| | |
|---|---|
| **Title:** The Renewable Heat Incentive: A reformed and refocused scheme | **Impact Assessment (IA)** |
| **IA No:** BEIS032(F)-16-RH | **Date:** 07/12/2016 |
| **RPC Reference No:** N/A | **Stage:** Final |
| **Lead department or agency:** | **Source of intervention:** Domestic |
| Department for Business, Energy and Industrial Strategy | **Type of measure:** Secondary Legislation |
| **Other departments or agencies:** N/A | **Contact for enquiries:** rhi@beis.gov.uk |

## Summary: Intervention and Options

**RPC Opinion:** Not Applicable

| Cost of Preferred (or more likely) Option | | | | |
|---|---|---|---|---|
| **Total Net Present Value** | **Business Net Present Value** | **Net cost to business per year** (EANDCB in 2014 prices) | **One-In, Three-Out** | **Business Impact Target Status** |
| £1,344m | N/A | N/A | N/A | NQRP |

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

The Renewable Heat Incentive (RHI) is an incentive to owners of renewable heat installations. It was introduced in the non-domestic sector in November 2011 and the domestic sector in April 2014. It is intended to help overcome the cost differential between renewable and conventional heating systems in order to incentivise deployment and contribute to meeting the UK's Carbon Budgets and legally binding 2020 Renewable Energy Directive target.

**What are the policy objectives and the intended effects?**

The aim of the RHI is to incentivise the cost effective installation and generation of renewable heat in order to contribute to meeting Carbon Budgets, generate renewable energy to help meet the UK's 2020 renewable energy target, and develop the renewable heat market and supply chain so that it can support the mass roll out of low carbon heating technologies. The reforms being made to the RHI are designed to ensure it focusses on long term decarbonisation; offers better value for money and protects consumers; and supports supply chain growth and challenges the market to deliver.

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

Three options for the RHI were assessed in the IA which accompanied the RHI reform consultation:

Option 1a: Do nothing / Leave scheme regulations as they were including no budget allocation or trigger changes to allow for future growth.

Option 1b: Counterfactual / Close the RHI. Had the budget and accompanying changes not been agreed, this would likely have resulted in the scheme being closed to new applicants after this date.

Option 2: Reform the Renewable Heat Incentive Scheme (Preferred): implementing the refocusing of the scheme is the preferred policy option because it offers the best potential for the scheme to deliver its objectives and benefits at good value for money, while ensuring the scheme remains affordable and fits with the Departments wider objectives.

**Will the policy be reviewed?** It will not be reviewed. **If applicable, set review date:**

| | | | | |
|---|---|---|---|---|
| Does implementation go beyond minimum EU requirements? | N/A | | | |
| Are any of these organisations in scope? | **Micro** N/A | **Small** N/A | **Medium** N/A | **Large** N/A |
| What is the $CO_2$ equivalent change in greenhouse gas emissions in Carbon Budget 4? (Million tonnes $CO_2$ equivalent) see Section 4.4 | **Traded:** ~1 Mt | **Non-traded:** ~25 Mt | | |

***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: Lucy Neville-Rolfe Date: 07/12/2016

## Summary: Analysis & Evidence

**FULL ECONOMIC ASSESSMENT**

| Price Base Year 16/17 | PV Base Year 16/17 | Time Period Years 25 | Net Benefit (Present Value (PV)) (£m) | | |
|---|---|---|---|---|---|
| | | | **Low:** -1,657 | **High:** 4,227 | **Best Estimate:** 1,344 |

| **COSTS (£m)** | **Total Transition** (Constant Price) | Years | **Average Annual** (excl. Transition) (Constant Price) | **Total Cost** (Present Value) |
|---|---|---|---|---|
| **Low** | | | | 2,853 |
| **High** | | | | 5,095 |
| **Best Estimate** | 1. | | | 4,791 |

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

The reformed RHI will see costs arising only from the lifetime resource cost of supporting all eligible renewable technologies, with a best estimate of £4,791m. This is mainly as a result of the additional costs of installing low carbon technologies. These estimates are subject to uncertainty, both in terms of the types of installations which may come forward and the additional costs they may face.

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

Rebound Effect: for some users, installing a low carbon heat technology could lead to lower fuel bills. This could lead to an overall increase in energy consumption, reducing energy saving and carbon benefits, but increasing welfare benefits from households comfort taking and organisations increasing their output, with an uncertain overall impact. Wider impacts on the waste, agriculture, and forestry sectors: potential costs of food waste collection from local authorities to achieve maximum carbon savings potential; and potential impacts on air quality resulting from spreading digestate from anaerobic digestion plants.

| **BENEFITS (£m)** | **Total Transition** (Constant Price) | Years | **Average Annual** (excl. Transition) (Constant Price) | **Total Benefit** (Present Value) |
|---|---|---|---|---|
| **Low** | | | | 1,859 |
| **High** | | | | 9,018 |
| **Best Estimate** | | | | 6,136 |

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

The main monetised benefit of the RHI is the reduction in carbon emissions which mainly occurs in the non-traded sector and is influenced by savings as a result of biomass and biomethane, best estimate £197m traded carbon and £5,487m non-traded carbon. The other important benefit is the air quality impact from principally as a result of displacing oil boilers. The air quality impact is highly uncertain, with a best estimate of £451m. For some installations there will also be benefits from saving energy.

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

Innovation & cost reductions: by supporting low carbon heat deployment BEIS expects that costs will reduce and performance may increase over time as supply chains are developed more fully, and barriers that customers currently face will be reduced if technologies are deployed successfully.

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

As the RHI is a demand led scheme, it is difficult to anticipate the level of deployment which will come forward as a result from the scheme reforms. Additional uncertainty comes from the potential for changes in markets such as fossil fuel prices. Availability, and counterfactual use, of feedstocks for anaerobic digestion is highly uncertain and could limit benefits. This results in an asymmetric risk profile on overall carbon abatement, with lower abatement more likely than higher. The counterfactual use of anaerobic digestion's digestate is very uncertain and will have an impact on the air quality impacts of the scheme. Assumptions regarding the efficiency of systems, fuels replaced, feedstocks used and their counterfactual, and price of carbon are the major sensitivities which affect overall benefits and the NPV of the scheme as a whole.

**BUSINESS ASSESSMENT (Option 1)**

| Direct impact on business (Equivalent Annual) £m: | | | Score for Business Impact Target (qualifying provisions only) £m: |
|---|---|---|---|
| **Costs:** N/A | **Benefits:** N/A | **Net:** N/A | N/A |

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# Section 1) Introduction and Background

1. The RHI is central to the Government's plans for the long-term decarbonisation of heating in the UK. It's also an important contributor to meeting the UK's binding renewable energy target, as set out in the EU Renewable Energy Directive.
2. The Non-Domestic RHI scheme was launched in November 2011. This was followed by the Domestic RHI scheme in April 2014. So far the RHI has supported over 50,000 domestic renewable heat installations, and over 15,000 non-domestic renewable heat installations in the UK. The majority of deployment to date has been in the bioenergy market. Non-domestic deployment has seen a lot of small biomass, biomethane, and to a lesser extent, medium biomass and biogas. In the domestic scheme biomass has also seen the largest spend by technology for new installations; however heat pumps have seen the largest number of installations within domestic sector.
3. In November 2015, the Government renewed its commitment to the transition to low carbon heat by confirming a continued budget for the Renewable Heat Incentive, rising from £430m in 2015/16 to £1.15bn in 2020/21 in nominal terms.

## 1.1. Rationale for Intervention

4. The current market for renewable heat is relatively small and these technologies are largely unable to compete on cost with conventional heating options such as gas, oil and electricity. This is partly due to the emerging nature of renewable heating which means that it does not benefit to the same degree from economies of scale, or from mature supply chains. Additionally, the full societal costs of fossil fuel combustion are not reflected in their market price, for example the impacts on health and climate change.
5. In addition to cost differences, there are a number of non-financial barriers to the uptake of renewable heat such as awareness of technologies, availability of local suppliers, and the hassle involved in changing heating systems.
6. The economic rationale for subsidising renewable heating in the domestic and non-domestic sectors has five main aspects:
   a. Reflecting the negative carbon externality associated with the conventional heating of buildings which is not currently reflected in the cost of those systems.
   b. The UK currently operates under the EU Renewable Energy Directive (RED) which sets out a legally binding target for the UK to generate 15% of its energy from renewable sources by 2020. Renewable heat is expected to make a significant contribution to this target.
   c. Preparing the supply chain (installer and manufacturer) for the mass roll-out and deployment of low carbon heat potential, which is needed to decarbonise heat use in buildings and some industrial processes, in order to meet legally binding carbon targets.

d. Raising awareness, reducing barriers and increasing innovation through increased deployment, as the spillover benefits to society of marginal increases in performance or marginal decreases in costs are not reflected in the price of renewable heating.

e. Renewable heat adds a further non-monetised benefit through diversifying the UK's energy supply, reducing UK exposure to the volatility of oil and gas prices.

7. The RHI is designed to address these, by incentivising cost effective installations, creating cost reductions for installation and operation, and improving performance of renewable heating systems.

## 1.2. Policy Objectives

8. The overarching aim of the RHI, both Domestic and Non-Domestic schemes, is to incentivise the cost effective installation and generation of renewable heat in order to:

a. Contribute directly to decarbonisation of heating in the UK and to meeting Carbon Budgets.

b. Contribute to renewable energy in order to help meet the UK's 2020 renewable energy target for sourcing 15% of energy demand from renewable sources.

c. Develop the renewable heat market and supply chain so that it is in a position to support the mass roll out of low carbon heating technology required in the 2020s and onwards in order to meet the UK's Carbon Budgets.

9. This document sets out the Government's reforms to both Domestic and Non-Domestic RHI schemes, designed to ensure the schemes' objectives are met in a manner which:

**a. Focusses on long-term decarbonisation:** The reforms promote deployment of the right technologies for the right uses, while ensuring the RHI contributes appropriately to short-term decarbonisation targets and retaining a credible plan for the UK's existing targets under EU law, as long as these apply.

**b. Offers value for money, protects taxpayers and consumers and is affordable:** Taken together the measures significantly improve the scheme's value for money and cost control, delivering carbon savings at half the price of the existing scheme.

c. **Supports supply chain growth, and challenges the market to deliver**: The reforms will drive cost reductions and innovation to help build growing markets that provide quality to consumers and are sustainable without Government support in future.

# Section 2) Analytical Approach

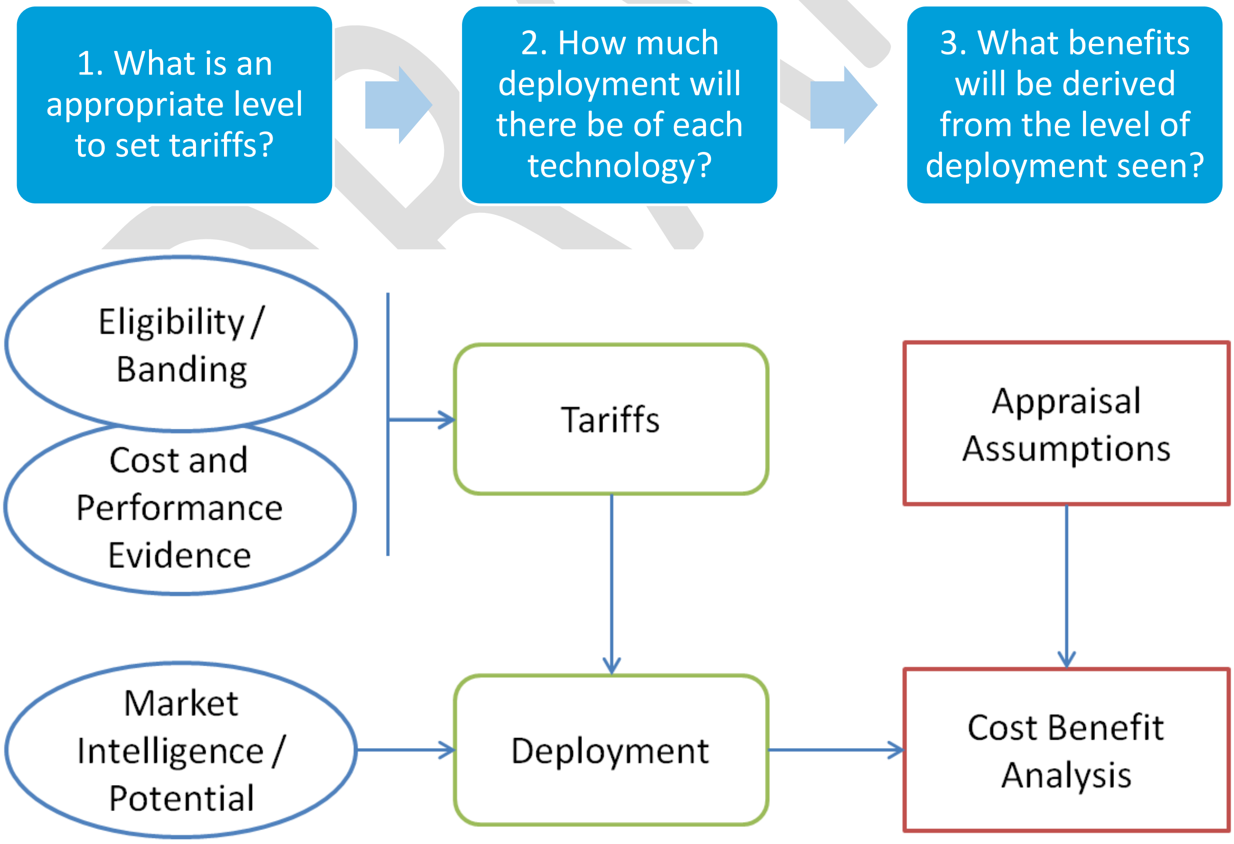
## This section outlines the analytical stages involved in assessing the costs and benefits of the Renewable Heat Incentive Schemes.

10. The analytical component of the refocus of the Renewable Heat Incentive seeks to answer three main questions, shown in the boxes below. Our high level approach to addressing these questions, shown schematically in the diagram below, is:

    a. Tariffs are set to compensate installations for the additional costs incurred and to provide a rate of return on the additional investment, taking into account the cost and performance of the renewable heating system as well as the counterfactual systems which would otherwise have been installed.

    b. Deployment is derived through market intelligence to assess the possible impact of the policy package and draws on a range of sources.

    c. Appraisal of the benefits of the given deployment is based on the appraisal assumptions which make use of the best evidence on the performance of systems, carbon emissions, and other impacts.



## 2.1. Evidence Base

11. A list of the major sources of evidence and a summary of the assumptions used in this Impact Assessment can be found in Annex B.

12. The evidence on the cost and performance of technologies used to inform tariff setting comes from a wide array of sources. These parameters will all feed in to the design of tariffs for different renewable heating technologies, as well as informing the impacts appraisal. There is uncertainty around many of these key assumptions:

    a. There is variation in the cost and performance of low carbon heating technologies arising from a variety of sources, including variation in the building stock, the types of technology solutions, and use.

    b. Many of the technologies are emerging, or are growing from very small deployment levels. This can cause large variation, and changes, in costs and performance across the market and over time.

    c. Technology specific aspects being reported can vary, including, for example, market segmentation, types of systems considered, or target building type.

    d. The relationship between different variables (for example where the performance of a system and the cost of a system may be linked), or where boundaries have been set (e.g. if the costs include just equipment, or installation costs as well).

13. For these reasons above, the evidence gathered needs to be examined and interpreted by experts within BEIS. This results in an agreed set of assumptions for parameters such as: the capital cost of technologies, their performance or efficiency, likely installation sizes, and the appropriate counterfactual technology to consider.

14. Since the consultation was published there have been a number of changes to our evidence base, including:

    a. Updated energy prices: the most recent BEIS publication of forecast retail price series have been used[1].

    b. Updated air quality impacts: the air quality damage costs of emissions associated with burning fuels have been revised (see Annex C).

    c. Large Biomass market: evidence received during the consultation has suggested a lower market potential than previously estimated due to:

        - Fewer large heat loads of the type that biomass can effectively supply than previously thought.
        - These heat loads will generally be smaller than envisaged and serviced by installations with lower capacities.

[1] Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

- These heat loads will be situated on the gas grid to a greater extent than anticipated, making fewer commercially viable at the proposed tariffs.

d. Anaerobic Digestion Market: evidence received during the consultation, as well as deployment and market evidence over the course of the year has shown greater market potential both for systems projected to come on during the interim period, as well as under the reformed scheme.

e. Heat Pump performance: the analysis of the Renewable Heat Premium Payment (RHPP) scheme field trial data has developed further, the results of a cropped sample of heat pumps are likely to be more accurate, with the least associated risks of data anomalies. The impact of the revised assumptions is to increase the contribution of heat pumps towards renewable energy and is included in the analysis and discussed in Annex D.

f. Resource Costs: revised calculations to more fully take account of changes to markets since they were last updated see Annex C.

g. Biomethane and Biogas Feedstocks: more detailed evidence on availability of different feedstocks to ensure deployment profiles are feasible.

## 2.2. Tariff Setting

15. Tariffs are set to compensate businesses and households for the additional costs of installing renewable heat technologies compared to conventional heating technologies such as oil or gas (for non-domestic) fuelled systems.

16. The tariff calculation methodology takes into account several components of cost which differ between the renewable and conventional heating technology, including:

a. **Additional capital cost –** The compensation for net capital costs is required because renewable heating systems are typically more expensive to install than conventional systems;

b. **Differences in operating and fuel costs** – Changes in the required maintenance, as well as the type and amount of fuel used can impact the ongoing costs faced by consumers. These can either be savings or increases depending on the case; and

c. **Rate of return** – Installing renewable heating systems often involves barriers which decision makers require a financial rate of return to overcome. For example, this can be additional work on the building, a risk premium associated with the technology. Additional returns are assumed to be required in the Non-Domestic scheme to compensate for the opportunity cost of funding the installation of the measure.

17. The tariffs available to different technologies may have changed over time either due to BEIS adjusting tariffs after receipt of additional evidence during well-defined tariff

reviews and consultation period, or due to degressions (trigger points that lower tariffs automatically when deployment reaches certain levels).

18. Scheme tariffs are not intended to offer a fixed rate of return to all installations for the duration of the scheme. Instead they act as a guide to the rate of return targeted when tariffs are set. There are many reasons why a householder or business may not achieve the above rate of return. For example, due to the high degree of heterogeneity in the building stock and in the operation of renewable heating installations. In addition, the function of degression is to protect budgets and ensure that there is diversity of deployment and value for money, so over time the actual rate of return may well change.

19. More detail on the tariff setting methodology, and differences between the Domestic and Non-Domestic scheme tariffs can be found in Annex B.

## 2.3. Deployment

20. The deployment estimates used in this Impact Assessment are derived by a combination of market intelligence and underlying analytical drivers. Deployment estimates in this IA reflect a balance between several factors including:
    a. What the policy objectives are.
    b. Changes being made to policy and resulting uncertainty.
    c. Capacity of markets to drive deployment under that policy.

21. It is not possible to model deployment in a more sophisticated manner at this time. This is because the renewable heat market constitutes a relatively small proportion of the much larger space and process heating market, and so small changes in overall take up could have outsized effects on the market for the technologies supported by the RHI. Additionally any modelling of take-up would need to be able to accurately predict the decision making of both domestic and non-domestic consumers.

22. The process of deriving deployment estimates combines all the information available to the Government; our understanding of the impacts our proposals will have on markets is necessarily reliant on information provided by industry. Deployment estimates of the current proposals draw on a sources including:
    a. Industry reports.
    b. Trade Association data.
    c. Pipeline data.
    d. Scheme learning to date.
    e. Stakeholder interviews.
    f. Feedback from the consultation.
    g. RHI Evaluation.
    h. BEIS judgement.

23. These are used to develop a central assessment of the likely deployment projected to come online over the 2016/17 to 2020/21 period. Alternative sensitivities, including higher or lower deployment are explored in more detail in Section 4: *Impacts Appraisal*.

Discussion of the uncertainties surrounding deployment and sensitivities in analysis can be found in Section 5: *Uncertainty*.

## 2.4. Monetised Costs and Benefits

24. In order to understand the impact of the RHI, a calculator has been developed which estimates the costs and benefits associated with the forecasts of deployment. This accounts for factors such as tariff tiering, seasonality of heat demand and deployment profiling.

25. The components of the monetisation of the costs and benefits contribution to the Net Present Value (NPV) are:

    a. **Resource costs** – the net economic cost of installing the renewable heating technologies over and above the counterfactual cost, including capital, fuel, and running costs; this is net of the benefits where there are reduced resources, such as fuel savings from efficiency gains.

    b. **Carbon savings** – our monetised estimates of the value of the carbon abated in both the traded and non-traded sectors.

    c. **Air quality impacts** – the costs/benefits of the health impacts of higher/lower emissions of nitrogen oxides and particulate matter due to fuel combustion and fuel switching.

26. In addition to the evidence base on technologies used for setting tariffs, additional information regarding appraisal values from various sources has been used including:

    a. **Emissions factors –** these look at the greenhouse gases, oxides of nitrogen (NOx) and particulate matter emissions for various low carbon options and the technologies they are replacing. These are sourced from BEIS and Defra emissions guidance and projected electricity carbon intensity factors.

    b. **Costs of emissions –** these look at monetising the costs to human health and the costs of carbon emission again using guidance from BEIS and Defra and carbon prices.

    c. **Other standard analysis –** is used, such as Green book appraisal guidance, and Office for Budget Responsibility (OBR) projected inflation series.

27. As many of the factors included in the policy appraisal may vary, sensitivity analysis on the main variables is also included, as outlined in Section 5 below.

28. It should be noted that while NPV assessment included in this impact appraisal is the main metric used for policy assessment and comparison, it is not always the ideal metric for assessing the desirability of undertaking a policy. For example assessing the RHI against a counterfactual of no renewable heat deployment implies that in the absence of the RHI the contribution the scheme is making to the RED or to Carbon Budgets would not be needed, both of which are legal obligations. This means that in

the absence of the RHI additional effort would be required to support renewable or low carbon technologies through another, potentially more expensive, means.

## 2.5. Non-Monetised Cost and Benefits

29. Although the main impacts of the revised scheme are included in the calculation of the NPV above, not all effects of the scheme are captured in the cost benefit analysis. This includes:

   a. Renewable heat generation towards RED targets is not monetised, as there is no agreed cost of renewable energy, however additional action would be required elsewhere in the absence of the RHI.

   b. Innovation & cost reductions: by supporting low carbon heat deployment BEIS expects that costs will reduce and performance may increase over time as supply chains are developed more fully, and barriers that customers currently face will be reduced if technologies are deployed successfully.

   c. Rebound Effect: for some users, installing a low carbon heat technology could lead to lower fuel bills. This could lead to increased energy consumption, reducing energy saving and $CO_2$ benefits, but increasing welfare benefits from households comfort taking and organisations increasing their output, with an uncertain overall impact.

   d. Electricity system impacts: some technologies supported within the RHI also support the production of low carbon electricity (CHP systems), while others increase electricity demand when switching from fossil fuels (e.g. Heat Pumps). Marginal impacts on production and demand of low carbon electricity have not been modelled.

   e. Air quality impacts: digestate from anaerobic digestion plants is typically spread on agricultural land as a fertiliser, but this results in the release of ammonia, that has an air quality impact. The direct impact from RHI-supported AD plants is dependent on the counterfactual use of the plants' feedstock and how the digestate is stored and applied to the land. Uncertainties around these factors have prevented quantification of the impact to date, but the Government intends to understand these better in future.

30. Additional policy design considerations which are not captured in the impacts assessment include:

   a. Reducing the risk of environmental impacts associated with the production of crops used in the energy sector (e.g. impacts on soil and water quality) by limiting support for food crops (see Chapter 4 and Questions 26 and 27 in Annex A of the Government response to the consultation, published alongside this document).

   b. Improving access to the scheme: in line with the objectives for the reform changes have been made to make the scheme more accessible to households which are less able to pay (see Chapter 2 and 3 and Questions 9 – 14, 15 – 18 and 25 in

Annex A of the Government response to the consultation, published alongside this document).

c. Wider impacts on the waste, agriculture, and forestry sectors have not been captured, and therefore additional costs or benefits impacting these sectors have not been included. These could include costs such as feed waste collection from local authorities, or benefits such as increasing biodiversity in UK forestry.

31. Qualitative assessments of the impacts and net effect of these is included in Section 4: *Impacts Appraisal*, below.

# Section 3) Policy Options

## 3.1. Policy Options Assessed

32. Three options for the RHI were assessed in the Impact Assessment which accompanied the RHI reform consultation:

    a. Option 1a: Do nothing / Leave scheme regulations as they were

    b. Option 1b: Counterfactual / Close the RHI

    c. Option 2: Reform the Renewable Heat Incentive Scheme (Preferred)

**Option 1a: Do nothing / Leave scheme regulations as they were**

33. Making no changes to the scheme would leave the RHI open with eligibility, tariff levels, and degression triggers as they were at the end of March 2016. This would result in degression rapidly reducing tariffs for those technologies deploying, because unchanged regulations would have left degression triggers flat, while rules are based on rising triggers. As such, flat degression triggers would mean that having a single application in a quarter could result in a degression of up to 25%. While there might be some early deployment of technologies which have not yet hit their current triggers, tariffs would rapidly fall if any significant deployment came forward.

**Option 1b: Counterfactual / Close the RHI**

34. The RHI did not previously have a budget settlement that would allow for new installations to be accredited onto the scheme after 31 March 2016. Had the budget for new applications over the spending review period not been agreed, it is likely that ministers would have taken the decision to actively close the scheme to new applicants. If the scheme were closed, the RHI would drive no additional benefits. More detail on the counterfactual can be found below.

**Option 2: Reform the Renewable Heat Incentive Scheme – Preferred**

35. The option of reforming the RHI is the preferred policy option because it offers the best potential for the scheme to deliver its objectives and benefits at good value for money, while ensuring the scheme remains affordable and fits with the Departments wider objectives.

36. The policy option has two broad components implemented in two packages:

    a. The first package of changes was made in April 2016 to maintain the affordability of the scheme, and simplifications to enhance the functioning of the scheme over the interim period before full reforms are enacted.

    b. The second package will implement the re-focusing of the RHI to take effect from 2017/18 onwards. This includes: tariff and eligibility changes, introduction of tariff guarantees, and establishing the budget management and affordability mechanism for the period.

37. Table 1, below, provides more detail on the changes included in the preferred policy proposal. For greater detail on the changes to tariffs, eligibility, and budget management, as well as to how the policy is different to the proposal at consultation, refer to the Government Response published alongside this document.

**Table 1 - Final policy changes of the Reformed RHI**

| Change | Brief description |
| --- | --- |
| **Budget Cap** | Introduction of a single overall budget cap based on the scheme's budget, covering expenditure from all technologies in the Domestic and Non-Domestic schemes. |
| **New Structure of Biomass Support** | Focusing biomass support to provide the best value for money and better align with the Government's longer-term decarbonisation strategy. Moving from three bands based on capacity, to a single band and making the scheme more attractive to larger more strategic installations by structuring tariffs to promote higher heat load factors (HLFs):<br>• Tier 1 tariff of 2.91p/kWh, Tier 2 tariff of 2.05p/kWh after threshold of 35% of maximum output;<br>Additionally the domestic tariff will be 'reset' to 6.43p/kWh as of April 2017, based on deployment evidence that this would be a level sufficient to support further deployment and supply chain development at a level which represents value for money. See Chapter 2 of the Government response to the consultation for details. |
| **Support for Heat Pumps** | Increasing domestic tariffs for Air Source Heat Pumps (ASHPs) to 10.02 (p/kWh) and Ground Source Heat pumps (GSHPs) to 19.55p/kWh respectively heat pumps, to better reflect current evidence base. Extending eligibility for shared ground loops in the Non-Domestic scheme. Mandating metering for domestic systems to help householders understand the performance of their systems (not for payment). |

| Change | Brief description |
|---|---|
| **Targeted Anaerobic Digestion (AD) support** | Focusing AD support for biomethane and biogas towards the feedstocks which are most consistent with delivering cost effective carbon abatement potential and optimal environmental outcomes, by:<br>• Limiting payments for crop-based feedstocks to 50% by output volume;<br>• Tightening criteria for eligible heat uses including removing payments for heat used to dry digestate;<br>• 'Resetting' the Biomethane tariff to the level available between 1 April 2016 and 1 July 2016, and Biogas tariffs to the level available as of October 1 2016, effective as of April 2017, to isolate future delivery from further degressions caused by accrediting plant during the current transitional period.<br>• Feedstock auditing for 1MWth and over. |
| **Tariff guarantees** | Improving the proposition for large investors by introducing tariff guarantees, allowing large installations with long lead times certainty about tariff levels for investment decisions. |
| **Introduction of Domestic Heat Demand Limits** | Promoting affordability, scheme robustness, and value for money by introducing heat demand limits to new participants, limiting the level of returns and potential for overcompensation for owners of larger properties. Set at 20,000 kWh/yr for ASHPs, 25,000 kWh/yr for biomass boilers, and 30,000 kWh/yr for GSHPs. |

## 3.2. Counterfactual Deployment

38. As noted above the RHI did not previously have a budget settlement to allow for new installations to be accredited onto the scheme after March 31st 2016. While the scheme could have carried on temporarily under existing regulations, in practice proper budget management is necessary so, in absence of this, the scheme would be closed.

39. For the consideration of the costs and benefits of deployment supported during this spending review period, it is therefore appropriate to consider a counterfactual of no deployment of renewable heat technologies supported under the RHI.

40. If the scheme were to close, it is likely that some low level of deployment of low carbon heating technologies would continue as suggested through the RHI evaluation[2,3].

[2] RHI Domestic Evaluation: https://www.gov.uk/government/news/evaluation-of-renewable-heat-incentive-rhi

However, it is not possible to accurately assess the level of deployment which might occur without support. As such the impacts of the proposed changes are presenting against a counterfactual of no deployment of renewable heat technologies supported by the RHI after March 2016. Sensitivity for the NPV impacts of testing the additionallity is presented in Section 5 below.

41. Assessing the proposed refocused RHI against a scenario of no deployment will also provide greater clarity and ease of engagement as to the proposals for the scheme than comparing to a market intelligence led counterfactual which would have a high degree of subjectivity. This also makes it a more appropriate benchmark against which to assess performance and benefits in future.

42. In addition to considering the level of renewable heat deployment which would be seen in the absence of the RHI, another consideration is to determine which non-renewable technology would have been installed instead of RHI supported technologies to fully assess the impacts, and therefore which type of fuel combustion is being displaced. These are outlined in Annex D.

[3] RHI Non-Domestic Evaluation: https://www.gov.uk/government/news/evaluation-of-renewable-heat-incentive-rhi

# Section 4) Impacts Appraisal

## 4.1. Main Impacts

43. This section of the Impact Assessment quantifies the costs and benefits of the RHI and changes to RHI proposed in this consultation. This includes renewable heat generated, air quality impacts, carbon savings and resource costs. Description of the costs and benefits assessed can be found in Section 2. There is uncertainty around many of the assumptions and full detail can be found in Section 5 and Annex D.

44. Table 2 below sets out the key impacts of the RHI by when the deployment occurs:

    a. **Changes to the Reformed RHI** – This records the impacts of the changes proposed to the RHI from April 2016 onwards and assessed in this IA. For clarity this has been split into Interim Deployment during 2016/17, and Reformed Deployment from 2017/18 through 2020/21.

    b. **Total impact of RHI** – For summary purposes the total impacts of the RHI as a whole are summarised. This includes RHI impacts for installations supported between 2011 and March 2016 and the changes proposed in this consultation.

**Table 2 - Headline impacts of the RHI**

| | Committed Deployment (up to 15/16) | Interim Deployment (during 16/17) | Reformed Deployment (17/18 - 20/21) | Total RHI Impact |
|---|---|---|---|---|
| **Nominal Spending in 2020/21 [£m]** | £580m | £163m | £356m | £1,103m |
| **Renewable Heat in 2020/21 [TWh]** | 9.9 | 4.1 | 8.1 | 22.1 |
| **CB4 Carbon Savings[4] (of which upstream) [MtCO2e]** | 14.9 (7.1) | 8.5 (4.6) | 18.2 (9.5) | 41.6 (21.2) |
| **NPV [Lifetime, real, discounted]** | Not in scope of this IA | £336 m | £1,009 m | Not in scope of this IA |

45. Deployment over the period assessed in this IA is estimated to support around 12 TWh of renewable heat in 2020/21, and to abate up to around 26 MtCO2e over each of Carbon Budgets (CB) 4 and 5. In total, including existing deployment, the RHI is estimated to support 22 TWh of renewable heat in 2020/21 and carbon savings up to around 40 MtCO2e over each of CB 4 and 5. The total estimated Net Present Value (NPV) of the deployment occurring over this spending review is £1,344m.

[4] Estimates of carbon savings uncertainty is discussed in Section 4.4 below.

46. Since the consultation a number of changes have been made, in particular with a different mix of deployment projected: more deployment in anaerobic digestion, and less in non-domestic biomass is now expected, based on updated market intelligence and changes to policy design.

47. The overall impact on the headline figures is a downward revision of the renewable heat estimated by around 1.5TWh, an upward revision of the carbon abatement potential by around 0.6Mt over CB4.

48. The result of this shift also means that in our central projection the estimated spend is around £35m lower in 2020/21 than estimated in the consultation; however there is a range around this which could see the scheme spending up to the budget, or lower, as discussed in the following section.

49. Table 3, below, sets out the change in our assessment of the spend and benefits since the consultation. The net impact on the NPV is an increase, as the greater carbon savings at slightly lower cost improve this assessment, while the loss in renewable heat contribution is not a monetised benefit and hence does not reduce the NPV.

**Table 3 - Changes in headline figures since consultation**

| | | Consultation Estimate* | Revised Estimate* |
|---|---|---|---|
| **Nominal Spending in 2020/21** [£m] | New deployment | £556m | £518m |
| | Total incl. existing | £1,139m | £1,103 |
| **Renewable Heat in 2020/21** [TWh] | New deployment | 13.7 | 12.2 |
| | Total incl. existing | 23.7 | 22.1 |
| **CB4 Carbon Savings** [MtCO2e] | New deployment | 13.1 – 26.1 | 12.6 – 26.7 |
| | Total incl. existing | 27.3 - 40.3 | 20.4 – 41.6 |
| **NPV of new deployment** [Lifetime, real, discounted] | | £831m | £1,344 m |

## 4.2. Deployment and Spend

50. As described in Section 2 above, there is uncertainty around the deployment which will result from the package of policy changes being made. In this impact assessment, deployment projections are based on evidence from a number of sources.

51. The deployment seen under the RHI is critical to quantifying the potential benefits and the costs of RHI and the changes proposed in this consultation. Deployment potential is considered in 3 parts to mirror the phases of the scheme:

   a. Committed deployment that occurred up to the end of 2015/16.

b. Interim deployment during 2016/17 (under new triggers and other changes[5]).

c. Reformed RHI deployment under new scheme rules from 2017/18 to 2020/21.

52. As outlined above it is deployment during this spending review period from 2016/17 through 2020/21 (b. and c. above) which is covered in this Impact Assessment. Previous deployment is included to give an assessment of the total impact of the RHI.

53. The interim deployment period occurs over the current financial year. This means that it includes a mix of current deployment statistics for those plants which have submitted applications so far this year as well as forecast deployment for the remainder of the year.

54. Three deployment sensitivities illustrate the variability around the central estimate of deployment projected over the spending review period from 2016/17 through 2020/21. This deployment is within the market potential and forms a central range of projected deployment. It does not consider degressions. More information is available in Annex C.

    a. High – This sensitivity shows the costs and benefits which would occur if the deployment increases such that the full budget is spent over the final two years of this spending review period.

    b. Central – Our main view on the likely deployment to occur over the period.

    c. Low – A lower estimate of possible deployment resulting from the changes to the scheme, within the central range of what deployment might be projected over the period.

55. The scheme is managed to an overall budget cap which covers both Domestic and Non-Domestic deployment, and both deployment already committed and new deployment over the forthcoming period. This means that there is likely to be an asymmetric nature to potential deployment, with downside impacts more likely to occur.

56. Table 4, below, shows the in-year spend estimates for each of the three sensitivities described above. Note that these only show changes in new deployment, while in practice there is variation year on year due to changes in how owners use their systems (which is not reflected here).

57. There is no likely higher deployment sensitivity assessed here as degression would act to reduce tariffs and reduce the deployment and spend on new deployment should markets pick up considerably. Further, the budget cap would act to stop greater levels of spend from occurring on the scheme.

[5] See: https://www.gov.uk/government/consultations/the-renewable-heat-incentive-a-reformed-and-refocused-scheme

**Table 4 - Nominal spend estimates under main deployment sensitivities**

| | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 |
|---|---|---|---|---|---|
| **Budget Cap** | £640m | £780m | £900m | £1,010m | £1,150m |
| **High** | £607m | £737m | £877m | £1,010m | £1,150m |
| **Central** | £596m | £722m | £857m | £979m | £1,103m |
| **Low** | £587m | £697m | £808m | £907m | £1,008m |

58. It should be noted that for deployment during the refocused RHI the degression triggers will be reset, and no degressions are projected to occur at the levels of deployment modelled in the main central projection. However, should deployment occur with a different mix of technologies than estimated, degressions are possible. Within the central range of total deployment it is therefore possible that there are degressions.

59. Detailed discussion of the impacts of budget management and the possibility of scheme closure are presented in the Government Response in Chapter 5 and in Questions 2 – 4 in Annex A. The detailed appraisal analysis is conducted on the central projections; however the headline results for the central range of deployment sensitivities are shown in Section 5.2 below.

60. It is worth noting that the RHI budget is an overall budget covering both deployment supported by changes proposed in this consultation, but also spending on deployment from the scheme to date. The annual budget in each given year therefore is based on expenditure on any new deployment on top of expenditure from the plants already supported. Therefore, if deployment is lower than budget in previous years there will be additional headroom for new deployment in subsequent years.

61. Figure 1, below, shows the in-year spend estimates for each of the three sensitivities described above set against the budget cap in chart form for illustration.

62. The technology level breakdown of the spend profile projected under the central estimate of deployment over the spending review period is provided in Table 5 below. Additional detail on the levels of deployment projected for each tariff under the central estimate is provided in Annex C.

**Figure 1 - Estimated nominal spend compared with budgets in each financial year**

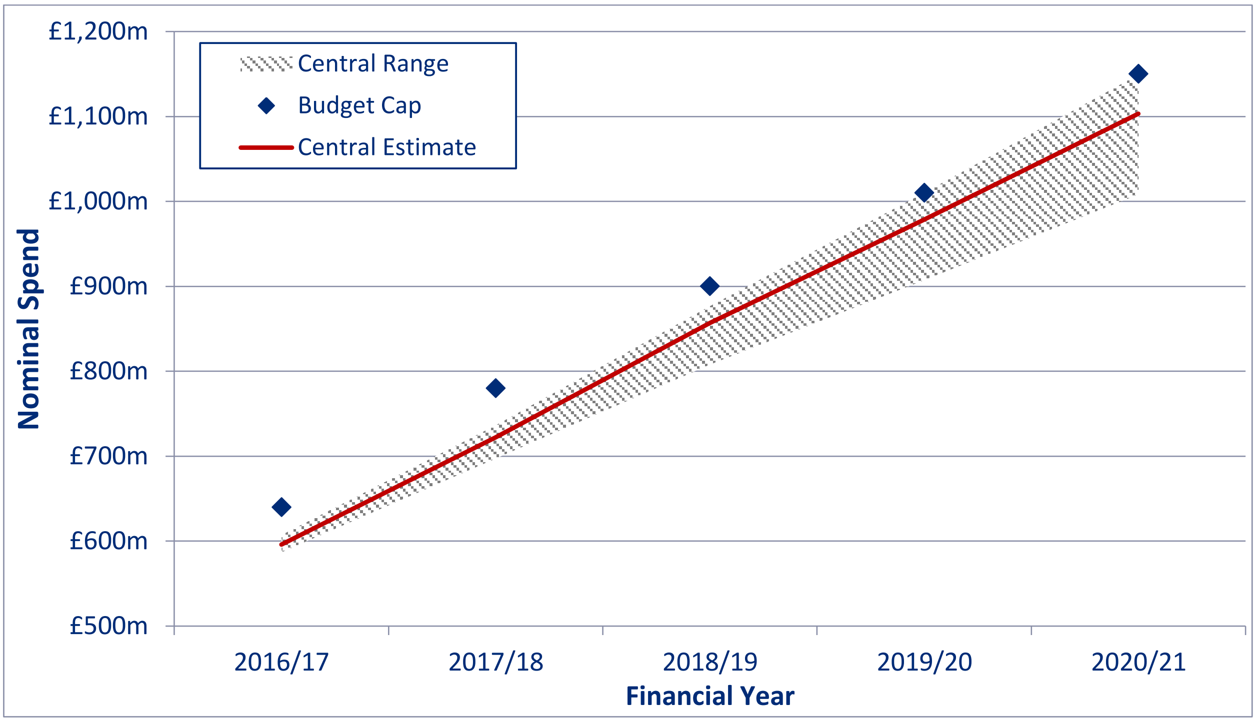



**Table 5 - Central deployment spend breakdown over SR period**

| | Nominal Expenditure in Year (£m) | | | | |
|---|---|---|---|---|---|
| | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 |
| Biomass | £38m | £75m | £100m | £127m | £154m |
| Anaerobic Digestion | £31m | £93m | £165m | £219m | £274m |
| Heat Pumps | £4m | £18m | £38m | £59m | £81m |
| Other | £0m | £2m | £4m | £6m | £9m |
| Total this SR period | £74m | £188m | £307m | £411m | £518m |
| Existing Scheme | £522m | £534m | £550m | £568m | £585m |
| Total RHI | £596m | £722m | £857m | £979m | £1,103m |

## 4.3. Renewable Heat Supported

63. With the level of spending set out above on the various technologies and the tariff proposals as described, the scheme is estimated to support approximately 12.2TWh of additional renewable heat by 2020/21.

64. Table 6 below provides estimates of the renewable heat generation in 2020/21 broken down by Interim Deployment, deployment under the Reformed RHI, as well as the total impact of the RHI including previous deployment.

65. Different technologies differ in what proportion of heat delivered is eligible for Renewable Energy Directive (RED) purposes. For example, for biomass, the RED definition is on the basis of total input energy, rather than output energy.

**Table 6 - Renewable Heat Supported in 2020/21**

| | **Interim Deployment** (during 16/17) | **Reformed RHI** (17/18 - 20/21) | **Total RHI Impact** (incl. existing plant) |
|---|---|---|---|
| **Biomass (<1MW / 1MW +)** | 1.8 TWh ( 1.2 / 0.6 ) | 3.4 TWh ( 1.5 / 1.9 ) | 12.0TWh ( 8.0 / 3.9 ) |
| **Anaerobic Digestion** | 2.2 TWh | 4.1 TWh | 9.2 TWh |
| **Heat Pumps** | 0.1 TWh | 0.5 TWh | 0.8 TWh |
| **Other** | < 0.1 TWh | 0.1 TWh | 0.1 TWh |
| **Total** (Domestic / Non-Domestic) | **4.1 TWh** (0.1 / 4.0) | **8.1 TWh** (0.7 / 7.4) | **22.1 TWh** (1.4 / 20.7) |

## 4.4. Greenhouse Gas Abatement

66. The greenhouse gas abatement which these proposals might support is dependent on the amount of heat supported by the RHI, the fossil fuel systems replaced, the feedstock used, and the efficiency of the systems. Table 7 below provides a breakdown of the carbon savings estimated to be supported over Carbon Budget 4 (2023 - 2027), through deployment under the Reformed RHI as well as the total impact of the RHI including previous deployment. Similar levels of abatement are estimated over Carbon Budget 5 (2028 - 2032). These carbon savings represent the lifecycle emission abatement, so as to properly take into account the carbon emissions from biomass.

67. A large proportion of the savings arise from biomethane and biogas, largely due to upstream savings. Upstream savings are those which result from the avoidance of emissions which would have occurred as a result of the feedstock being put to a different use, rather than those avoided at the point of fuel combustion. For example food waste which is used in anaerobic digestion might have ended up in landfill where it would have decomposed into methane – a very potent greenhouse gas – using it in AD instead means that in addition to avoiding the emissions from the fossil fuel which would have been consumed, the emissions from the decomposition into methane are also avoided.

68. However, the estimated carbon abatement which will result from upstream emissions abatement associated solely with the RHI is especially uncertain. On balance, the uncertainty means the figures presented here for upstream savings should be interpreted as an upper bound, as shown in the sensitivity analysis in section 5.2. This is because emerging evidence suggests that availability of feedstocks could limit overall deployment of the AD with the most carbon saving potential. Consideration of additional measures to increase the collection of unavoidable food waste, especially household food waste, would improve the likelihood of achieving upstream savings. The counterfactual disposal of the feedstock is also highly uncertain. In the case of

food waste, it is assumed that it is diverted from landfill, however, it may have been diverted from other uses (e.g. composting) – which would result in fewer carbon savings. Further discussion is provided in Annex D.

69. The table below shows the estimated carbon abatement over CB4 split out by technology and period of deployment. Additionally the total savings from upstream emissions abatement for Anaerobic Digestion are separated out for clarity, because of the greater uncertainty.

**Table 7 – Carbon abatement over CB4 in MtCO2e**

| | **Interim Deployment** (during 16/17) | **Reformed RHI** (17/18 - 20/21) | **Total RHI Impact** (incl. existing plant) |
|---|---|---|---|
| **Biomass** | 1.8 | 3.4 | 10.9 |
| **Anaerobic Digestion** (of which upstream) | 6.6 (4.6) | 13.6 (9.5) | 29.0 (21.2) |
| **Heat Pumps** | 0.1 | 1.1 | 1.6 |
| **Other** | <0.1 | 0.1 | 0.1 |
| **Total** (Traded/Non-Traded)* | **8.5** ( 0.4 / 8.1 ) | **18.2** ( 0.9 / 17.3) | **41.6** ( 2.1 / 39.5) |

* These splits are provided because only carbon savings in non-traded sectors (i.e. sectors not covered by the EU emissions trading scheme) count towards UK Carbon Budgets.

**Table 8 - Profile of carbon savings over time in MtCO2e**

| **(upstream savings in parentheses)** | **CB3** (2018 - 2022) | **CB4** (2023 - 2027) | **CB5** (2028 - 2032) | **Lifetime** |
|---|---|---|---|---|
| **Interim Deployment** during 16/17 | 8.5 (4.6) | 8.5 (4.6) | 8.5 (4.6) | 34.0 (18.4) |
| **Reformed RHI** 17/18 – 20/21 | 13.5 (7.0) | 18.2 (9.5) | 18.2 (9.5) | 72.9 (38.0) |
| **Total RHI Impact** incl. existing plant [Traded / Non-traded] | **37.1** (18.7) [ 1.9 / 35.2 ] | **41.6** (21.2) [ 2.1 / 39.5 ] | **41.4** (21.2) [ 2.1 / 39.4 ] | **166.7** (84.7) [ 8.3 / 158.3 ] |

## 4.5. Monetised Costs and Benefits

70. The components of the NPV calculation are shown in more detail below, based around our assumed central deployment. NPV calculations are based on discounted values cumulative over the policy lifetime.

71. There is uncertainty around the benefits the RHI is likely to deliver for a variety of reasons including: the unknown deployment and performance of systems in this

emerging market; not knowing the mix of deployment which may come forward; not knowing the mix of feedstocks that will be used, or how systems will be used by owners; and uncertainty over the carbon and air quality impacts. NPV should therefore be treated with caution and with consideration of the principle sensitivities presented in Section 5.2 below.

72. The net resulting impact is an overall increase of the estimate of NPV of just over £500m since the consultation. Compared to the estimate of NPV presented in the consultation, the estimates of the resource cost components of the different technologies and the appraisal of the air quality impacts have been revised (see Annex C, Table 16 for more information). Both of these have been reduced, but the reduction in the estimate of resource costs is larger than the reduction in estimate of air quality benefits, resulting in a higher NPV. The changes to the projected mix of deployment also led to slightly higher carbon savings estimate.

73. The overall air quality benefits have been reduced owing to updated guidance on the calculation of emissions and damage costs of particulate matter (PM) and nitrous oxides (NOX). As noted earlier, large uncertainties have prevented the inclusion of the impacts of ammonia released from digestate spreading on farmland. See Annex C for more detail.

74. The NPV of the domestic scheme has become negative over the reformed scheme in the central assumptions as a result of taking on board the lower air quality assumptions relating to PM and NOX emissions. This should be viewed in the context of the contributions to the non-monetised costs and benefits which the NPV is not able to capture but should, if valued, have overall beneficial impacts. These are discussed further below.

**Table 9 - Central NPV of new RHI deployment occurring during this spending review**

| | Resource Cost | Value of $CO_2$ Traded | Value of $CO_2$ Non-traded | Air Quality Benefits | NPV |
|---|---|---|---|---|---|
| **Interim Deployment** (during 16/17) | | | | | |
| Non-Domestic | £-1,536 m | £54 m | £1,714 m | £105 m | £337 m |
| Domestic | £-37 m | £1 m | £23 m | £12 m | £-1 m |
| **Reformed RHI** (17/18 – 20/21) | | | | | |
| Non-Domestic | £-2,779 m | £132 m | £3,473 m | £212 m | £1,039 m |
| Domestic | £-439 m | £11 m | £276 m | £123 m | £-30 m |
| **Total SR Period** (16/17 – 20/21) | **£-4,791 m** | **£197 m** | **£5,487 m** | **£451 m** | **£1,344 m** |

## 4.6. Non- Monetised Costs and Benefits

75. As outlined in Section 2.5 above, there are a number of impacts of the scheme which cannot be quantified. Our overall qualitative assessment of the likely direction of impacts is set out in the table below.

**Table 10 - Impact of Non-Monetised Costs and Benefits**

| Non Monetised Impact | Likely impact on NPV of scheme reforms if quantified |
|---|---|
| Renewable heat generation | Positive – contribution currently not monetised |
| Innovation & cost reductions | Positive – Improvements to technologies and cost reductions |
| Rebound Effect | Uncertain / mixed – Potential reduced carbon savings with increased welfare benefits |
| Electricity system impacts | Negative - Increased costs if the whole costs of expanding the grid as a result of greater heat pump take-up are not fully factored in to electricity prices |
| Environmental Impacts | Negative – Some increased costs from unintended environmental impacts possible, for instance, due to land use change not being reflected in sustainability criteria– risk reduced as a result of scheme changes |
| Ammonia release | Negative –air quality impacts of ammonia released from spreading digestate may be significant if the AD plants' waste feedstocks would otherwise be sent to landfill. However, these emissions might be able to be mitigated at a lower cost. |
| Food Waste Collection Costs | Negative – possible additional resource costs from food waste collection and separation are not reflected here. |

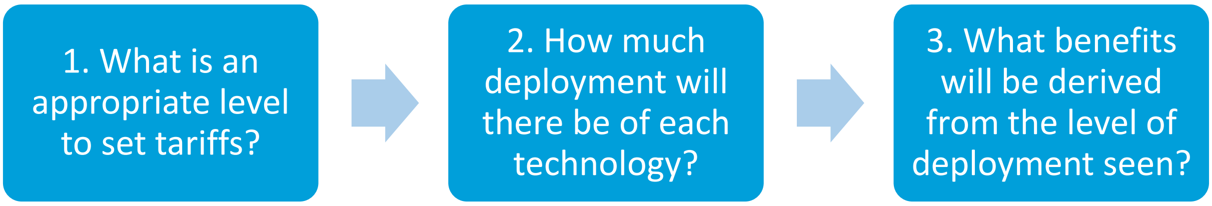
76. Given the large positive monetised NPV of the reformed scheme as a whole, the overall impact, combined with the non-monetised costs and benefits, is still likely to support the objectives of the policy and goals of the reform.

# Section 5) Uncertainty

## 5.1. Main Sources of Uncertainty

77. The market for renewable heat technologies is still in a relatively emerging state in the UK which means that data, evidence, and understanding of the technologies remains uncertain. This also means market sizes and consumer awareness can change rapidly. The existing evidence also often has large ranges for the same types of applications and varies from source to source.

78. The main sources of uncertainty can best be understood as affecting three key questions which need to be answered to set policy and determine the costs and benefits for the purpose of policy appraisal:




79. The uncertainty affecting each of these has knock-on effects for each subsequent question. For example if tariffs are not set correctly (either too low or too high) this will affect the likely deployment, likewise the main driver of total benefits in the scheme (such as renewable heat generation supported) is the total level of deployment. The principal uncertainties affecting each of these areas include:

**Table 11 - Main sources of uncertainty**

| **Uncertainty which affects tariff setting** |
|---|
| Tariff setting is affected by the large amount of heterogeneity in heating systems. Both heat demand and renewable heat installations are extremely varied. This is particularly true in the non-domestic sector. For example, the cost per unit of heat varies considerably for a single technology, dependent on factors such as location, heat load, size, and user behaviour. There is also uncertainty about the appropriate level of tariff to offer due to factors described above. For example, the data on cost and performance can be combined in a number of ways which leads to a wide range of potential tariffs. |
| **Uncertainty in estimating deployment** |
| The factors which lead households and firms to install renewable heating systems are not consistent or predictable. They rest on factors outside of the control of Government through this policy, such as fossil fuel prices. Coupled with the uncertainty about the cost and performance of technologies, this means that technical potential and likely deployment are very uncertain.<br><br>As the RHI is a demand led scheme, it is difficult to anticipate the level of deployment which will come forward as a result from the scheme reforms. Additional uncertainty comes from the potential |

for changes in the market (e.g. variations in fossil fuel prices), and from interactions with other policies (e.g. support for renewable electricity is a competitor of solar thermal, but required for CHP).

**Uncertainty in 2016/17 transition year**

In addition to the deployment uncertainty listed above, there are additional factors during the 2016/17 financial year. As published in the consultation at the start of the year, industry has had an idea about what the likely shape of the refocused RHI scheme will be, but no certainty on which to base investment decisions. The consultation proposed to change the eligibility and tariffs of some technologies, and the markets – both in demand for technologies and installers/suppliers – will have had to consider how much to invest until the final policy decisions are announced. This is particularly true for projects and installations with longer lead in times.

**Uncertainty of the costs and benefits deriving from deployment**

The level of aggregate benefits will principally be determined by the total deployment, and mix of technologies. However, for any given level of deployment there are a number of uncertainties remaining for quantifying the benefits which will accrue to the scheme. For example the carbon savings of any renewable heat installation will depend on: the type of system which was replaced; the efficiency of the system; and how it is used. The latter is affected by changes in business conditions or the weather, and the extent to which businesses ramp-up production over time – a particular uncertainty for biomethane production. The largest source of uncertainty over carbon abatement for a given level of deployment is the upstream emissions saving based on the feedstocks used in AD and what would have occurred to the feedstock had it not been used in AD. However a related uncertainty is the ammonia released from spreading the digestate on farmland, where the net impact depends on whether the feedstock is being diverted from a different source which also releases ammonia; this uncertainty has prevented its quantification to date. Additional uncertainties include: the lifecycle emissions from biomass which are subject to a high degree of uncertainty and depend on sourcing, and the level of decarbonisation of the electricity grid. There is additional uncertainty about deployment in the final period of the scheme as it will be driven in part by what the policy landscape looks like post 2020/21 as installers enter or exit markets in anticipation of future changes.

80. For both tariff setting and deployment, market intelligence (MI) and stakeholder views expressed through consultation responses have been used to offer a more complete picture than our modelling, analysis, and data offer. In addition the 5 years of experience with the operation of the scheme has been considered, and the learning that has taken place from the reaction of markets to different changes in the past. The following sections outline the approach taken to appraisal for this IA given the challenges set out above.

## 5.2. Key Analysis Sensitivities

81. There is uncertainty in many elements of this analysis, for reasons previously outlined in this Impact Assessment. This section looks at the impact of the main uncertainties; the impact of the sensitivities on NPV, carbon abatement and renewable energy generation.

82. The sensitivities shown below are only for the deployment being appraised during the spending review period of 2016/17 – 2020/21. Sensitivities related to deployment previous to that time are not in scope for this Impact Assessment. More information on all the sensitivities can be found in Annex D below.

83. The main sensitivities presented are:

    a. Central Deployment Range: high/low impact on the scheme of around 15% higher overall deployment (resulting in hitting the budget cap in 2020/21) and 25% lower overall deployment respectively.

    b. Low Deployment: a lower deployment sensitivity should the overall policy landscape shift to reduce demand for renewable heat technologies (RHTs), showing a roughly 40% drop.

    c. Counterfactual RHT Deployment high: impact of assuming around 30% of the renewable heat installations would have been installed even without the RHI.

    d. Carbon Abatement potential from the system: high/low savings due to system efficiency and carbon intensity variation, which result in a roughly 30% increase or 40% decrease in emissions abatement.

    e. No upstream AD savings: this includes no carbon abatement emissions savings in biomethane or biogas from upstream feedstocks, such as food waste, which would otherwise go to landfill. This results in an approximately 50% reduction in carbon abatement.

    f. Carbon Prices: high/low variation in the monetised cost of carbon, as detailed in BEIS's carbon price projections. The variation in price is roughly +/- 50%.

    g. Air Quality: high/low variation in the monetised cost of NOx & PM emissions. Detailed assumptions can be found in Annex C: Appraisal Assumptions. The change in damage cost of NOx is roughly +/- 60%, while for PM it is +/- 15%.

    h. Heat Pump Performance: high/low variation of the proportion of heat pumps which meet the minimum accounting requirements for RED, roughly +/- 10%.

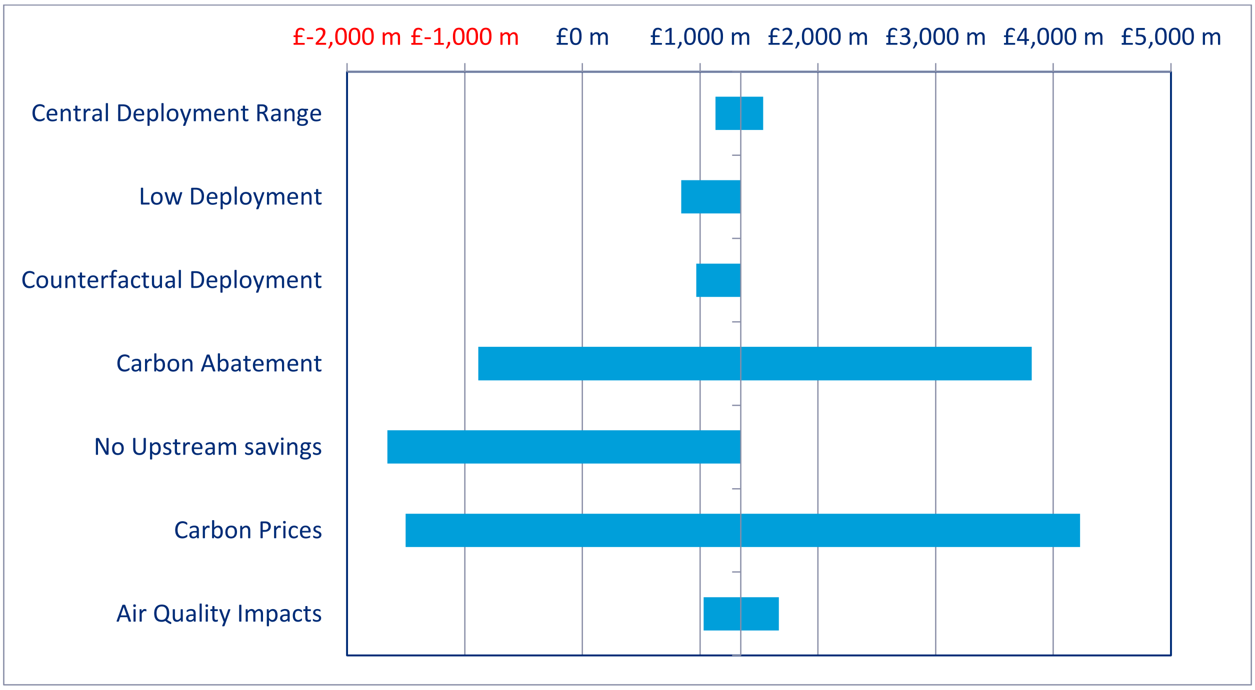
84. Table 12 and Figure 2 below illustrate the main impact of the sensitivities on the calculation of NPV. As can be seen the principle sensitivities relate directly to the carbon abatement and its monetisation. This is because the principle benefit in the NPV calculation is the carbon value (see Section 4.5); therefore the two sensitivities which change the estimate of carbon abated – Carbon Abatement and No Upstream Abatement – impact this directly, as do the prices attached to the carbon saved.

85. The level of deployment seen in the RHI over the period to 2020/21 will be a major factor in determining whether the scheme is successful and impact directly on the benefits achieved in the form of renewable heat generated and carbon abatement achieved. However renewable heat is not a component of the NPV calculation, and furthermore when deployment is scaled up or down both the costs and benefits scale roughly in proportion. This means that NPV is less sensitive to overall deployment than to changes that affect only the benefits component of the calculation.

**Table 12 - Sensitivity of NPV calculation**

| | Low | Central | High |
|---|---|---|---|
| **Central Deployment Range** | £1,129 m | £1,344 m | £1,534 m |
| **Low Deployment** | £838 m | £1,344 m | N/A |
| **Counterfactual Deployment** | £968 m | £1,344 m | N/A |
| **Carbon Abatement** | £-885 m | £1,344 m | £3,817 m |
| **No Upstream savings** | £-1,657 m | £1,344 m | N/A |
| **Carbon Prices** | £-1,503 m | £1,344 m | £4,227 m |
| **Air Quality Impacts** | £1,029 m | £1,344 m | £1,668 m |

**Figure 2 - Breakdown of NPV sensitivities**




86. The sensitivities shown above are not additive, and cannot be combined to create additional scenarios. However it is possible that some of the variation could be correlated. For example if installations are of low quality, this is likely to reduce the carbon abatement they will achieve, increase the harmful pollutants associated with air quality and increase the resource cost as they will not last the 20 years assumed.

87. This analysis of the Net Present Value illustrates the uncertainty around the monetised benefits the RHI could deliver. In particular there are several sensitivities which would see the NPV become negative; however, as mentioned above, not proceeding with the RHI could mean not meeting legal obligations towards RED or Carbon Budgets.

88. More detail on the sensitivities assessed and their impacts on the carbon abatement and renewable heat generated are provided in Annex D.

# Annex A) Policy Proposals and Changes since Consultation

## Policy Timeline

89. The scheme has undergone updates and extensions since the Non-Domestic scheme launch in 2011. These have included:

    a. Support for new technologies in the Non-Domestic scheme, consulted on in 2012, launched in 2014.

    b. A tariff review for non-domestic technologies consulted on in 2013, launched in 2014;

    c. Launch of the domestic scheme in 2014.

    d. A review of the biomethane tariff in 2014/15.

    e. Introduction of biomass sustainability criteria in 2015.

    f. Introduction of the RHI Budget Cap and minor changes alongside publication of the consultation in March 2016

90. The budget for the RHI is determined through the spending review process. The spending review settlement for the RHI, in 2013, confirmed a budget of £430m for the financial year 2015/16. No budget for subsequent financial years was confirmed.

91. Annual budget caps for each year, from 2016/17 to 2020/21, were agreed as part of the Spending Review 2015.

## Changes made since the Consultation

92. The consultation process and parallel engagement with stakeholders were used to improve our estimates of likely deployment under the proposals. The Government now believes that implementing the changes as proposed in the consultation would result in:

    a. Less large biomass than previously projected due to: restricted market opportunity, high market entry barriers, and targeted plant being smaller than thought.

    b. Less large Biomass CHP deployment due to the introduction of a power efficiency threshold and the market being constrained by reduced electricity support and due to Contract for Difference (CfD) auction uncertainty (this is separate to the biomass CHP regulation changes which have taken place and primarily affect deployment during 2016/17)[6].

[6] See Chapter 3 of the accompanying Government response

c. An increase to biomethane and biogas deployment, both during the interim deployment period of 16/17 due to a larger number of systems being market ready, as well as a continued strong pipeline of projects projected during the reformed scheme as the supply chain and market develop.

d. Potentially no deployment of domestic biomass, as degressions have pushed the tariff down below a rate which could sustain a minimally sized supply chain.

e. A slight reduction in the deployment of heat pumps, owing to constraints on the growth of the supply chain, and continued low fossil fuel price levels.

93. Of these, the lowering of the projected large biomass and biomass CHP would on their own lead to significant reductions to estimated benefits, but the projected increase in anaerobic digestion deployment acts to offset this change. However, in order to continue to support markets, the policy proposals have been refined; the changes to the proposals include:

a. Raising the tariff on offer for domestic biomass to 6.43p/kWh, undoing several degressions, to keep sufficient deployment to avoid supply chain closure and to reflect the relatively high carbon cost-effectiveness of domestic biomass.

b. Continue supporting shared ground loops for GSHP in the non-domestic scheme, but with payments based on deeming for domestic properties, based on responses of the heat pump industry (this was an open question during the consultation).

c. Maintaining support for Solar Thermal; the consultation had proposed to remove eligibility on the basis of low deployment and minimal long term supply chain impacts, but evidence received during the consultation has changed this view.

d. Extending eligibility for tariff guarantees for biomass plant above 1MW in capacity (compared to a proposed 2MW threshold).

94. The net result remains an increased risk of underspend as well as a reduction in the renewable heat delivery estimated (as laid out in Section 4 above) compared to the consultation estimates, although the renewable heat estimated remains in line with the 2015 Spending Review announcement.

# Annex B) Evidence Base

## Major Sources of Evidence

95. This annex provides an overview of the main sources of evidence used when analysing tariffs, returns, and appraising the costs and benefits of the scheme; it is not an exhaustive list. Additional information on evidence where there have been policy changes since the consultation proposal can be found in the sections below. More detail on the evidence used for policy proposals which have not changed since consultation can be found in the consultation Impact Assessment[7].

**Table 13 - Main sources of evidence**

| Source | Description |
|---|---|
| Ofgem RHI scheme data | The administration of the scheme provides detailed information regarding the types of installations supported by the scheme.<br>This is used to inform the design of the scheme as appropriate. |
| Market Intelligence | Through direct industry contact and through established channels such as the Industry Advisory Group, BEIS gathers market intelligence to support the development of policy and interpretation of evidence to inform scheme design. |
| Sweett Cost and Performance Report (2013) | Evidence collated on the cost, performance and use of low carbon heating systems. |
| Renewable Heat Premium Payment (RHPP) metering evidence | In-situ performance evidence for heat pumps supported under the RHPP. |
| NERA/AEA Report (2009 onwards) | Wide review of cost and performance of low carbon heating technologies in the domestic and non-domestic sector. |
| Evidence collated from previous schemes | BEIS has previously run several heat schemes. Where possible evidence from these has been used to inform the RHI evidence base, such as RHPP. This includes cost and performance data. |
| Industry evidence received during consultations | During calls for evidence or consultation on changes, industry often provides evidence on a wide range of issues and questions. This |

[7] https://www.gov.uk/government/consultations/the-renewable-heat-incentive-a-reformed-and-refocused-scheme

| | |
|---|---|
| | includes data on costs, deployment and performance.<br><br>BEIS publishes summaries of the evidence received during consultation in Government Responses[8]. |
| Additional engineering consultancy reports | BEIS engineers commission reports to address specific evidence gaps. Where possible these are published on BEIS's website. These include reports on performance. |
| Air Quality Emissions and Damage Costs | Official guidance provided by Defra on the uses of emission data from the National Atmospheric Emissions Institute (NAEI) database, as well as the values to be used when valuing costs. Further information provided in Annex C. |
| Carbon Prices | Projections of carbon prices, both traded and non-traded, as provided within the Green Book guidance[9]. |
| Emissions Values | Collation of work produced by BEIS scientists and engineers in quantifying carbon emission factors of RHT. Sources have remained the same from the Consultation stage Impact Assessment. |
| Evidence on availability of feedstocks | Information on the availability of different feedstocks for biomethane and biogas has come from Defra and from WRAP. This information has been supplemented by evidence from the consultation as well as from stakeholders involved in the supply chain. |

## Tariff Setting

96. Tariffs are set to compensate businesses and households for the additional costs of installing renewable heat technologies compared to conventional heating technologies such as oil or gas (for non-domestic) fuelled systems. This takes into account additional capital costs, differences in operating and fuel costs, as well as a rate of return assumed to be required to compensate for the opportunity cost of funding the installation of the measure. Differences between the Domestic and Non-Domestic tariffs are shown in Table 14 below:

[8] Links to RHI Consultations and Government Responses for both the Domestic and Non-Domestic scheme are at: https://www.gov.uk/government/publications/renewable-heat-incentive-policy-overview
[9] https://www.gov.uk/government/collections/energy-generation-cost-projections

**Table 14 - Differences between domestic and non-domestic tariffs**

| Property | Domestic Scheme | Non-Domestic |
|---|---|---|
| Period payable | 7 years | 20 years |
| Rate of return on additional investment when setting tariff level | 7.5% | 12% |
| Payment basis | Deemed renewable heat output (metering required for bivalent systems and second homes) | Metered total heat output for eligible heat uses |
| Payment timing | Quarterly in arrears (following submission of meter readings for metered systems) | Quarterly in arrears when meter reading provided. |
| Degression | Tariffs can be reduced (degressed) if spending hits certain triggers; these are discussed further in the benefits management section. | |
| Other requirements (examples) | Microgeneration Certification Scheme (MCS) certification; Energy Performance Certificate and loft and cavity wall insulation where appropriate; Sustainability requirements for biomass installations; Metering standards. | Various (e.g. Coefficient of performance (COP) levels for heat pumps and design standards); Combined Heat and Power Quality Assurance (CHPQA) certification for Combined Heat and Power (CHP) systems); Sustainability requirements for biomass, biogas and biomethane installations; Metering standards. |

97. In previous Impact Assessments tariff setting was based on incentivising 50% of the supply curve of renewable heat. The objective of this method was to avoid overcompensation while also setting the tariff that would work for a reasonable proportion of technical potential. This method however required a high bar of evidence, both for cost and performance, but also the potential market size. This has a high degree of uncertainty, particularly for non-domestic buildings.

98. The new tariff setting methodology retains the same overall objective as the previous one, but does, however recognises the evidence limitations. It uses the cost and performance information available to create a range of tariffs for different types of installation and targets what is anticipated to be the median installation.

99. This approach allows greater clarity about the impact tariffs might have. For example, for various installations, this method more closely matches policy objectives and properly captures the benefits and impacts of issues such as capping payments.

100. Table 15 below sets out which tariffs have been set using the current or previous methodology, or where other considerations have been taken into account.

**Table 15 - Tariff setting description for each technology**

| | Technology | Tariff Setting Rationale | Notes |
|---|---|---|---|
| Non Domestic | | | |
| | Solid Biomass Boilers | Reset to target RoR | Tariff set to target large installations, with tiering thresholds set above previous levels to minimise difference between tier 1/2 tariffs, lower gaming potential, and encouraging higher HLF installations. |
| | CHP Biomass | Previously set to target RoR | |
| | Biomethane | Reset with deployment evidence | 'Reset' tariff in April 2017 to the April 2016 level to ensure to degressions during bubble limit deployment of refocused (better carbon) scheme. |
| | Small Biogas | Previously set to target RoR | 'Reset' tariff in April 2017 to the October 2016 level to ensure to degressions during bubble limit deployment of refocused (better carbon) scheme; and to ensure alignment with FITs tariff adjustments for the same period. |
| | Medium Biogas | | |
| | Large Biogas | | |
| | Ground Source HPs | At VfM cap | Shared loop analysis – limited evidence, but indication of limited risk of overcompensation. |
| | Air to Water HPs | Previously set to target RoR | |
| | Small Solar Thermal | At VfM cap | |
| | Deep Geothermal | Previously set to target RoR | |
| Domestic | ASHP | Reset to target RoR | Heat demand limit (HDL) accounted for in tariff and when assessing returns. |
| | Biomass | Reset with deployment evidence | 'Reset' tariff in April 2017 to the Dec 2015 level, to take account of deployment evidence of what is needed for a viable market size. HDL accounted for in average return. |
| | GSHP | At VfM cap | HDL accounted for in average return calculations |
| | Solar Thermal | | |

101. In addition to the tariff level there are other tools for limiting overcompensation. These include degression for all technologies, proposed caps on payments in the Domestic scheme, tiering in the Non-Domestic scheme. Taken together these provide assurance on overcompensation risks.

# Annex C) Appraisal Assumptions

## Resource Costs

102. As noted within the monetised cost and benefits description in the main document above, one of the main variables affecting the calculation of the Net Present Value is the 'resource cost'.

103. The resource cost is intended to represent the true additional cost to the economy of an investor installing a renewable heating technology; it should strip out the transfer of benefits to the installer that is received from the overall subsidy cost. Our analysis is based on the same population assumed for tariff setting, i.e. the whole potential market.

104. The resource costs are estimated as a percentage of the relative tariff differing for each technology, which also means that they can change over time as tariffs change. For illustration the level of resource cost per unit of heat generated for the reformed scheme period of 2017/18-2020/21 is given in Table 16 below. However as the RHI is a demand led scheme it is likely that those people who choose to come forward are those for whom the scheme is most beneficial.

**Table 16 - Reformed RHI Resource Cost Estimates**

| Scheme | Technology | Reformed RHI Resource Cost [£ 2016/17] [p/kWh] |
|---|---|---|
| Non-domestic | Small Solid Biomass Boiler | 1.66 |
| | Medium Solid Biomass Boiler | 1.66 |
| | Large Solid Biomass Boiler | 1.66 |
| | GSHP/WSHP | 6.61 |
| | Small Solar Thermal | 10.00 |
| | Small Biogas | 3.36 |
| | Biomethane | 4.40 |
| | Medium Biogas | 3.38 |
| | Large Biogas | 1.26 |
| | CHP- Biomass and Bioliquids | 4.10 |
| | Deep Geothermal | 5.00 |
| | ASHP | 2.50 |
| Domestic | ASHP | 7.93 |
| | Biomass | 5.52 |
| | GSHP | 19.51 |
| | Solar Thermal | 19.20 |

## Deployment

105. The majority of deployment to date seen under the RHI has been in the bioenergy market. For Non-Domestic RHI this has been small biomass (<199kW) and biomethane, and to a lesser extent medium biomass (200-999kW). Within the Domestic RHI biomass has also seen the largest spend by technology for new installations.

106. Our estimates of the potential market size of each technology have been revised in light of evidence received during the consultation as well as through additional stakeholder engagement. This has also included revising our understanding of the profile of deployment, which has been taken into account in the deployment sensitivities presented in the main analysis above.

107. There remains a high degree of uncertainty around the deployment profiles, particularly regarding how markets react to the increased certainty of the RHI continuing, market response during 2016/17 and reaction to the proposals outlined in this consultation.

108. The table below presents a summary of an illustrative market size which would be consistent with the central deployment projection presented in this Impact Assessment. It should be noted that in reality the number, capacity, and heat load factor of installations will be varied. Additionally these figures do not represent the evidence or sizing upon which tariffs were set but are used as an illustrative understanding of the market size implications of our deployment profiles.

**Table 17 - Illustrative market intelligence assessment of scheme deployment potential**

| | Technology | Installations in 2020/21 | |
|---|---|---|---|
| Non-Domestic | Biomass Boilers | 20 per year 4,000 kW installations, and 400 per year systems under 1,000 kWh | HLF: 35% |
| | Biomass CHP | 1-2 per year 10,000 kW installations | HLF: 53% |
| | GSHP | 350 per year 30kW installations | HLF: 22% |
| | ASHP | 220 per year 40 kW installations | HLF: 22% |
| | Deep Geothermal | 1 per year 6,000 kW installations | HLF: 55% |
| | Biomethane | 16 per year 6,000 kW installations | HLF: 80% |
| | Small Biogas | 300 per year 50 - 160 kW installations | HLF: 65% |
| | Medium Biogas | 20 per year 480 kW installations | HLF: 65% |
| | Large Biogas | 5 per year 1,600 kW installations | HLF: 65% |
| | Solar Thermal | 115 per year 15kW installations | HLF: 6% |
| Domestic | ASHP | 14,000 per year 10kW installations | HLF: 17% |
| | GSHP | 2,500 per year 11 kW installations | HLF: 17% |
| | Biomass | 2,000 per year 20 kW installations | HLF: 14% |
| | Solar Thermal | 1,800 per year 3 kW installations | HLF: 17% |

## Air Quality Impacts

109. Table 18 below shows the breakdown of the total air quality impacts into the constituent parts including Particulate Matter (PM) and Nitrogen Oxides (NOx), split by the domestic and non-domestic scheme.  Ammonia ($NH_3$) impacts have not been quantified due to large uncertainties.

**Table 18 - Air Quality impact breakdown**

| | PM | NOx | Net Costs / Benefits |
|---|---|---|---|
| **Non-Domestic** | -£149 m | £466 m | £317 m |
| **Domestic** | £34 m | £100 m | £135 m |
| **Total** | -£115 m | £566 m | £451 m |

110. In order to take account of the net costs on air quality, the analysis includes assumptions on the emissions per unit of heat and the associated cost of those emissions. These are derived from:

    a. Emission factors from NAEI (see Table 19):  These are emission factors for NOx and PM10 that have been sourced directly from NAEI's database and converted into the relevant units. These emission factors are used for all the non-domestic technologies.

    b. Damage cost values from Defra (see Table 20): Non-domestic values use the 'NOx' and 'PM Industry' damage costs which are consistent with Defra's previous work on AQ damage cost calculations. These damage costs are estimates of the costs to society of the likely impacts of changes in emissions. They assume an average impact on an average population affected by changes in air quality. The damage costs used come from the IGCB Air Quality subgroup and include values for the impacts of exposure to air pollution on health, morbidity effects, damage to buildings and impacts on materials.

111. The sensitivities analysed are based on the central emission factors from NAEI and high/low damage cost values from Defra. These values are shown in Table 20 below. Variation between the Damage Cost values reflects uncertainty about the time lag between the exposure to air pollution and the associated negative health impact. There are no sensitivity tests for domestic RHI technologies.

**Table 19- Air Quality Emissions Factors**

| | | | NAEI Emission factors[10] | |
|---|---|---|---|---|
| | | | PM [kg/GWh] | NOx [kg/GWh] |
| Renewable Heat Fuel | | Biogas | 36.0 | 863.0 |
| | | Biomethane | 3.0 | 193.0 |
| | | Electricity | 3.0 | 108.0 |
| | | Biomass | 108.0 | 540.0 |
| Counterfactual Fuels | Non-Domestic | Natural Gas | 2.7 | 253.0 |
| | | LPG | 12.0 | 240.0 |
| | | Coal | 391.0 | 578.0 |
| | | Oil | 68.4 | 1750.0 |
| | | Electricity | 1.0 | 100.0 |
| | | Biomass | 108.0 | 540.0 |
| | Domestic | Natural Gas | 4.1 | 75.5 |
| | | LPG | 12.0 | 240.0 |
| | | Coal | 1110.0 | 425.0 |
| | | Oil | 6.5 | 174.0 |
| | | Electricity | 1.0 | 100.0 |
| | | Biomass | 108.0 | 540.0 |

**Table 20 - Air Quality Damage Costs**

| | Air Quality Damage costs [2015 £/t][11] | | |
|---|---|---|---|
| | Low | Central | High |
| **Nitrogen Oxides (NOx)** | | | |
| Industry | £4,337 | £10,943 | £17,508 |
| Domestic | £4,822 | £12,205 | £19,529 |
| **Particulate Matter (PM10)** | | | |
| Domestic | £26,396 | £33,713 | £38,311 |
| Industry | £23,665 | £30,225 | £34,347 |
| | | | |
| | | | |

[10] http://naei.defra.gov.uk/data/

[11] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/460398/air-quality-econanalysis-damagecost.pdf

# Annex D) Analytical Detail

## Sensitivities

112. This section provides additional detail on the main sensitivities assessed and the impacts on the NPV, Carbon Abatement, and Renewable Heat delivered by renewable heat technologies (RHT). A description of the changes in assumptions or figures which have been used to complete the sensitivity analysis in this impact assessment is included further down. Table 21, below, demonstrates the impact of sensitivities on renewable heat generated, carbon savings, and NPV.

**Table 21 – Impact to benefits and NPV of sensitivities assessed**

| | **Renewable Heat in 2020/21** [TWh] | | **CB4 Carbon Savings** [$MtCO_2e$] | | **NPV** [Lifetime, real, discounted] | |
|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High |
| Central Estimates | 12.16 | | 26.7 | | £1,344 m | |
| **Central Deployment** | -2.2 | +1.3 | -4.8 | +2.7 | £-215 m | + £190 m |
| **Low Deployment** | -4.5 | N/A | -10.2 | N/A | £-506 m | N/A |
| **Counterfactual Deployment** | -3.2 | N/A | -7.6 | N/A | £-377 m | N/A |
| **Carbon Abatement** | N/A | N/A | -10.6 | +11.6 | £-2,230 m | + £2,472 m |
| **No Upstream AD Savings** | N/A | N/A | -14.1 | N/A | £-3,001 m | N/A |
| **Carbon Prices** | N/A | N/A | N/A | N/A | £-2,847 m | + £2,883 m |
| **Air Quality Impacts** | N/A | N/A | N/A | N/A | £-315 m | + £324 m |
| **Heat Pumps Performance** | -0.1 | +0.1 | N/A | N/A | N/A | N/A |

**Figure 3 - Breakdown of Carbon Abatement Sensitivities**

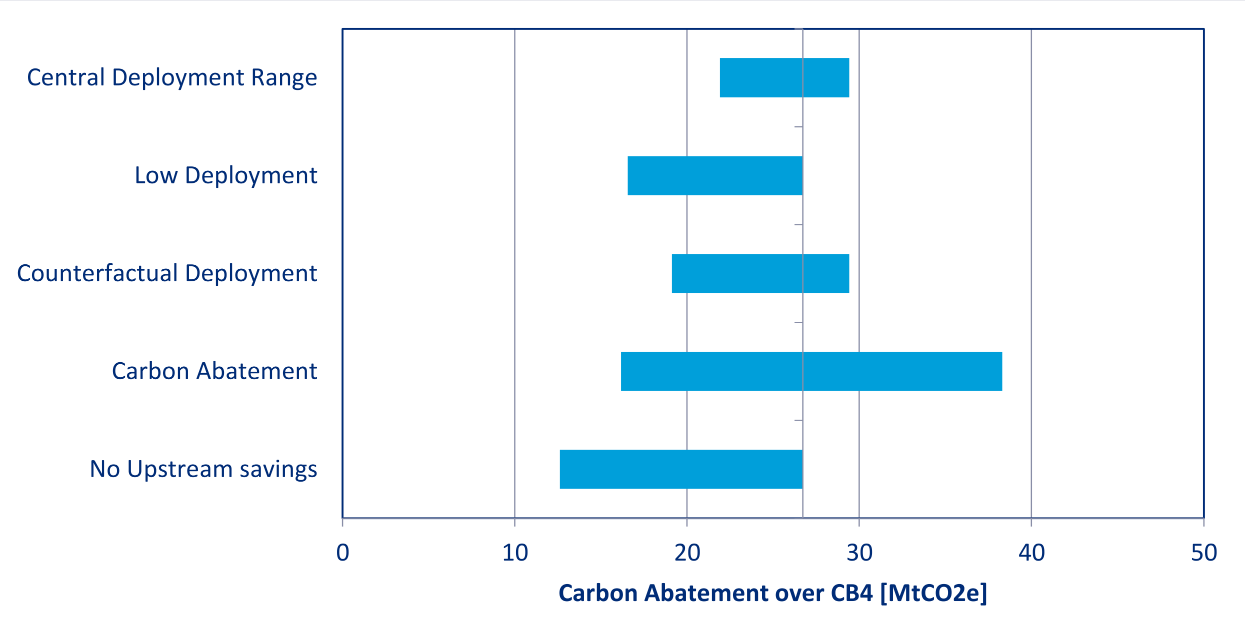



**Figure 4 - Breakdown of Renewable Heat Sensitivities**

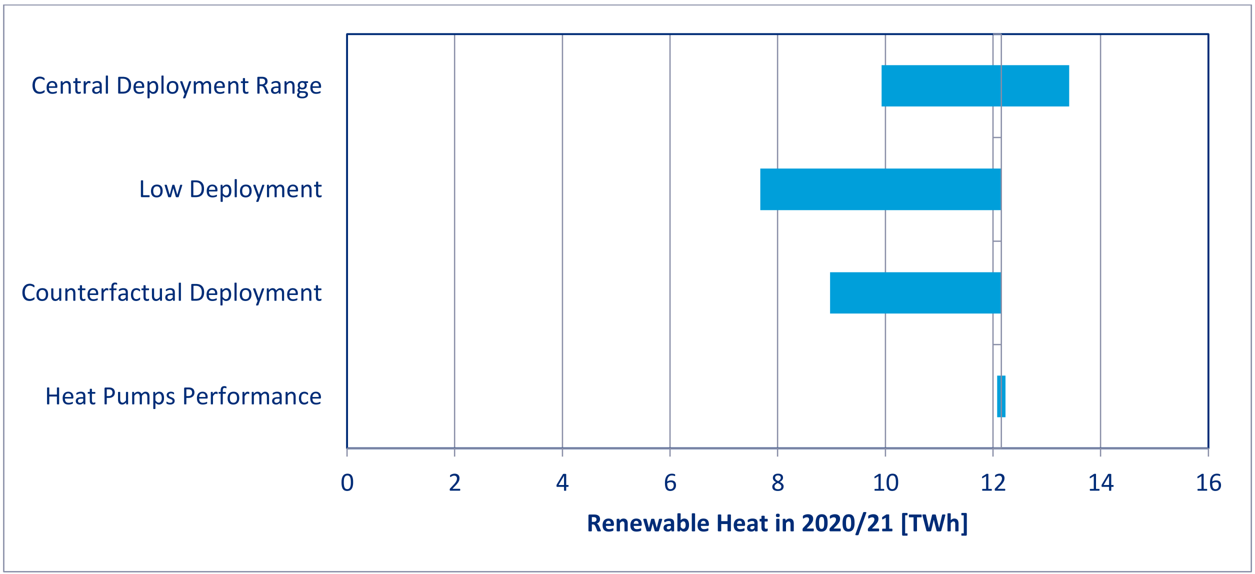


**Table 22 - Details of sensitivity assumptions**

| Low | High |
|---|---|
| **Central Deployment Range** | |
| The low deployment in the central sensitivity shows the lower end of the possible range of central deployment for the scheme, assuming that several of the technologies do not see the level of deployment projected. A particular mix of technologies under deploying has not been assumed as the mix could vary in practice. | The high sensitivity has been designed to show the level of benefits (renewable heat, carbon savings) which wold occur if the projected deployment were to ramp up to hit the budget cap over the last two years of the Spending Review. This sensitivity is well within the market potential for the technologies supported, however would likely involve several technologies deploying highly, which could result in effects of degression on the markets.<br>This sensitivity does not assume any degression takes place, and does not offer a view on when or if the scheme could close. In the event of higher than projected deployment the budget management process will likely be engaged. More information can be found in Chapter 4 of the Government response to the consultation. |
| **Low Scheme Deployment** | |
| The low deployment sensitivity shows the outcome of the reformed scheme not having the intended effect on deployment. Broadly it assumes that areas where the scheme is acting to increase deployment do not have any effect and those technologies continue to deploy at rates similar to current levels, and that areas of eligibility restrictions have a greater than estimated negative impact on total deployment reducing uptake to very low levels. | N/A |
| **Counterfactual RHT Deployment** | |
| This sensitivity is based on the evaluation evidence on whether respondents said they would have installed a Renewable Heat Technology (RHT) even without the RHI (either the same or different). One adjustment is made to not reduce deployment in the industrial sector as this differs from space/water heating in that the process itself is an economic activity seeking profit. More detail is provided below. | N/A |

| | |
|---|---|
| **Carbon Abatement** | |
| Takes a low value for both technology efficiency and CO2 factors. Mix of counterfactual deployment for all technologies has been moved to 100% gas | Takes a high value for both technology efficiency and CO2 factors. Mix of deployment against the counterfactuals for all technologies (apart from biomethane) has been moved to 100% Oil. |
| **No Upstream AD savings** | |
| In this sensitivity it is assumed that there are no upstream emissions savings from any of the feedstocks which are used in AD. This could be because, for example, though the calculation of savings from food wastes assume diversion from landfill, the food waste may be diverted from other uses such as composting resulting in fewer carbon savings. | N/A |
| **Carbon Prices** | |
| Low BEIS Price Series – See Annex C | High BEIS price series. – See Annex C |
| **Air Quality Impacts** | |
| Uses the low estimates of air quality damage cost per tonne of emissions of Nitrous Oxides, and Particulate Matter, per Defra guidance. – See Annex C | Uses the high estimates of air quality damage cost per tonne of emissions of Nitrous Oxides, and Particulate Matter, per Defra guidance. See Annex C. |
| **Heat Pumps Performance** | |
| This sensitivity assumes both a higher number of Domestic ASHP and GSHP do not meet the RED accounting target, and that the average SPF of those that do is lower for the purpose of RED accounting. This has no impact on carbon savings and thus no NPV impact as RED contributions are not monetised. See Heat Pump Performance section below. | This sensitivity assumes both a high number of Domestic ASHP and GSHP do meet the RED accounting target, and that the average SPF of those that do is higher for the purpose of RED accounting. This has no impact on carbon savings and thus no NPV impact as RED contributions are not monetised. See Heat Pump Performance section below. |

## Counterfactual renewable heat deployment sensitivity

113. Evidence from the evaluations[12,13] was used to create the counterfactual RHT deployment projection sensitivity. The domestic evaluation provided figures split by technology, while there were not enough respondents in the non-domestic evaluation to split these out. One adjustment has been made to account for the share of heat

[12] RHI Domestic Evaluation: https://www.gov.uk/government/news/evaluation-of-renewable-heat-incentive-rhi
[13] RHI Non-Domestic Evaluation: https://www.gov.uk/government/news/evaluation-of-renewable-heat-incentive-rhi

generated by non-domestic technologies which is industrial in nature: these have not been considered to have any counterfactual RHT deployment, because they are economic activities in their own right. For example a rural home or business may choose to pay more for an RHT (without subsidy) because they would like to make a difference for the environment, however biomethane generation and injection to the gas grid is an industrial plant set up for the purpose of making a profit, and it is unlikely that without a subsidy a company would choose to invest large sums to do so while running at a loss each year. Table 23 shows the levels of assumed take-up of renewable heating technologies in the absence of the RHI subsidy.

**Table 23 - Counterfactual Renewable Heat deployment sensitivity**

| | Technology | Counterfactual RHT deployment |
|---|---|---|
| Non Domestic | Small Biomass Boilers | 33% |
| | Medium Biomass Boilers | 30% |
| | Large Biomass Boilers | 8% |
| | Ground Source Heat Pumps | 36% |
| | Small Solar Thermal | 36% |
| | Small Biogas | 34% |
| | Biomethane | 29% |
| | Medium Biogas | 29% |
| | Large Biogas | 29% |
| | CHP Biomass | 28% |
| | Deep Geothermal | 0% |
| | Air to Water HPs | 36% |
| Domestic | ASHP | 32% |
| | Biomass | 13% |
| | GSHP | 36% |
| | Solar Thermal | 51% |

## Anaerobic Digestion Feedstock Availability

114. The mix of feedstock used in anaerobic digestion is an important component of the overall benefits estimated to be achieved by the scheme, as different feedstocks have different levels of greenhouse gas abatement associated with them. It is important to note that estimates of total deployment are based on estimates of project pipelines, but that estimates of the likely availability of feedstock are highly uncertain and could limit the achievable deployment.

115. The Benefits and NPV calculations for the RHI are sensitive to changes in the assumption of upstream carbon savings (which is highly uncertain), and are also affected by assumptions on total deployment of plant, the proportion of feedstock used which is food waste, and where that waste would have ended up if not in AD. This uncertainty is linked to the uncertainty on ammonia emissions discussed in Section 5,

but not quantified. Differences in total realised deployment or feedstock type and what counterfactual use that feedstock would have been put to, will affect the realised benefits of the scheme. Carbon savings from upstream abatement are highlighted separately in Section 4 because of the particular sensitivity of abatement to AD feedstocks for carbon abatement is one of the reasons that carbon savings from upstream abatement are separated out for clarity in Section 4.

116. Within the consultation stage IA it was recognised that feedstock constraints could be a potential risk to deployment. A number of consultation responses and recent market reports[14,15] highlighted food waste as a potential constraining factor to industry deployment, not due to the overall level of food waste being generated, but whether it is available for use in the AD sector. This is because the majority of food waste which is produced (in households, businesses and industry) ends up being mixed with other wastes which cannot be used for AD. It is also important to make the distinction between avoidable and unavoidable food waste, as action to limit the creation of food waste could reduce the supply of some feedstocks where these are avoidable.

117. New market intelligence was compared with estimates of feedstock availability, in order to understand whether feedstocks were likely to be a key constraint. In certain circumstances food waste availability could be a constraint on AD deployment without measures to increase separate capture of food waste, particularly by Local Authorities (LA). These potential costs to LAs have not been factored in to this Impact Assessment.

118. However, it must be noted that not all food waste in the RHI is assumed to come from Local Authority collection; there are some commercial arrangements which see large suppliers of food waste (e.g. food manufacturers, distilleries) contract directly with AD plant for the disposal of the waste. There could also be additional Industrial and Commercial collection of food waste to supply RHI plant, but further work will be necessary to assess the carbon benefits of this when deployment occurs to take into account of what counterfactual use the food waste could have seen.

119. Once other potential uses of food waste are taken into consideration there is a risk that food waste availability would be constrained for the AD market as a whole, which could limit deployment within the RHI. As a result of this, and additional information on the likely pipeline of AD projects, the assumed mix of feedstocks has been revised in the current IA. It should be noted that availability of feedstock and therefore uncertainty of the level of deployment is not limited to food waste, but exists for all feedstocks.

120. Based on Market Intelligence (MI) and current deployment, the initial Impact Assessment assumed that the feedstock mix of plants supported under the reformed RHI would be around two thirds food waste, while our revised assessment assumes around 40% of new deployment to use food waste as a feedstock (either from Local

[14] WRAP (2012) http://www.wrap.org.uk/content/household-food-and-drink-waste-uk-2012
[15] Eunomia report

Authority or industrial/commercial sources), with the remainder coming from sewage sludge and agriculture (including energy crops, residues and farm waste such as manures and slurries) (see Table 24, below).

**Table 24 - Proportions of AD plant using different feedstock assumed in the reformed RHI**

| | Food Waste | Sewage | Agriculture* |
|---|---|---|---|
| **Consultation Stage IA** | ~67% | ~25% | ~7% |
| **Government Response IA** | ~40% | ~25% | ~35% |

*Agriculture includes energy crop, manures and slurries and also agricultural residues.

121. The change in assumption has a subsequent effect on the benefits reported for biomethane and biogas, as food waste generates the most carbon savings when accounting for upstream emissions, with further considerations discussed within the next section on carbon cost effectiveness.

122. The cost of disposing of food waste and the accessibility of food waste varies greatly depending on its location and source. Improved strategies for accessing food waste may continue to grow supply (e.g. from commercial and industrial sectors) where it is cost effective to do so. Market and technology developments may also result in a diversification to a wider range of feedstocks, for which there is a greater potential availability. If current barriers to the provision of LA collection of separate food waste, are overcome, along with improved capture of the food waste, it may be able to offer additional supply in future.

## Carbon Cost Effectiveness (CCE) of Anaerobic Digestion

123. The consultation stage Impact Assessment demonstrated our initial consideration of the cost of abating 1 tonne of $CO_2$ through the production of biomethane.

124. The conclusion of said work was that whilst there were a wide range of potential outcomes depending on the assumptions, the choice of feedstock has a significant effect on the abatement potential of biomethane production, and its associated costs, and that in a typical scenario, wastes are more effective at delivering cost effective GHG emissions compared to crops.

125. As a part of the consultation process, views on whether limiting the use of some feedstocks would deliver more cost-effective carbon abatement (question 26a) were requested. A wide range of responses were received, including a range of points relating to the carbon cost effectiveness work that was undertaken for the initial Impact Assessment.

126. The key analytical challenges brought up in the responses were:

    a. The scope was too narrow, not including biogas or using a range of crops.

b. The overall approach was wrong due to: taking a typical plant type as opposed to a range of individual cases; mixing of attributional and consequential approaches; and using resource costs as oppose to subsidy costs.

c. Not accounting for factors that affect CCE such as: benefits of spreading digestate on land; the higher emissions associated with the transport and processing of wastes; Carbon Capture Storage; the impact of RHI reforms on costs; and changes over time to feedstock prices.

d. The use of incorrect assumptions such as those concerning the spreading of digestate; the landfill counterfactual; and the suggestion that large efficient crop plants would be better performing than small waste ones.

127. In addition to these, a range of studies were cited as part of the responses, some of which supported the conclusions of the initial IA and some of which raised other issues such as the impact of biodiversity. They included alternative CCE analysis which challenged the idea that crops are not good value for money.

128. After considering the wide range of responses and exploring their implications for the analysis previously performed it was concluded that:

a. Even when increasing the scope of analysis in terms of crops or biogas the underlying findings that waste as feedstocks are better value for money than crops in terms of CCE still stand.

b. Our underlying approach was rightly conservative showing a typical plant that would likely come forward as opposed to a “best individual case” due to the need to understand the potential impact on a scheme wide basis as using the best possible plant for each feedstock would not be representative of the average deployment.

c. Though the CCE was calculated on a societal cost basis, rather than a purely subsidy cost basis so as to better reflect the true cost to society, this does not have any bearing on the relative merit order of feedstock CCE.

d. It was not possible to accurately calculate the impacts from most of the factors feedback suggested were missing, due to a lack of robust evidence to do so. However, it is believed that these factors would not change the underlying findings of the CCE work as their impacts are of a smaller order of magnitude.

129. There are additional pieces of analysis and evidence which would add value and understanding to the impacts appraisal of the AD feedstock supply chain; however, it was felt that the best available evidence currently available is being used and that the overall impact of additional work would likely not change the merit order decisions for support. Additional analysis could be performed, in particular relating to the landfill counterfactual and full resource costs of feedstocks reaching the market.

130. Our conclusion is that while the number could change markedly, the overall findings of the CCE of waste versus crops is robust to a wide range of assumptions.

## Domestic Returns and Heat Demand Limits

131. Incentives across the sizes of households assumed to deploy renewable heating technologies are shown in the figures below. These also include the impact of the revision of the offer to biomass boilers as well as the change in heat demand limit for ground source heat pumps.

132. The charts show the average returns estimated for households of a given size, taking heat demand limits into account. The actual return for any given household will vary depending on a range of factors including the cost and size of the system chosen, the efficiency and performance of the system, and how much the system is used.

133. The returns achieved by ground source heat pumps are particularly sensitive to system sizing and heat use, due to the additional capital expenditure requirements for e.g. ground loops. For illustration the chart therefore shows the returns achievable at the high end of heat load factors assumed for domestic systems of 21% (this is equivalent to installing a smaller system to supply the same total heat).

134. The ground source heat pump chart does not show the potential returns for shared loop systems which will be included in the non-domestic scheme. Shared loops offer the potential for smaller domestic properties to achieve economies of scale and higher heat load factors by sharing the cost and use of a single larger ground loop compared to having multiple smaller loops for each property.

**Figure 5 - Financial Returns for Domestic Biomass Boilers**

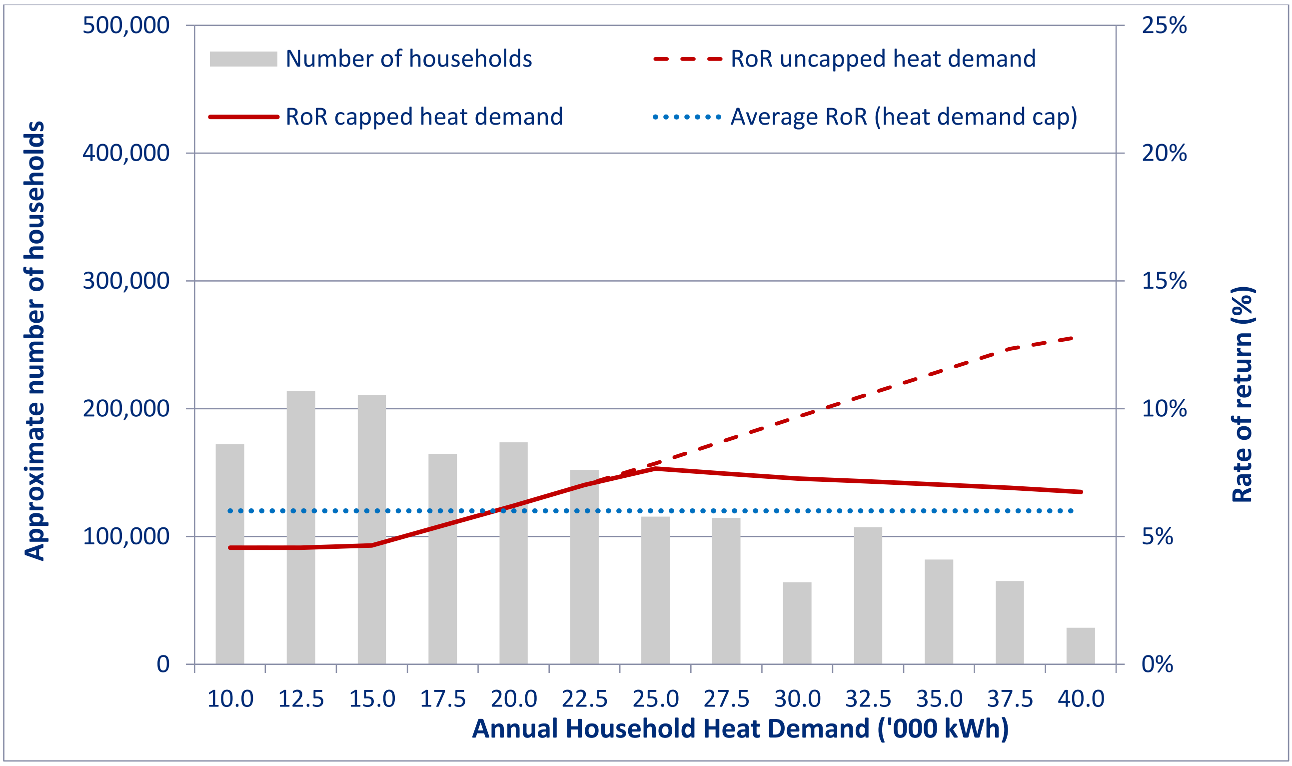


**Figure 6 - Financial Returns for Domestic GSHP**

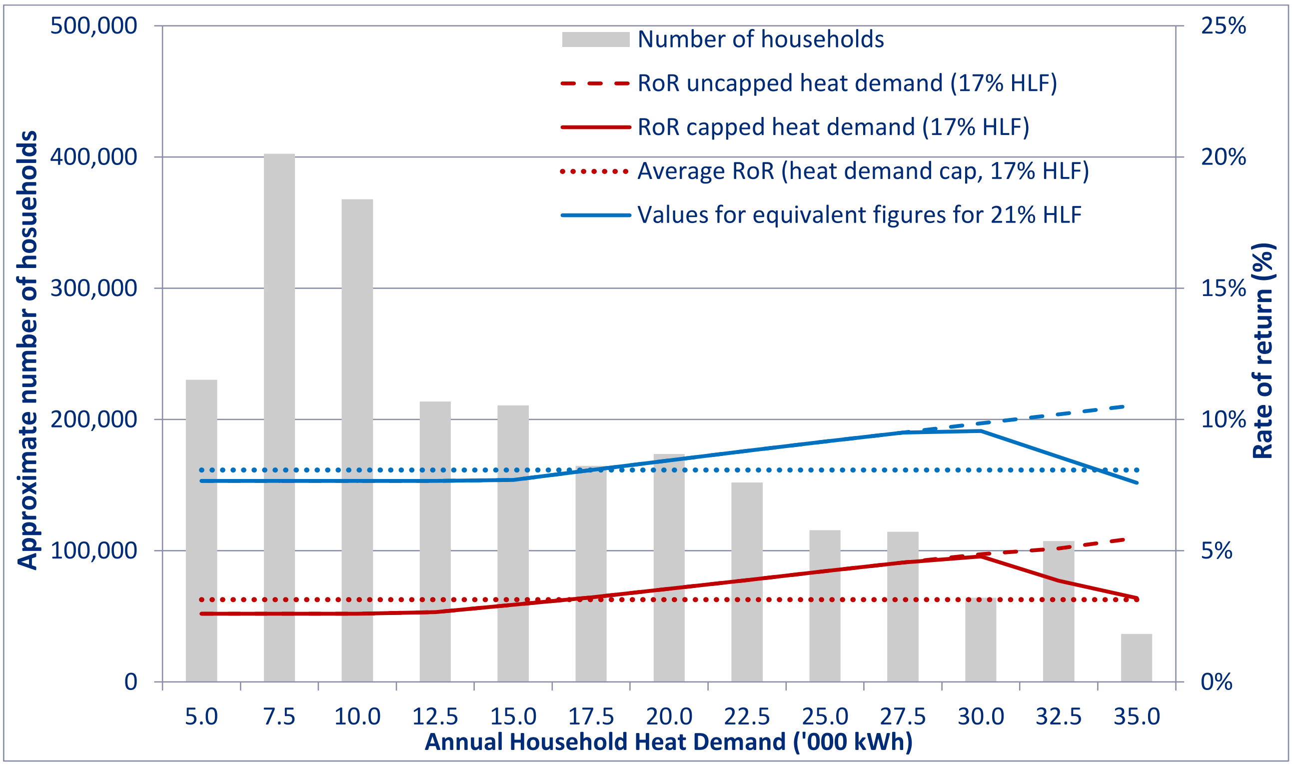
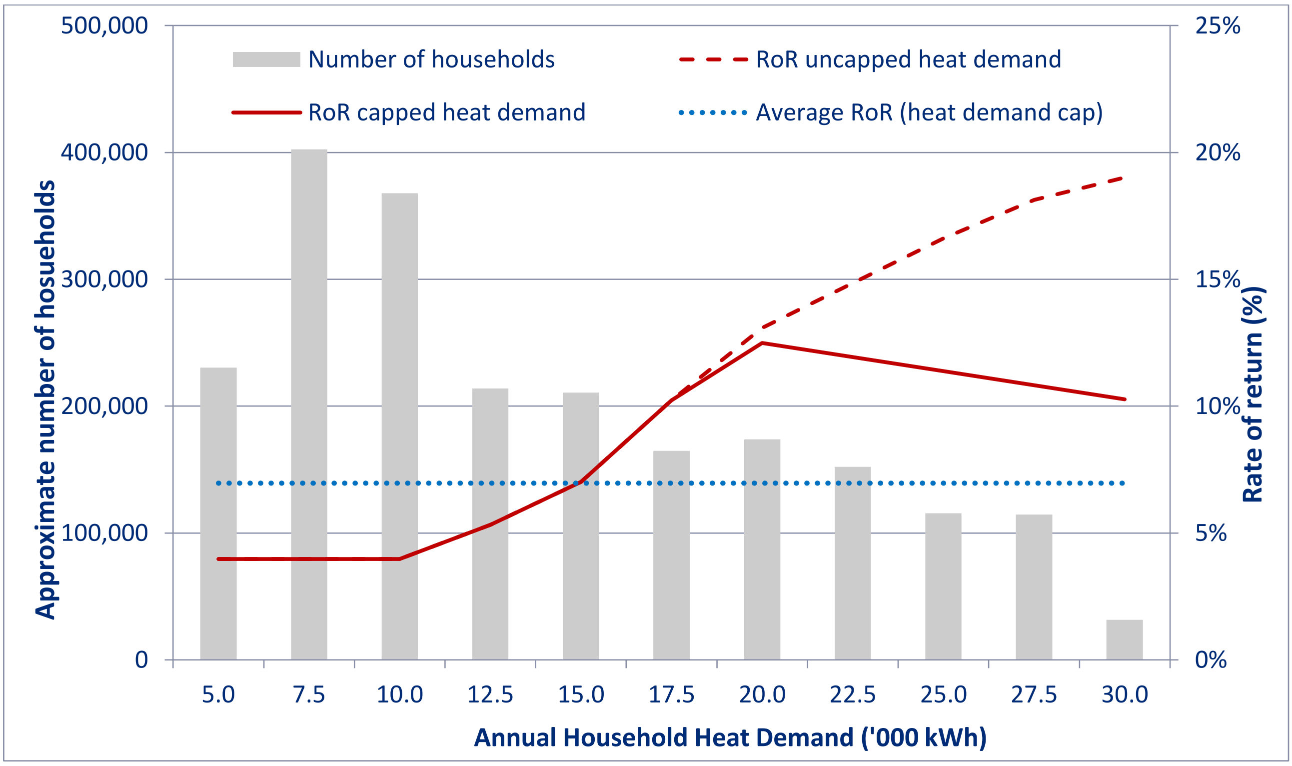



**Figure 7 - Financial Returns for Domestic ASHP**



## Heat Pump Performance

135. The performance of a heat pump system is measured by the amount of heat produced per unit of input energy (electricity). This can vary between each case depending on the design, installation and operation of the system.

136. BEIS commissioned monitoring of just over 700 domestic heat pumps installed under the Renewable Heat Premium Payment (RHPP), carried out between 2011-2014, and 21 ground and water source heat pumps installed under the Non-Domestic Renewable Heat Incentive (NDRHI), carried out between 2012-2014, to establish the installed performance of heat pumps and identify causes of variations in heat pump performance.

137. The main findings from these reports[16,17] are that the in-situ performance of heat pumps is lower than their design specifications. Specifically, of the systems monitored, a proportion of both domestic ASHP and domestic GSHP had seasonal performance factors (SPF) lower than 2.5 and therefore did not meet the Renewable Energy Directive (RED) accounting definition of renewable heat.

138. Since the initial findings were published in February, engagement work with stakeholders has identified some anomalies in the data, and queried the degree to which the RHPP monitored sample is representative of heat pumps installed via the RHI. The Government has worked with our consultants to improve data sampling with the aim of removing major anomalies. On this basis, our assessment is that findings on mean and median SPF from the RHPP are relatively stable and not expected to be influenced significantly by the anomalies in the data. Other statistics, particularly, the percentage of air source heat pumps meeting the renewable criterion, are likely to be more affected.

139. When using these findings in the context of the RHI, a judgement is required as to how indicative these RHPP monitoring results are of the population of heat pumps already and yet to be installed under the RHI. For example, the major revision of the Microgeneration Certification Scheme (MCS) standards which occurred during the period of RHPP heat pump installations, the introduction of a minimum design SPF in the RHI, financial support available for projects under each scheme, and the types of properties monitored may all have an impact. The impact of these factors is complex to assess and the evidence available to do so is limited, however from the information available and engineering judgement it is the Department's view that performance of

[16] UCL Energy Institute (2016) "Detailed analysis of data from heat pumps installed via the Renewable Heat Premium Payment Scheme" https://www.gov.uk/government/publications/detailed-analysis-of-data-from-heat-pumps-installed-via-the-renewable-heat-premium-payment-scheme

[17] Graham Energy Management (2016) "Monitoring of Non-Domestic Renewable Heat Incentive Ground-Source and Water-Source Heat Pumps Interim Report" https://www.gov.uk/government/publications/monitoring-of-non-domestic-renewable-heat-incentive-ground-source-and-water-source-heat-pumps-interim-report

heat pumps installed under the RHI is likely to be similar to or better than the RHPP values.

140. The Government's current assessment of the evidence on in-situ performance of RHPP heat pumps, and how this compares to the previous assumptions, is presented in the table below. It should be noted that this evidence is expected to be a worst case for RHI installations.

**Table 25 - Change in RED accounting assumptions for domestic heat pumps**[18]

| | | Original Assumptions | Consultation Assumptions | Revised Evidence |
|---|---|---|---|---|
| Domestic ASHP | Average in-situ SPF of heat pump stock | 2.51 | 2.30 (2.18 – 2.83) | 2.52 (2.32 - 2.80) |
| | Proportion with in-situ SPF above 2.5 | 100% | 53% | 63% (± 10%) |
| | Average in-situ SPF of those heat pumps | N/A | 2.93 | 2.93 (± 0.02) |
| Domestic GSHP | Average in-situ SPF of heat pump stock | 2.84 | 2.75 (2.61 – 3.27) | 2.81 (2.71 - 3.30) |
| | Heat pumps with in-situ SPF above 2.5 | 100% | 77% | 81% (±10%) |
| | Average in-situ SPF of heat pumps above 2.5 | N/A | 3.19 | 3.10 (± 0.06) |

141. Therefore the main benefits reporting in this Impact Assessment are based on the latest evidence, which is likely to be published shortly. Further evidence of the performance of RHI heat pumps may be available in time, and the installed performance of new systems is expected to continue to improve over time as the policy changes designed to increase performance take effect, and the supply chain and consumers become more familiar with the technology and its performance.

142. Policy measures are already in place in the Domestic RHI to increase both design and installed performance, including requirements for MCS standards compliance, requirement of a minimum design SPF of 2.5 and RHI payments being calculated on the basis of renewable heat. These may have driven performance improvements compared to the RHPP systems, but data is not available to assess whether this is the case. The RHPP analysis has also highlighted some detailed technology issues (for example, use of inappropriate controls) which led to underperformance, some of which have now been addressed by the market. Through the present reforms, the scheme will have a new requirement for all new ASHPs and GSHPs supported by the scheme to

[18] For the calculation of cost and benefits reporting the performance is calculated on the SPF H3 system boundary, however for RED reporting the relevant boundary is SPF H2

have installed one of a specified set of electrical metering arrangements alongside their heating system. This requirement will help to drive continued improvements in heat pump performance.

143. For non-domestic heat pumps the evidence is more limited. The monitored NDRHI units do not include ASHPs and it was not possible to obtain a representative sample of G&WS HPs. In general, non-domestic heat pump performance is expected to be different, and in some cases better, than domestic heat pump performance. However, the limited evidence to date does not support the hypothesis that non-domestic heat pumps are performing better than domestic heat pumps. Scheme metering data will be analysed to evaluate the performance on non-domestic heat pumps in the scheme.