[37] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401379/150202_PRS_Final_Stage_Revised_For_Publication.pdf

84. Approximately 40% of households living in F or G rated PRS properties are in fuel poverty[38], which is much higher than in other tenures. This means the PRS includes some of the highest priority dwellings for this policy to target and many of the households that stand to benefit the most. Therefore their exclusion would remove a large proportion of the intended benefits of the policy. Their inclusion will also mean equality of treatment between all tenures, including between social landlords and the private rented sector.

85. The costs incurred by landlords as a result of the regulations are likely to be on a per-property basis meaning landlords with small property portfolios will not be disproportionately burdened by the new standards. Landlords can opt for the cheapest measure available: load compensators. The additional upfront cost here of £50 is small when considering the average boiler replacement cost of £2,500 (~2% of product costs).

[38] Annual fuel poverty statistics report (2016) https://www.gov.uk/government/collections/fuel-poverty-statistics

Conclusion of Impact Analysis

86. This IA considered three ways of assessing the impact of the policy to improve minimum standards for households heating replacements in England: cost to society (NPV analysis and carbon savings), offer to the consumer (upfront cost, bill saving and payback) and cost to business (EANDCB). These are summarised in Table D1.

Table D1 Summary of Impact Assessment

Technology installed in all in-scope households:	NPV (£ 2016)	CB5 Carbon Saving	Additional upfront cost for all households (£ 2016)	Average bill saving in 2018 (£ per year)	EANDCB (£ 2014, discounted)
Learning Thermostats (Specified Smart Control)	**+£784m**	**5.2 MtCO2e**	**Year 1: £190** **Year 2 onward: £150**	**£17**	**£15.4m**
Load Compensators	**+£181m**	**1.1 MtCO2e**	**Year 1: £50** **Year 2 onward: £30**	**£4**	**£3.5m**
Central Scenario (equal split of learning thermostats and load compensators)	**+£483m**	**3.2 MtCO2e**	**Year 1: £120** **Year 2 onward: £90**	**£11**	**£9.5m**

87. BEIS considers that consumers wishing to minimise upfront cost are likely to select load compensators whilst those seeking to maximise annual bill savings are likely choose learning thermostats. This approach allows for the construction of the central scenario view as to how consumers would behave and what costs and benefits could accrue.

88. The assessment of the central scenario illustrates that the policy is effective in meeting its primary objectives to reduce carbon emissions from domestic heating and provide additional energy bill savings for consumers.

89. The threshold analysis illustrates that improved payback periods could be achieved through product innovation and mass roll-out, increasing technology performance or reducing cost. Given the technologies in scope currently have low take-up across the English housing stock, there is certainly potential for this.

90. The cost to business mainly reflects the upfront cost of additional heating measures to PRS landlords. In reality the EANDCB may be lower than the central scenario as landlords may be more inclined to select the lower cost load compensators.

Annex 1: Other Wider Impacts

91. This section considers the wider impacts of the policy. It covers the standard test, but also considers the qualitative impacts on other major policies in the area of home heating system replacement.

Fuel Poverty

92. We anticipate that this policy will have a small impact on fuel poverty in England. The proposed minimum standards can save households money by reducing a proportion of their annual heating bills, and where heating bills are above average the savings will be correspondingly higher than average.

93. Households are in fuel poverty where high heating bills exist parallel with low income, so there is potential for some fuel poor households to achieve greater benefits than the average household.

ECO interaction

94. BEIS will be bringing forward proposals for the structure and design of ECO from October 2018 shortly. We will examine the potential for interaction at that point.

Human Rights

95. Proposals for the private rented sector engage Article 1 of Protocol 1 to the European Convention on Human Rights, as they will affect landlords' "property rights by controlling the use of rented property".

Wider Environmental Issues

96. This IA covers potential carbon emissions and air quality impacts savings. Any other environmental impacts are considered out of scope.

Justice System

97. Enforcement of these standards will be conducted through the present Building Regulations framework.

Annex 2: In Scope Technologies

98. This annex summarises the measures that may be used to comply with the proposed minimum standards, a description of what they do and sets out the evidence base for the costs and performance of these measures.

    a. Domestic boilers
    b. Central timers
    c. Room thermostats
    d. Weather compensation
    e. Load compensation
    f. Specified smart controls
    g. Passive Flue Gas Heat Recovery

<table>
<tr><th>Policy Measure:</th><th colspan="2">Boiler Efficiency</th></tr>
<tr><td colspan="3">Central heating is the most common method used to heat homes in England. Central heating systems are typically comprised of a boiler and controls, with pipework connecting a network of radiators throughout the home. The heat released when the boiler burns fuel is used to heat water which is circulated by a pump in the pipework and the radiators transfer heat to each room.

In England the majority are condensing boilers, which can recover some of the waste heat exiting the system to maximise efficiency. Some less efficient, non-condensing boilers, are still available for exceptional circumstances where condensing boilers are not practical.

Increasingly householders are selecting combination (‘combi’) boilers which can provide space heating and hot water on demand[39]. Alternatively, many households use non-combi ‘system’ boilers, which have a cylinder for storing hot water.

Boiler efficiency is the relationship between how much of the input fuel is converted into output heat. This can be measured in a number of different ways:
- Design performance: Efficiency of a boiler reached under standard test conditions and calculated according to a set methodology (e.g. SEDBUK or ErP)
- In-situ performance: Observed performance – reported in the EST field trial[40].

The current regulations require that new gas boilers must reach an efficiency of 88% under the SAP/SEDBUK 2009 methodology or 90% under the SEDBUK 2005 method[41].

The available sales data reports the SEDBUK 2005 efficiency of newly installed boilers - this demonstrates that average current efficiency is ~90.5%. Analysis of Product Characteristics Database information suggests that ~96% and ~65% of recently registered gas-fired boilers would be compliant at 91% and 92% minimum ErP efficiency requirements, respectively.</td></tr>
<tr><td>Costs (£ excl. VAT)</td><td colspan="2">Costs vary by installation capacity. Market intelligence suggests the average cost of a boiler, including installation is between £1,900 and £2,900.</td></tr>
<tr><td>Efficiency Levels</td><td>SEDBUK 2005</td><td>SEDBUK 2009</td></tr>
<tr><td>Building Regulations minimum efficiency</td><td>90%</td><td>88%</td></tr>
<tr><td>Typical market design efficiency</td><td>90.5%</td><td></td></tr>
<tr><td>Assumed design efficiency & in-situ efficiency gap</td><td>5.5 percentage points (pp) – difference between minimum standard and EST field trial average efficiency</td><td>3.5 pp – difference between minimum standard and EST field trial average efficiency</td></tr>
</table>

[39] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/595785/2015-16_EHS_Headline_Report.pdf

[40] https://www.gov.uk/government/publications/in-situ-monitoring-of-efficiencies-of-condensing-boilers-and-use-of-secondary-heating-trial-final-report-2009

[41] http://webarchive.nationalarchives.gov.uk/20151113141044/http://www.planningportal.gov.uk/uploads/br/domestic_building_services_compliance_guide.pdf

Policy Measure:	Central Timer					
A central timer allows the householder to control their heating system by setting specific times of the day and week when it turns on and off.						
Evidence available	Evidence is based on the English Household Survey (2015/16) which states that 99% of gas- and oil-fuelled households have central timers[42]. Other evidence suggests that new boilers being sold on the market already have a central timer installed on the unit as standard. Shipworth et al[43] and Kelly et al[44] have respectively investigated the impact of timer controls from a heating duration and internal temperature perspective.					
Costs (£ excl. VAT)	Low	0	Central	0	High	0
Source of cost data	As boilers being sold on the market already have a central timer installed on the unit as standard, we assume the cost is absorbed in the boiler unit price.					
Quality of cost data	This assumption has been affirmed by industry.					
Heat demand reduction	Low	0%	Central	0%	High	0%
In use factor	n/a					
Source of demand reduction	Evidence based on field temperature measurements, central heating settings reported by householders, alongside building, technical and behavioural data.					
Quality of demand reduction	Research does not directly address energy saving. Shipworth et al. found no statistically significant effect on the length of heating duration in homes with or without timers. Kelly et al. found the use of an automatic timer did not lead to a statistically significant change to internal temperatures when compared with a manually controlled system. The estimation of duration of heating from temperatures may however be subject to significant error.					

[42] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539230/Energy_-_Ch_3_Figures_and_Annex_Tables.xlsx

[43] https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/11586/7/Shipworth%20et%20al%202010%20CH%20thermostat%20settings%20and%20timing%20-%20building%20demographics%20-%20Accepted%20Manuscript.pdf

[44] http://discovery.ucl.ac.uk/1362438/1/1362438_Kelly%20et%20al%202012%20A%20panel%20model%20for%20predicting%20the%20diversity%20of%20internal%20temperatures%20from%20English%20dwellings%20-%20Tyndall.pdf

Policy Measure:	**Room Thermostat**					
Room thermostats are a common form of control usually located in a regularly heated area (e.g. a hallway or living room without supplementary heating). They allow the householder to select and manually adjust the target room temperature as desired. A temperature sensor within the thermostat measures room air temperature and feeds a signal back to switch on and off the space heating as necessary in order to maintain the desired room temperature.						
Evidence available	Evidence is based on the English Household Survey (2015/16) which states that 85% of gas- and 81% of oil-fuelled households have room thermostats[45]. Both Shipworth et al[46] and Kelly et al[47] have investigated the impact of room thermostats on mean internal room temperature.					
Costs (£ excl. VAT)	Low	0	Central	0	High	0
Source of cost data	Although room thermostats have a retail price, it is assumed that all consumers installing new boiler units purchase room thermostats. Therefore there is no additional cost to the consumer.					
Quality of cost data	-					
Heat demand reduction	Low	0%	Central	0%	High	0%
In use factor	n/a					
Source of demand reduction	Shipworth et al. found no statistical difference between the average of the maximum daily living room temperatures in homes without thermostatic control and the homes with a thermostat. Kelly et al. reported that the mere presence of a thermostat had the effect of reducing average internal temperature by ~0.24°C.					
Quality of demand reduction	Kelly et al. noted the contrast with the findings of Shipworth et al. This was attributed to the latter examining maximum rather than mean daily internal temperatures. Furthermore, each analysis used the same dataset over different time periods. Research findings have to-date not directly addressed matters of energy saving. The quantification of absolute savings may be challenging in the presence of any changes to temperature set-points, heating period and/or spatial extent of heating[48].					

[45] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539230/Energy_-_Ch_3_Figures_and_Annex_Tables.xlsx

[46] https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/11586/7/Shipworth%20et%20al%202010%20CH%20thermostat%20settings%20and%20timing%20-%20building%20demographics%20-%20Accepted%20Manuscript.pdf

[47] http://discovery.ucl.ac.uk/1362438/1/1362438_Kelly%20et%20al%202012%20A%20panel%20model%20for%20predicting%20the%20diversity%20of%20internal%20temperatures%20from%20English%20dwellings%20-%20Tyndall.pdf

[48] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/573888/Final_Report_-_Heating_Controls_Scoping_Review_Project.pdf

Policy Measure:	**Weather Compensation**					
Boilers are designed to provide sufficient output under cold weather design conditions. A weather compensator can reduce the heat output of the boiler to correspond to different external temperatures so that less fuel is consumed to achieve the desired thermal comfort. This is achieved by measuring the temperature outside the building and adjusting the flow water temperature of the heating system accordingly. There are a variety of weather compensators available, some of which have a temperature sensor on the outside of the building, and some of which use local weather station data.						
Evidence available	The proposed Standard Assessment Procedure 2016 updates include details of recommended efficiency adjustments for various control (including weather compensation) and emitter temperature options[49].					
Costs (£ excl. VAT, incl. installation)	Low	£90, reducing to £60 in Year 2	Central	£130, reducing to £100 in Year 2	High	£150, reducing to £140 in Year 2
Source of cost data	Externally commissioned technical report, consultation responses, stakeholder engagement with industry and BEIS review of products on the market. The high scenario costs have been adjusted for the presence of a programmable thermostat.					
Quality of cost data	There is significant spread in the costs by different product types, with higher end products bringing extra functionality and integrating extra features. These extra features may offer additional potential for demand control and reduction.					
Boiler efficiency adjustment	Low	0%	Central	0.7%	High	1.8%
In use factor	Evidence source includes an adjustment to account for potential discrepancies between predicted and observed measure impact.					
Source of demand reduction	**High:** Assumes modelled evidence impact closest to idealised compensation control is achieved. **Central (for appraisal purposes):** Mains gas-fired condensing boiler efficiency improvement for an Ecodesign Class II equivalent control (design flow/return temperature 80/60ºC or 70/60ºC). **Low:** Certain buildings & heating systems/schedules may allow for limited/no reduced flow temperatures - no impact assumed as bottom of range.					
Quality of demand reduction	Predicted impact is based on modelling (single set of external temperature, plant size ratio, dwelling floor area, insulation and thermal mass level assumptions) rather than observed in-situ performance. Measure effectiveness is expected to vary according to building characteristics, heating schedules and occupant behaviour. Appropriate selection of compensation curve and positioning of outdoor temperature sensor (where required) are also anticipated to influence effectiveness.					

[49] https://www.bre.co.uk/filelibrary/SAP/2016/CALCM-02---SAP-2016-SEASONAL-EFFICIENCY-VALUES-FOR-BOILERS--ALL-FUELS----DRAFT3.pdf

<table>
<tr><th>Policy Measure:</th><th colspan="6">Load Compensation</th></tr>
<tr><td colspan="7">Load compensation adjusts the flow temperature of the heating system in a similar manner to weather compensation. However, instead of using the external temperature to determine heat demand, an internal sensor is used to measure temperature within the building and the flow temperature is adjusted accordingly.</td></tr>
<tr><td>Evidence available</td><td colspan="6">The proposed Standard Assessment Procedure 2016 updates include details of recommended efficiency adjustments for various control (including load compensation) and emitter temperature options[50].</td></tr>
<tr><td>Costs (£ excl. VAT, incl. installation)</td><td>Low</td><td>£25, reducing to £15 in year 2</td><td>Central</td><td>£50, reducing to £30 in year 2</td><td>High</td><td>£150 reducing to £110 in year 2</td></tr>
<tr><td>Source of cost data</td><td colspan="6">Externally commissioned technical report, stakeholder engagement with industry and BEIS review of products on the market. All costs have been adjusted for the presence of a thermostat.</td></tr>
<tr><td>Quality of cost data</td><td colspan="6">There is variety in the costs by different product types, with higher end products bringing extra functionality and integrating extra features. These extra features may offer additional potential for demand control and reduction.</td></tr>
<tr><td>Efficiency improvement</td><td>Low</td><td>0%</td><td>Central</td><td>0.7%</td><td>High</td><td>1.8%</td></tr>
<tr><td>In use factor</td><td colspan="6">Evidence source includes an adjustment to account for potential discrepancies between predicted and observed impacts.</td></tr>
<tr><td>Source of demand reduction</td><td colspan="6">High: Assumes modelled evidence impact closest to idealised compensation control is achieved.

Central (for appraisal purposes): Mains gas-fired condensing boiler efficiency improvement for an Ecodesign Class V equivalent control (design flow/return temperature 80/60ºC or 70/60ºC).

Low: Certain buildings & heating systems/schedules may allow for limited/no reduced flow temperatures - no impact assumed as bottom of range.</td></tr>
<tr><td>Quality of demand reduction</td><td colspan="6">Predicted impact is based on modelling (single set of external temperature, plant size ratio, dwelling floor area, insulation and thermal mass level assumptions) rather than observed in-situ performance.

Measure effectiveness is expected to vary according to building characteristics, heating schedules and occupant behaviour.</td></tr>
</table>

[50] https://www.bre.co.uk/filelibrary/SAP/2016/CALCM-02---SAP-2016-SEASONAL-EFFICIENCY-VALUES-FOR-BOILERS--ALL-FUELS----DRAFT3.pdf

<table>
<tr><th>Policy measure:</th><th colspan="6">Specified smart controls</th></tr>
<tr><td colspan="7">Smart controls are a broad range of products which combine (but are not limited to) room thermostat, central timer and one/or both of: automation or optimisation functionalities. Additional features can include external communication connectivity, learning algorithms, etc.

Automation turns the heating system on or off based on occupancy, depending on the location of householders and the calculated time required to achieve the desired internal temperature. Methods employed to detect presence or relative location of householders to their property include occupancy sensors and/or smart phone geolocation services.

Optimisation calculates and brings the heating system on at the latest possible time to achieve desired room temperature. This can result in the heating switching on later during milder weather conditions when shorter pre-heat times are required.</td></tr>
<tr><td>Evidence available</td><td colspan="6">Preliminary findings of an independently commissioned manufacturer field trial reporting on 2,000+ customers each with and without their smart heating control product.
The smart meter roll-out programme summarises evidence related to In-Home Display (IHD) benefits and saving mechanisms.[51]</td></tr>
<tr><td>Costs (£ excl. VAT, incl. installation)</td><td>Low</td><td>£150, reducing to £130 in Year 2</td><td>Central</td><td>£190, reducing to £150 in Year 2</td><td>High</td><td>£230, no future cost reduction</td></tr>
<tr><td>Source of cost data</td><td colspan="6">Stakeholder engagement with industry, market intelligence and BEIS review of products on the market.</td></tr>
<tr><td>Quality of cost data</td><td colspan="6">Smart controls are a novel and developing technology and therefore costs are uncertain.</td></tr>
<tr><td>Demand reduction</td><td>Low</td><td>0%</td><td>Central</td><td>3.8%</td><td>High</td><td>5.8%</td></tr>
<tr><td>In use factor</td><td colspan="6">Assumptions are based on empirical trial results & are therefore include any potential comfort taking & direct rebound effects.</td></tr>
<tr><td>Source of demand reduction</td><td colspan="6">High: (Central) field trial savings are achieved and there is no overlap with smart metering In-Home Display (IHD) saving mechanisms.

Central: Field trial savings are reduced by 2% to account for overlap between IHD and smart control saving mechanisms.

Low: Assumes policy measure has no impact.</td></tr>
<tr><td>Quality of demand reduction</td><td colspan="6">Reported field trial savings have a wide margin of uncertainty (±3.2%). A follow-up trial is expected to be more representative of the wider population with an improved counterfactual to evaluate performance against. Furthermore, end user surveys are expected to better evaluate end user behaviour and occupant thermal comfort.

Such trials tend currently not to disaggregate savings according to the various control functionalities concerned. It is also anticipated that the effectiveness of similar functionalities may vary across products on the market as they are based upon proprietary algorithms.</td></tr>
</table>

[51] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/567168/OFFSEN_2016_smart_meters_cost-benefit-update_Part_II_FINAL_VERSION.PDF

<table>
<tr><th>Policy Measure:</th><th colspan="6">Flue Gas Heat Recovery (FGHR)</th></tr>
<tr><td colspan="7">Flue Gas Heat Recovery (FGHR) is the extraction of waste heat from the products of combustion (flue gases) which can then be used for the purpose of pre-heating domestic hot water (DHW). By doing so, the amount of gas used to heat DHW can be reduced, thereby increasing the overall efficiency of the boiler. Current products are designed to work only with combination boilers (products for system boilers are expected to be much more expensive and complex to develop).

FGHR products can broadly be segmented into two types: those with additional thermal storage and those without. For the purposes of this assessment we assume that all FGHR systems installed come with some integrated storage. Systems without integrated storage are expected to have lower capital costs at the expense of overall product impact.</td></tr>
<tr><td>Evidence available</td><td colspan="6">BEIS technology evidence gathering report[52].</td></tr>
<tr><td>Marginal Costs (£ excl. VAT, incl. installation) (PFGHR with storage)</td><td>Low</td><td>£300, reducing to £130 in Year 2</td><td>Central</td><td>£460, reducing to £200 in Year 2</td><td>High</td><td>£800, reducing to £530 in Year 2</td></tr>
<tr><td>Source of cost data</td><td colspan="6">Stakeholder engagement with industry and interviews with FGHR suppliers and manufacturers to inform BEIS's FGHR evidence gathering report.</td></tr>
<tr><td>Quality of cost data</td><td colspan="6">Central costs are taken from an independent review of FGHR.</td></tr>
<tr><td>Eff. Improvement (Low DHW demand)</td><td>Low</td><td>2.02%</td><td>Central</td><td>2.72%</td><td>High</td><td>3.37%</td></tr>
<tr><td>Eff. Improvement (Avg. DHW demand)</td><td>Low</td><td>2.20%</td><td>Central</td><td>2.93%</td><td>High</td><td>3.66%</td></tr>
<tr><td>Eff. Improvement (High DHW demand)</td><td>Low</td><td>2.94%</td><td>Central</td><td>3.95%</td><td>High</td><td>4.91%</td></tr>
<tr><td>In use factor</td><td colspan="6">Evidence indicates that new-build regulatory compliance is the main driver for product uptake. Rebound effects are not applicable to such installations. Policy measure is not anticipated to drive widespread retrofit installations – efficiency adjustment therefore not considered.</td></tr>
<tr><td>Source of demand reduction</td><td colspan="6">EST[53] domestic hot water consumption monitoring report, EFUS[54] energy consumption data and BEIS FGHR evidence gathering report modelling using accepted assumptions on heating cycles (during seasons when space heating is required) and domestic hot water usage patterns (also referred to as 'tapping cycles').</td></tr>
<tr><td>Quality of demand reduction</td><td colspan="6">Actual savings may vary from one property to the next, and will be dependent on: the volume of thermal storage, total domestic hot water demand, the heating season (i.e. how often the boiler operates in space heating mode), and the extent to which DHW demand overlaps with periods of space heating.</td></tr>
</table>

[52] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/545245/PFGHR_Report_-_FINAL__1_.pdf
[53] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48188/3147-measure-domestic-hot-water-consump.pdf
[54]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/274771/3_Metered_fuel_consumption.pdf

Annex 3: Changes in NPV from Consultation IA

We cannot directly compare the values produced in the NPV analysis (Table C3) with the Consultation IA. However we can step through in approximate terms how the NPV has changed through updates to modelling and assumptions since the Consultation IA. A worked example for learning thermostats is provided below.

Assumption & Modelling Change	Learning Thermostats	
	NPV	Change in NPV
Consultation IA (Weather compensator and learning thermostat package)	**+£172m**	**-**
Change in policy design to fully account for upfront cost and performance *(Adjusted comparator with Final IA)*	**+£240m**	**Approximately +£70m**
Net modelling changes	**+£235m**	**-£5m**
Fossil fuel price change	**+£125m**	**-£110m**
Change in number of households in scope	**+£300m**	**+£175m**
Performance changes	**+£175m**	**-£125m**
Cost changes	**+£784m**	**Approximately +£610m**
Final IA NPV	**+£784m**	**-**