Title: Introduction of air quality requirements into the Renewable Heat Incentive (RHI)	Impact Assessment (IA)
IA No: DECC0092	**Date:** 11.07.2013
Lead department or agency: Department of Energy & Climate Change (DECC)	**Stage:** Final
Other departments or agencies: Department for Environment Food and Rural Affairs (Defra)	**Source of intervention:** Domestic
	Type of measure: Secondary legislation
	Contact for enquiries: Daniel Newport (0300 068 6023), Iain Mathieson (0300 068 5732)

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

Cost of Preferred (or more likely) Option				
Total Net Present Value [£m]	**Business Net Present Value**	**Net cost to business per year**	**In scope of One-In, One-Out?**	**Measure qualifies as**
2,396.0	N/A	N/A	No	N/A

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

The combustion of biomass in renewable heat generation creates, through the emissions of air pollutants, a negative externality. Although the impact of biomass heat generation is currently small, due to uptake expected to be driven by the RHI subsidy future biomass air pollution may result in a material cost to society. Air pollutants reduce the air quality of an area which adversely affects public health and damages ecosystems. The impact is particularly acute in urban and suburban areas. The RHI in its current form does not take these negative externalities into account. It offers tariffs that intend to compensate for the higher costs of abatement equipment without requiring that such equipment is installed. As such, the RHI over-incentivises the generation of unfiltered biomass based renewable heat and the emissions of air pollutants.

What are the policy objectives and the intended effects?

The policy objective is to reduce the potential for harmful emissions from biomass heat installations within the RHI and through this reduce any adverse effects of air pollution on public health and the environment, without resulting in a substantial reduction in deployment of renewable heat, which is a key contributor to the UK's legally binding 2020 renewables target. The policy also intends to avoid the RHI harming UK progress to achieving EU air quality standards.

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

Option 1: (Do-nothing-option) No emission limits for biomass based renewable heat installations are introduced into the RHI. RHI tariffs do not compensate for any capital expenditure on equipment needed to meet the emission limits. This option employs lower tariffs for biomass boilers, biomass District Heating (DH) and Combined Heat and Power (CHP) than currently offered in the RHI. Option 2 (preferred option): Introduce emission limits into the current (non-domestic) RHI[1]. The emission limits are 30g/GJ[2] for particulate matter (PM_{10}) and 150 g/GJ for oxides of nitrogen (NOx)[3]. These are considered to be achievable with some additional cost but not expected to substantially reduce deployment of renewable heat. RHI tariffs for heat generators using biomass as feedstock reflect the higher capital expenditure necessary to meet the emission limits. (The current RHI tariff levels already include this compensation). Applicants for RHI support document compliance by submitting certificates to the regulatory body (Ofgem).

Will the policy be reviewed? It will be reviewed. **If applicable, set review date** July / 2015					
Does implementation go beyond minimum EU requirements?			**N/A**		
Are any of these organisations in scope? If Micros not exempted set out reason in Evidence Base.	**Micro** Yes	**< 20** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO2 equivalent change in greenhouse gas emissions? (Million tonnes CO2 equivalent (Negative values indicate emission savings.)			**Traded:** - 5 MtCO2	**Non-traded:** - 0.2 MtCO2	

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: Gregory Barker Date: 17th July 2013

[1] The air quality emission limit requirement will be extended to future RHI schemes (domestic RHI, extensions of non-domestic RHI) and will be assessed separately for each scheme in future Impact Assessments.
[2] grammes pollutant per GigaJoule net thermal input
[3] These emission limits have been consulted on in 2010.

Summary: Analysis & Evidence Policy Option 2

Description: Proposal of making Renewable Heat Incentive support for biomass based heat generation conditional on PM_{10} and NOx emission limits.

FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) [£m] Low:	High:	Best Estimate:
2012	2012	29	1,122	3,379	2,950

COSTS (£m)	Total Transition [£m] year: 2012	Average Annual (excl. Transition) (PV) [£m]	Total Cost (PV) [£m]
Low	n/a	n/a	n/a
High	n/a	n/a	n/a
Best Estimate	0.06	15.0	419.0

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

DECC estimates a resource cost increase of £417m relative to option 1 resulting from a combination of a rise in biomass and CHP tariffs and an increase in capital expenditure of biomass installations to meet the emission limits, which together slightly increase total deployment. The option will also give rise to an estimated £2m of additional administrative costs. We have run a high cost scenario, however, as it is not consistent with the benefit sensitivity (which look at the high and low valuations of AQ impacts) it has not been added to table of costs above. It can be found in section VI.

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

BENEFITS (£m)	Total Transition (Constant Price) Years [£m]	Average Annual (excl. Transition) (PV) [£m]	Total Benefit (PV) [£m]
Low	0.0	55.0	1,540.8
High	0.0	135.6	3,797.9
Best Estimate	0.0	120.3	3,368.6

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

Monetised benefits take account of health benefits (mortality effect) and those from reduced CO2 emissions. Based on Defra's estimates, we forecast that the mortality effects of the improvement in air quality amount to a Present Value of £3,185m over the lifetime of the policy. The estimated Present Value benefit from an increase in CO2 emissions savings is £184m.

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

The monetised benefits do not reflect the impacts of an improvement in air quality on biodiversity, nor on health in terms of morbidity effects.

Key assumptions/sensitivities/risks **Discount rate** **3.5**

(1) This IA assumes that the additional costs of meeting air quality standards, included in RHI biomass tariffs (10% to 15% of capex) would not occur if air quality restrictions were not bought in. We have run a sensitivity analysis assuming a higher capital cost scenario of a 25% increase, as indicated by some stakeholders.
(2) Manufacturers or installers of biomass installations will incur negligible additional certification and testing costs, relative to option 1, as current regulation already requires testing and certification.
(3) Administrative cost estimates for option 2 are based on Ofgem's cost assumptions for the first three years after the introduction of the policy. These estimates assume an IT based submission of applications and an auditing process that includes site visits. Ongoing costs per biomass based installation are assumed to be constant from the third year onwards.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			In scope of	Measure qualifies
Costs: n/a	**Benefits:** n/a	**Net:** n/a	No	N/A

Evidence Base

I. Problem under consideration

1. The combustion of biomass in renewable heat generation is a source of air pollutants, a negative externality leading to market failure in the biomass renewable heat market. Although the contribution of biomass heat generation to emissions of air pollutants is currently small, the projected growth in Renewable Heat Incentive (RHI) driven deployment of biomass combustion over the next decade could, through increasing air pollution in aggregate, result in a material cost to society.

2. Whether the introduction of a biomass installation has a positive or negative impact on the air quality of its surroundings depends on which counterfactual technology is being replaced: Where the biomass installation replaces a non-net-bound fuel based installation, such as heating oil or coal, its introduction can improve emissions. Where, however, biomass displaces electricity or gas fired heat, the air quality impacts are negative.

3. The most significant air quality impacts from biomass are thought to stem from emissions of particulate matter (both PM_{10} and $PM_{2.5,}$ two size fractions of particles that are of health concern) and oxides of nitrogen (NOx). The health impacts of PM are not thought to be subject to a concentration threshold and so improvements in public health can be achieved by reducing concentrations even where limit values are not exceeded. PM and NOx reduce outdoor air quality which adversely affects public health, particularly in urban and suburban areas. Reduced air quality also damages ecosystems and air pollutants have been shown to be linked to the sources of greenhouse gases that cause climate change.

4. The levels of PM and NOx in parts of the UK are relatively high when measured against air quality targets in the Ambient Air Quality Directive (2008/50/EC) and the UK seeks to reduce current levels to lessen the risk of infraction.

5. Air quality impacts of biomass combustion depend on the size of the installation. The regulatory regimes that already apply to solid non-waste biomass appliances of different sizes are:
   a) Large scale installations (over 50MWth capacity): Emissions from biomass installations are regulated by the Integrated Pollution Prevention Control (IPPC) legislation administered by the Environment Agency or the Scottish Environment Protection Agency. This is shortly to be replaced by the Industrial Emissions Directive which however will make little change to this sector.
   b) Large installations (of 20 to 50MWth capacity): Individual units are regulated by the Scottish Environment Protection Agency or local authorities in England and Wales.

   There are, however, no emission limits consistently applying to all biomass boilers under 20MWth capacity in the UK beyond the Clean Air Act 1993 which limits the emission of dark smoke[4]. Installations of this size are currently considered to be inadequately covered by legislation.

[4] This requires appliances burning over 45.4kg/hour of solid fuel to agree with the local authority on the appropriate chimney height and dust arrestment equipment.

II. Rationale for intervention

6. The emissions of PM and NOx are a negative externality of biomass combustion. The Renewable Heat Incentive (RHI) is designed to incentivise the replacement of fossil fuel based heat generation with renewable heat technologies, including biomass combustion. In its current form the RHI offers tariffs intending to compensate for the costs of abatement of air pollutants, however to date, the RHI application requirements do not include any limit values for PM and NOx emissions from unfiltered combustion of biomass. Over-subsidising high-emitting equipment potentially leads to excess health and ecosystem damage. The introduction of air quality considerations into the RHI will lead to a welfare improvement for society, as long as the costs of compliance do not outweigh the benefits.

III. Policy objective

7. The policy objective is to reduce the rate of increase in harmful emissions from biomass heat installations and through this reduce adverse effects of air pollution on public health and the environment, without resulting in substantial reductions in the deployment of renewable heat.

8. Existing EU legislation[5] and UK laws[6] set legally binding limits for concentrations of major pollutants in outdoor air such as particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2). Introducing air quality criteria into the RHI will support the UK's efforts to progress towards compliance with these limit values.

9. The UK has a legally binding target of 15% of all energy coming from renewable sources by 2020. The contribution of the RHI, and biomass boilers in particular, to this target is considered cost effective compared to alternative options: Any loss in deployment would need to be replaced, likely at a higher cost, by deployment of other renewable technologies in the heat, transport or electricity sector (e.g. offshore wind) to meet the target.

IV. Policy options considered

10. For the purposes of this IA, two options have been assessed. The expected impact of the introduction of emission limits into the RHI (option 2) is compared to a counterfactual scenario (option1).

11. An alternative option of pricing-in the externality was decided against on the basis of not being practicable. A complex landscape of tariffs would have to be created to correctly internalise the externality as tariffs would need to be set at different levels for a large suite of available boilers. The necessary ongoing assessment of specifications of products on the market and the frequent adjustments of tariff levels for each product would be associated with high administrative costs and a significant risk of setting tariffs at an inefficient level.

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[5] 2008 Ambient Air Quality Directive (2008/50/EC); 4th Air Quality Daughter Directive (2004/107/EC)

[6] EU directives have been made law in England, Scotland, Wales and Northern Ireland through regulations, for example in England, through the Air Quality Standards Regulations 2010.

Option 1: Counterfactual: No AQ requirements and no AQ compensation in tariffs

12. In option 1 no air quality emission limits for PM_{10} and NOx are introduced for biomass-based heat generators receiving RHI. Tariffs for biomass boilers, biomass district heating and combined heat and power (CHP) are set such that they do not compensate for any additional capital expenditure that would be required to meet these emission limits. There is no incentive for the biomass heat generator to reduce emissions of air pollutants under option 1.

Counterfactual: PM and NOx emissions of biomass based heat

13. Without air quality requirements in place we assume that new biomass boilers and biomass district heating (biomass DH) under 20MWth capacity applying for RHI support in the future on average will not meet the proposed emission limits, as this would require a higher capital expenditure. Furthermore, we also assume that CHP plants below 20MWth currently do not meet the two emission limits, based on advice by AEA[7] to DECC. These are somewhat conservative assumptions we make due to the limited evidence available to us. According to Defra, the current average PM emissions from wood burning are equivalent to 76 g/GJ and new biomass boilers currently are typically thought to emit around 60 g/GJ (PM) and 150 g/GJ (NOx)[8]. The PM emission levels exceed the emission limit of 30 g/GJ (PM_{10}) proposed under option 2. In 2010 the Forestry Commission Scotland, on the other hand, received advice[9] that many small boilers (50-2000 kWth capacity) on the market meet the proposed emission limit for PM_{10} without the need for additional bolt-on equipment. It is therefore possible that a non-negligible proportion of new biomass installations will already meet at least one of the proposed emission limits. This may be the case, for instance, where installations face planning restrictions involving PM emissions, or where generators have preferred a top-of-the-range boiler. Due to the limited evidence available on counterfactual emissions, however, we assume that new biomass installations on average will not meet any of the proposed emission levels. This assumption is conservative as a higher degree of compliance in the counterfactual would likely decrease overall additional resource costs linked to the introduction of the emission limits and so increase the chances that the benefits of this policy change outweigh its costs.

14. Under the above assumptions air pollutants are likely to be emitted above the efficient level under option 1, as the health costs to society associated with a reduction in air quality are external to this market segment of biomass heat generation (i.e. not reflected in heat production costs). This also applies to heat generators receiving RHI support.

Counterfactual tariffs for biomass boilers, biomass district heating and CHP

15. The “do-nothing” option differs from the RHI policy as currently implemented[10]. Although no emission limits have been introduced to the RHI, the current biomass boilers and biomass district heating tariffs already intend to compensate for additional expenditure that would be necessary to meet them. The tariffs compensate for the levelised net cost of renewable heat and take additional capital expenditure on emission abatement into account. For the purposes of constructing a counterfactual scenario, we have therefore calculated a specific,

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[7] The impact of the costs of complying with the RHI emissions thresholds on Biomass and Bio-liquid CHP tariffs and deployment. Report by AEA, Oct 2012, available to DECC.

[8] Based on PM and NOx emission factors published by the UK National Atmospheric Emissions Inventory 2011 (http://naei.defra.gov.uk)

[9] The assessment of flue gas particulate abatement in wood burning boilers. Report by AEA for Forestry Commission Scotland, 2010 (http://www.usewoodfuel.co.uk/media/234619/assessment-of-flue-gas-particulate-abatement-in-wood-burning-boilers-phase-1.pdf)

[10] Please note that the previous Impact Assessment accompanying the consultation on this policy assumed that the implemented RHI policy could be understood as the counterfactual situation.

lower tariff for biomass boilers and biomass district heating, which extracts the effect of this capital cost compensation[11].

Option 2: Introduction of "30/150" emission limits and air quality compensation in tariffs

16. Under option 2 RHI support is provided to renewable heat generators with biomass installations under 20 MWth capacity on the condition that they comply with emission limits of 30g/GJ for particulate matter (PM_{10}) and 150g/GJ for oxides of nitrogen (NOx). The requirements will apply to future applicants to the current RHI scheme[12] and a number of additional technologies included in a recent RHI consultation[13]. Emission limit requirements are expected to be extended to any heat generation technology based on biomass combustion that will be included in future RHI schemes (e.g. domestic RHI). Future Impact Assessments will separately assess air quality impacts for each new RHI scheme.

17. In the 2010 RHI consultation, DECC consulted on the 30/150 emission limit values. The option of lower emission limits was rejected as their negative effect on renewable heat deployment was considered too large in the context of the UK's renewable energy policy objectives. The current limits are considered achievable with some additional cost, but not expected to lead to a substantial reduction of renewable heat deployment.

18. Under option 2 biomass heat generators applying for RHI support will have to document compliance by submitting an appropriate "RHI emission certificate" (RHI-ec) to Ofgem in their application. These emission certificates will have to be issued by an accredited[14] test house[15]. Ofgem will carry out on-site audits of heat installations to monitor compliance.

V. Monetised and non-monetised costs and benefits of option 2 and Net Present Value

19. The policy change under option 2 is expected to affect the following groups in society:
    a) The general public will benefit from the improvement in air quality.
    b) Heat generators who switch from fossil fuel based to biomass based heat generation using installations of below 20MWth capacity and who apply for RHI support will be directly affected. They have to ensure that their installation meets air quality emission limits and submit documentation together with their RHI application to demonstrate their compliance.

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[11] For information on the tariff setting methodology of the RHI please refer to Annex 2 of the recent Impact Assessment on the extension of the non-domestic RHI: http://www.decc.gov.uk/assets/decc/11/consultation/RHI/6446-renewable-heat-incentive-expanding-the-nondomest.pdf

[12] The air quality requirements described under option 2 will not apply to existing recipients of RHI support but only to future applicants who file RHI applications after the regulation has come into force.

[13] This IA takes into account all non-domestic RHI technologies and tariffs that have been consulted on in autumn 2012, except Biomass Direct Air as it is not yet clear how this technology will be dealt with. Although we are interested in a change only affecting biomass installations the modelling of the impact of the policy change has to take account of other RHI technologies to avoid a distortion of deployment patterns. Tariffs included are: Biomass boilers (3 bands), Biomass District Heating (3 bands), Air Source Heat Pumps (Air-to-Air and Air-to-Water), Ground Source Heat Pumps (2 bands), Solar Thermal and Combined Heat and Power.

[14] accredited in accordance with ISO 17025 by a member of the European Co-operation for Accreditation, or International Accreditation Forum Multilateral Recognition Agreement.

[15] Manufacturers of ranges of boilers below 5MWth output will be able to obtain RHI emission certificates for a boiler type. Boilers with individual specifications and all those above 5MWth output will require testing at the point of commissioning of the plant. An RHI-ec can also be obtained for any specific combination of boilers fitted with abatement equipment if compliance can be demonstrated by on-site testing. Where relevant, instead of a RHI emission certificate a current environmental permit for a particular boiler installation can be submitted.

c) The RHI administrator, Ofgem, will take over additional duties to ensure RHI applications are accompanied by adequate emission certificates and include air quality requirements in their audits.
d) Indirectly, manufacturers and installers of biomass installations may be affected by the policy as demand will switch to biomass heat equipment that can comply with the air quality emission limits.

1. Costs of option 2

20. Option 2 is expected to introduce additional resource costs (including testing and certification costs) to the production of RHI supported renewable biomass heat and to increase the costs of administering the policy.

i.) Resource costs

21. Resource costs under option 2 are likely to increase relative to a RHI without air quality emission limits in place (option 1). The additional resource costs originate primarily from an increase of capital expenditure on biomass heat installations with integrated or added abatement functionality. Resource costs also include a range of costs associated with documenting compliance with the policy, such as testing and certification.

22. When modelling resource costs in the context of the RHI we have taken costs of renewable heat technologies net of costs of counterfactual technologies into account. The net costs include capital expenditure, operational expenditure, fuel costs and monetised barrier costs[16].

23. In setting Biomass tariffs as part of RHI phase 1, DECC used assumptions provided by AEA[17] of a 10% to 15% increase in capital costs occurring due to the requirement to meet air quality standards.

24. Under option 2, these costs are expected to persist, as the air quality restrictions would be introduced as planned. In option 1, with in the absence of air quality restrictions, these costs are assumed to be removed.

25. The proposed emission limit values of option 2 are in most cases expected to be achievable by abatement technologies based on inertia currently on the market, such as cyclones or multicyclones[18]. The magnitude of the capital expenditure increase assumed above seems to be supported by reports on capital cost increases associated with ceramic filters, a more effective abatement technology that typically has higher capital costs. Advice to the Forestry Commission Scotland in 2010 shows that ceramic filters add between 15% and about 21% to capital costs of biomass installations, depending on the capacity of the boiler. The highest of these two values of capex increases may therefore be seen as an upper limit for capex increases modelled under option 2.

26. RHI model estimates suggest that the higher capital expenditure incurred under option 2 leads to a total resource cost increase of £417m (+8%) over the lifetime of the policy to

[16] These include “hassle” costs, such as installing a storage for biomass feedstock.
[17] Review of technical information on renewable heat technologies, Report by AEA for DECC, 2011 January, page 4.
[18] Reference for effectiveness of inertial abatement technologies and remainder of paragraph: AEA report to Forestry Commission Scotland; see footnote 9. The capital costs of ceramic filters mentioned includes costs of boilers, chimneys and fuel storage facilities. The information is based on AEA’s communication with manufacturers.

2040[19]. The impact on total resource costs is the outcome of multiple effects: A large increase due to the increase in capital expenditure for the average biomass installation and a decrease of total resource costs resulting from a change in deployment and technology ratios (reflected in modelling by a re-ordering of 'stepped' supply curves[20]). The estimates suggest that the increasing effect dominates.

27. As explained above, the average additional capital expenditure is highly uncertain. To assess the impact of a higher cost increase on the Net Present Value we have run a sensitivity simulating a capital expenditure increase of 25%, presented in part VI below.

Testing and certification costs

28. The testing and certification process, involving an accredited test house, will generate costs for heat generators, manufacturers or importers/installers. Heat generators may purchase already type-approved and certified biomass boilers from an installer or manufacturer. A manufacturer/installer may acquire certification for a specific on-site installation, which can then be used for any identical future set-ups. The costs may alternatively fall directly on the heat generator e.g. in the case of retrofitting abatement equipment to existing boilers, where compliance has to be demonstrated by on-site testing. In all of the above cases the additional costs are expected to at least in part affect heat generators, either directly or indirectly where boiler manufacturers pass costs through in the price of the installation.

In the context of this IA, we only assess the <u>additional</u> testing and certification costs introduced by option 2. This means that costs are only taken into account where they would not already have been incurred under current legislation. We assume that most biomass installations under option 1 have to be tested and certified for air quality to fulfil existing regulation under the European Machinery Directive[21] or air quality regulation of other countries. The additional testing and certification costs due to the RHI Air Quality requirements are therefore expected to be very low[22]. They are considered here to have been captured as part of the average increase in capital expenditure in the central scenario, as they are likely to be passed on from manufacturers to operators in the equipment cost.

Impact on total renewable heat deployment under the RHI

29. Option 2 is designed to minimise impact on deployment relative to option 1. Because tariffs seek to compensate for the additional costs caused by air quality restrictions the overall level of incentive is expected to be the same, and so not impact the deployment of RHI Biomass. A 10% to 15% capex increase in option 2 translates into 4% to 15% higher tariffs, depending

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[19] RHI applications can be filed until 2020 when the last supported installations will start receiving RHI support which then is paid out for 20 years. The last payments under the RHI will therefore be made in 2040. Costs and Benefits are annuitised and spread over the entire payment period of an installation.

[20] This links again to the explanation in section V.1.i) The supply curves used to generate tariffs consist of a number of steps (representing different installation types) of different length (technical potential) and height (cost). When different cost increases (10% and 15%) are applied, we see a re-ordering of the supply curve such that slightly less technical potential is available at the cost of the 50th percentile (as e.g. a shorter step occupies that position). This results in the small decrease in deployment that occurs. - In reality we would equally expect some change in deployment as the assumed cost increases are an average, and will vary from installation to installation.

[21] For instance, the EU Standard applying to the testing of biomass boilers (BS EN 303-5:2012 Heating boilers Part 5: Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW — Terminology, requirements, testing and marking) has recently been harmonised under the Machinery Directive (2006/42/EC). It is mandatory for manufacturers and importers to comply with this standard, which involves testing equipment to document compliance. To comply with the EN303-5 boilers are currently already tested for PM_{10} and testing for NOx is not yet required but recommended.

[22] DECC is aware that the testing and certification costs as such are not negligible. For instance, DECC have received cost estimates from stakeholders, showing that the full compliance testing of a medium sized boiler in situ alone can incur costs of above £10,000. We assume, however, that these costs would also be incurred under current legislation.

on tariff band. However, in reality, not every installation will face the same circumstances, so the additional costs of option 2 will vary from participant to participant. As such the RHI incentive may increase or decrease slightly for any individual installation. This may mean some small impacts on deployment patterns even if the average cost increase is reflected in tariffs.

30. In modelling the impacts of these options we do not capture this in detail, as capex increases caused by air quality restrictions are generic assumptions which do not vary across individual plants. However the modelling does partially mimic the effect, to the extent that AEA estimates of capex increases vary between 10% and 15%, which causes some small changes in the incentive to invest between options 1 and 2. The following paragraphs explain why modelled deployment changes between options. In reality, although we might expect some changes in deployment (in option 2 relative to option 1), a decrease in deployment is considered no less likely than an increase.

<u>Explanation of change in modelled deployment between option 1 and 2</u>

31. In the modelling work, each discrete (stepped) renewable heat supply curve of the model is made up of number of rural, urban and suburban segmentations (steps) and is used to set the tariff at the 50^{th} percentile for one of the technology bands. Due to our assumptions about differential capex increases we observe a slight rearrangement of these steps after the introduction of the emission limits. This results in different tariffs being set. The new tariffs again incentivise a slightly different composition of sectors (steps) than before: at the margin, sectors swap in and out of being just below or just above the 50th percentile and hence, just under- or just over-incentivised. Where this re-shuffling results in the 50th percentile step being shorter (or longer) than before, the model estimates will show a small decrease (or increase) in overall uptake.

32. As discussed under a)-c) some change in overall renewable heat deployment can still be expected in reality, as well as in the modelled estimates. The modelling suggests that, relative to the counterfactual, the renewable heat deployed in 2020 under option 2 increases by 5% from 44TWh to 46.2TWh. Over the lifetime of the policy, the projected total renewable heat deployed equally rises by about 5%.

33. Finally, it is not considered likely that any deployment will take place outside the RHI as a result of these regulations as the cost of meeting the regulation is lower than the subsidy that would be forgone.

ii.) Administrative costs

34. The RHI is administered by Ofgem. Option 2 will increase Ofgem's costs, which can be divided into set-up costs, ongoing costs of administering applications (varying with the number of RHI applications for biomass based installations) and ongoing audit costs (varying with cumulative biomass based installations).

Set-up costs

35. Some of the additional administrative costs will be up-front transitional costs associated with the training of staff and adjustments to Ofgem's IT system. Ofgem estimates that it will incur £58,000 in set-up costs.

Ongoing variable costs

36. The assessment process of RHI applications and audits of supported installations have to take account of additional emission certificates and air quality emission limits under option 2. According to Ofgem it will take an employee on average 30 minutes to process a faultless air quality certificate accompanying a RHI application. Ofgem assumes that the IT based processing costs in the first three years after the introduction of the air quality limits will fall from about £28 per biomass based installation to £23.50. We have assumed £23.50 as the constant processing cost per relevant application from then onwards up to 2020 when the RHI closes for application. The total costs associated with administering applications are estimated to sum up to a Present Value of £812,000.

37. For each year up to 2020, the estimated cost per application is scaled by the total number of biomass based RHI applications to Ofgem. Although it is likely that a small number of applications will not succeed we use the estimated installation numbers as a proxy for the number of applications.

38. Ofgem expects some additional on-site auditing costs as the air quality requirements add to the scope of work of the audit. Additional audit costs, including site visits, are estimated by Ofgem to vary in the first three years between £3.60 and £2.30 per biomass based installation covered[23]. We have assumed £2.30 as constant audit cost per relevant installation from the third year onwards until the end of the lifetime of the policy. The total audit costs are estimated to amount to a Present Value of £1,171,000.

39. Over the lifetime of the policy, from 2013 to 2040, we estimate average ongoing administrative costs with a Present Value of £71,000 per year.

40. Under the above assumptions the total additional administrative costs incurred over the lifetime of the policy sum up to a Present Value of £2m, or 0.5% of total costs of option 2.

2. Benefits of Option 2

41. The introduction of emission limits under option 2 is expected to reduce the negative air quality impacts of RHI supported biomass combustion. DECC has worked with Defra to assess and quantify these benefits.

Modelling of air quality benefits

42. The modelling of the benefits is carried out in several stages. The steps are the following:
    a) First, the emissions occurring under option 1 and 2 are estimated, based on each option’s projected renewable heat uptake pattern under the RHI. (table 1)
    b) The emission estimates are then used to model the (population weighted) mean concentration of pollutants in 2020 for each option. (table 2)
    c) In a next step, concentration-response functions link a change in pollution concentration to changes in health impacts. Mortality effects are used as a measure of the change of health.

[23] This audit cost per installation takes account of the fact that only a proportion of biomass installations will be audited.

d) The improvement in health outcomes (when moving from option 1 to option 2) is subsequently monetised. (table 3)
e) Finally, a time profile of benefits over the lifetime of the policy is created, by using the 2020 value of the change in mortality effects and scaling it by the biomass heat deployed under the RHI of each year. (NPV table)

The health impacts owing to air pollutant emissions were estimated following the best practice appraisal approaches recommended by the Defra led Interdepartmental Group on Costs and Benefits (IGCB)[24]. Steps a) and b) were carried out by AEA using the Pollution Climate Mapping (PCM) model. The impacts of biomass combustion on the air quality depend not only on the amount of biomass burned but also on factors such as the location of the biomass combustion plants. The PCM model therefore uses maps of pollutant emissions for specific future years to model their concentrations on a 1km by 1km grid. RHI biomass uptake estimates for options 1 and 2 were used as inputs in the mapping process, broken down by location (rural, sub-urban and urban locations). Further inputs included Department for Transport traffic forecasts and agricultural activity projections by Defra. Maps of fuel use patterns in the commercial and public sectors[25] were applied to estimate the spatial distribution of the counterfactual technologies displaced by biomass under option 1 and 2. The resulting emission maps of both options were then added each to a map of baseline emission projections[26]. The PCM model outputs include comparisons both with air quality limits and target values, as well as the population weighted mean concentrations.

Modelling Results

43. Table 1 below shows results of step a), the total emissions estimated to result under options 1 and 2, based upon each option's projected renewable heat uptake pattern under the RHI.

Table 1: Total emissions from RHI biomass installations in 2020

2020	Counterfactual - without AQ requirements (option 1)	RHI with AQ requirements and compensating tariffs (option 2)
PM_{10} emission [tonne]	3,649	1,644
NO_x emission [tonne]	1,333	1,329
benzo[*a*]pyrene emission [kg]	205	206

44. Emission estimates are then used to estimate the population weighted mean concentrations for each option (step b), as summarised in table 2.

Table 2: 2020 Population weighted mean concentration

2020 Population weighted mean concentration	Counterfactual - without AQ requirements (option 1)	RHI with AQ requirements and compensating tariffs (option 2)
PM_{10} µg/m^3	14.343	14.262
$PM_{2.5}$ µg/m^3	9.582	9.505
Nitrogen dioxide (NO_2) µg/m^3	13.413	13.412
Benzo[*a*]pyrene ng/m^3	0.249	0.249

45. Next (step c), concentration-response functions are applied to the results of the concentration modelling above, linking a change in pollution concentration to a change in health impacts. In this IA the mortality effects are measured in "life years lost" and "deaths

[24] http://www.defra.gov.uk/environment/quality/air/airquality/panels/igcb/pathway.htm
[25] by the National Atmosphere Emission Inventory (NAEI)
[26] Map of baseline emission projections by NAEI

brought forward". The health response to the 2020 concentration is calculated for the lifetime of the population, assumed to be 100 years. The health outcomes of both options are subsequently monetised (step d)[27].The change in lifetime social cost, when moving from option 1 to option 2, represents the monetised benefit that results from the change in emissions in 2020 following the introduction of air quality requirements into the RHI. The results of modelling steps c) and d) are shown in table 3, where positive values indicate a benefit.

Table 3: Lifetime Social Costs: AQ benefits resulting from change in emissions in 2020**

Reduction in lifetime social costs in 2020, [option 2 – option 1, £m, 2012 prices, PV]			
	Low - 40 year lag	Central - 5 year lag	High - no lag
Low (1%)	13	30	35
Central (6%)	78	**184***	208
High (12%)	157	367	417

**Value used to calculate central NPV; ** here: lifetime = lifetime of population (100 years)*

46. Table 3 also includes sensitivity analysis around two assumptions: the time lag between the change in concentration and the resultant health impact; and the concentration-response coefficient. For the time lag, the Department of Health's Committee on the Medical Effect of Air Pollution (COMEAP)[28] recommend a range of 0-40 years with the central value representing a lag of around 5 years[29]. The concentration-response coefficient range also follows advice from COMEAP, applying 6% as the central value with a range of 1-12%. The high and low benefit values in this IA use the range generated from varying the length of the lag, £98-261m for 2020. The IGCB recommend this as the central range to apply, reflecting reasonable levels of uncertainty[30]. The concentration-response coefficient sensitivity uses a wide statistical interval and is reported here purely for completeness[31].

47. To account for the benefits over the entire lifetime of the policy, a time profile of benefits is calculated, by using the central benefit value for 2020 and scaling it by the biomass heat deployed under the RHI of each year. The resulting estimates are integrated in the Net Present Value table below.

48. The estimates above show that the introduction of air quality criteria under option 2 are expected to significantly reduce the negative health impacts of the RHI, producing an estimated benefit of a Present Value of £184m in 2020 and resulting in a central air quality benefits estimate of a Present Value of £3,368.6m over the lifetime of the policy. It is important to note, however, that only mortality impacts have been included. The estimated benefit of option 2 is conservative as wider impacts such as on morbidity (in terms of hospital admissions and reduced activity days) and impacts on the environment (in the form of ecosystem impacts) were not assessed.

[27] The monetisation keeps the "Value of Life" constant at the 2020 value.
[28] *The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom. A report by the Committee on the Medical Effects of Air Pollutants,* COMEAP, 2010(http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1317137020357)
[29] This is in accordance with evidence suggesting more weight should be given the high end of the range (i.e. a shorter lag).
[30] Please refer to http://www.defra.gov.uk/environment/quality/air/air-quality/economic/impact/ for full discussion.
[31] The consultation stage IA only used the concentration-response coefficients for sensitivity calculations. Since then IGCB have advised that the 0-40 year lag range should be used in preference.

3. Net Present Value of option 2

	Additional Resource Costs	Additional Administrative Costs	Value of Impact on CO2 Emissions	Air Quality Benefits - central	Air Quality Benefits -low	Air Quality Benefits - high
	[£m] (2012 Prices)	[£m] (2012 Prices)	[£m] (2012 Prices)	[£m] (2012 Prices)	[£m] (2012 Prices)	[£m] (2012 Prices)
2012	-	0.06	-	-	-	-
2013	-	0.08	-	14.91	6.35	16.91
2014	-	0.09	0.34	33.08	14.09	37.53
2015	2.16	0.12	1.06	54.97	23.42	62.38
2016	6.50	0.13	1.83	79.22	33.75	89.89
2017	10.95	0.15	2.62	104.48	44.52	118.56
2018	15.92	0.17	3.45	131.24	55.92	148.93
2019	21.12	0.19	4.37	158.34	67.47	179.68
2020	25.92	0.19	5.44	183.66	78.26	208.42
2021	27.68	0.07	6.47	190.81	81.30	216.53
2022	26.70	0.07	7.05	184.36	78.55	209.21
2023	25.15	0.06	7.58	178.13	75.90	202.13
2024	23.04	0.06	8.07	172.10	73.33	195.30
2025	20.99	0.06	8.51	166.28	70.85	188.69
2026	19.95	0.06	8.92	160.66	68.45	182.31
2027	19.88	0.06	9.28	155.23	66.14	176.15
2028	19.82	0.05	9.61	149.98	63.90	170.19
2029	19.77	0.05	9.91	144.91	61.74	164.44
2030	19.74	0.05	10.17	140.01	59.65	158.88
2031	19.72	0.05	10.73	135.27	57.64	153.50
2032	19.71	0.05	11.25	130.70	55.69	148.31
2033	19.36	0.04	11.71	118.79	50.61	134.80
2034	17.96	0.04	11.28	105.38	44.90	119.59
2035	15.72	0.03	9.89	90.26	38.46	102.42
2036	13.29	0.03	8.38	74.08	31.57	84.07
2037	5.93	0.02	6.77	57.54	24.52	65.29
2038	-	0.01	5.00	40.37	17.20	45.81
2039	-	0.01	3.07	23.15	9.86	26.27
2040	-	-	1.05	6.95	2.96	7.89
	417.0	2.0	183.8	3,184.8	1,357.0	3,614.1

Total Costs	**419.0**	**Total Benefits**	**3,368.6**	1,540.8	3,797.9
			CENTRAL	**LOW**	**HIGH**
		NPV [£m]	**2,949.6**	1,121.8	3,378.9

49. Over the lifetime of the RHI the abatement activity of option 2 associated with an estimated increase in resource costs of £417m (through the impact of increased capital costs and an increased tariff) and additional administrative costs of £2m, is expected to result in £3,184.8m of air quality benefits (central estimate) and £183.8m of benefits from reductions in CO2 emissions due to additional renewable heat deployment. The Present Value of total benefits is therefore estimated to outweigh the Present Value of total costs by 8:1, resulting in a large positive Net Present Value of £2,949.6m. This indicates that the introduction of air quality requirements as described under option 2 may lead to welfare improvements for society.

VI. Assumptions and Sensitivities

50. Our Net Present Value result is based on a series of assumptions. These include:
    - The introduction of emission limits increases capital expenditure on biomass installations by 10% to 15% relative to the counterfactual situation.
    - The additional testing and certification of biomass installations to demonstrate compliance with the RHI air quality requirements under option 2 only give rise to negligible additional costs. This is the case as they can be easily added to the currently required testing and certification regimes.
    - Administrative cost estimates are based on Ofgem's cost assumptions for the first three years after the introduction of the policy. Ongoing costs per biomass based installation are assumed to be constant from the third year onwards.

Sensitivities - resource cost modelling assumptions

51. The introduction of the emission limits increases the resource costs faced by biomass installations. Our estimates so far assume that this rise can be adequately modelled as a 10% to 15% increase in capital expenditure which is passed on through price. Due to the limited evidence available the percentage increase of capital expenditure is, however, uncertain. The increase assumed so far represents an average increase in costs, which in reality will vary from case to case. For instance, one consultation response referred to a biomass boiler of 10MWth capacity for which additional costs to meet the RHI emission requirements amounted to a substantially higher capex increase.

52. To assess the impact of such a higher cost increase on the Net Present Value we have run a sensitivity analysis, in which we assume that the increase of total resource cost, including capital expenditure and certification cost, is modelled as a 25% increase of capital expenditure.

53. **Net Present Values of +25% CAPEX sensitivity**

	Additional Resource Costs	Additional Administrative Costs	Value of Impact on CO2 Emissions	Air Quality Benefits - central
	[£m] (2012 Prices)	[£m] (2012 Prices)	[£m] (2012 Prices)	[£m] (2012 Prices)
2012	-	0.06	-	-
2013	0.85	0.07	-1.28	17.50
2014	3.79	0.08	-1.51	40.63
2015	6.53	0.10	-2.12	67.46
2016	13.22	0.12	-2.67	98.19
2017	12.13	0.11	-4.54	128.69
2018	8.34	0.13	-6.62	159.84
2019	-0.70	0.13	-9.18	190.23
2020	-14.65	0.14	-12.43	218.00
2021	-18.90	0.05	-13.81	226.07
2022	-18.26	0.05	-13.91	218.42
2023	-17.64	0.05	-13.99	211.04
2024	-17.04	0.05	-14.04	203.90
2025	-16.47	0.05	-14.08	197.00
2026	-15.91	0.05	-13.84	190.34
2027	-15.37	0.04	-13.57	183.91

2028	-14.85	0.04	-13.25	177.69
2029	-14.35	0.04	-12.91	171.68
2030	-13.86	0.04	-12.53	165.87
2031	-13.40	0.04	-12.92	160.26
2032	-13.16	0.04	-12.84	154.84
2033	-12.93	0.03	-12.26	140.81
2034	-13.99	0.03	-12.08	124.13
2035	-14.96	0.02	-11.51	105.76
2036	-17.92	0.02	-11.06	85.59
2037	-17.00	0.01	-9.21	65.70
2038	-14.72	0.01	-7.02	45.63
2039	-9.82	0.00	-4.33	26.10
2040	-2.47	-	-1.14	8.03
	-263.5	1.6	-270.7	3,783.3
	Total Costs	**-261.87**	**Total Benefits**	**3,512.64**
				CENTRAL
			NPV [£m]	**3,774.51**

54. The cost increase in this scenario leads to a reduction of overall renewable heat deployment under the RHI which in turn reduces total resource costs. Instead of rising by £417m in the central scenario total resource costs are expected to fall by -£263.5m over the lifetime of the policy, a difference of £680.5m. Over the lifetime of the policy, the change in renewable heat deployment has the expected effects on the other costs and benefits when compared to that of the central scenario: it lowers administrative costs, raises air quality benefits (as less biomassbased heat generation replaces gasfuelled heat generation) and reduces replaced CO2 emissions to a degree that the CO2 impact of the policy change becomes negative and now adds to the costs.

55. The sensitivity analysis results in a higher Net Present Value relative to the central scenario. This is mainly the result of increased air quality benefits due to reduced biomass deployment. The cost-benefit analysis, however, does not explicitly take account of the opportunity cost attached to the decrease in renewable heat deployment under the RHI in 2020, which is estimated to fall by 1.7TWh relative to option 1, a reduction of 4%. In the context of the UK 2020 renewable energy target this decrease would have an opportunity resource cost of between £1.3bn and £1.8bn attached to it[32]. Given that the UK is committed to meeting its 2020 renewable target, this suggests that overall costs to society are higher under the sensitivity scenario than under the central scenario.

VII. Direct costs and benefits to business calculations

56. The RHI is a voluntary scheme and does not fall under the one-in-one-out rule.

VIII. Wider impacts

1. Competition Impacts

57. There are no clear competition impacts of the proposed policy (option 2) as the RHI is a voluntary scheme. However, the current tariff structure may be overcompensating biomass relative to other technologies as a result of paying tariffs that intend to compensate for air

[32] reflecting costs of renewable energy generation through offshore wind power at a levelised resource cost of between 6.3p/kWh and 9p/kWh paid over the lifetime (20 years) of the power plant. (-as previously assumed in RHI tariff calculations, see also footnote 11)

quality abatement, which is not currently included as an application criterion in the scheme. This policy seeks to address this.

58. The introduction of air quality requirements (option 2) may lead to innovation in biomass combustion and abatement equipment.

2. Social impacts/ impacts on rural and urban areas

59. The RHI emission criteria apply to biomass combustion installations of RHI applicants independent of their geographical location. Rural areas may be differentially affected by the policy changes introduced under option 2 compared to urban and suburban areas. The negative health impacts of PM and NOx emissions are felt more strongly in areas of high population density, or urban areas, but are less pronounced in less densely populated areas, or rural areas. The change of health risks for an exposed individual, however, is the same in a rural or urban area[33]. The lower population density in rural areas only means that the change in the social cost of air pollution in a rural area is smaller.

60. Option 2 has no obvious further impacts on social, wellbeing or health inequalities.

3. Air quality impacts

61. Please refer to section V.2 on the benefits of option 2.

4. Carbon Assessment

62. CO2 emission savings are modelled as being higher under option 2, than in the counterfactual. This is in line with the estimated overall change in total renewable heat deployment. Compared to option 1 an additional 0.2MtCO2 savings are expected in 2020 and 5.2MtCO2 over the lifetime of the policy, a change of approximately 3% in both cases. The model suggests this is mostly achieved through the installation of industrial (traded) Biomass Boilers. The value of the additional carbon savings increases in parallel and amounts to £183.8m over the policy lifetime, with all years showing additional carbon savings.

    The increase in CO2 emissions savings mainly occurs in sectors traded in the EU Emissions Trading Scheme (5MtCO2), whereas replaced emissions in non-traded sectors increase only by 0.2MtCO2.

63. These small changes in CO2 emissions mirror the small positive impact of option 2 on the total renewable heat deployment, described under section V.1.i) and they occur for the same reasons, which we discussed under V.1.i) point 28. a) - c).

IX. Summary

64. This IA assesses the net costs and benefits associated with an introduction of air quality requirements into the RHI in the form of emission limits for PM and NOx emissions for biomass installations under 20MWth capacity (option 2), against a counterfactual (option 1). The relevant RHI tariffs in both options reflect the required level of expenditure on abatement technology and are adjusted accordingly.

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[33] The World Health Organisation advises that there is no safe exposure level to PM, independent of location.

65. Our assessment suggests that an assumed 10% to 15% increase in resource costs incurred under option 2, mainly due to capital expenditure increases, leads to a total resource cost increase of £417m (+8%) over the lifetime of the policy to 2040. As testing and certification requirements for biomass installations are already in place, additional testing and certification costs under option 2 are expected to be very small and to have been accounted for in the resource cost increase. Total additional administrative costs incurred over the lifetime of the policy sum up to £2m, or 0.5% of the total costs of £419m.

66. Although modelling suggests an increase in total deployed renewable heat of 5% to 46.2TWh for 2020 the result is based on somewhat strong assumptions and may be spurious. In reality, we expect the policy's overall effect on renewable heat deployment to be neutral.

67. The introduction of emission limits is expected to reduce the negative impact of RHI supported biomass combustion on air quality. Impact modelling suggests that, relative to option 1, option 2 may lower negative health impacts, resulting in a central benefit estimate of about £3,370m over the lifetime of the policy. This estimate is conservative as wider impacts such as on morbidity and ecosystem impacts were not assessed.

68. The increase in renewable heat deployment is associated with an additional saving of 5.2MtCO2, estimated over the lifetime of the policy, adding an equivalent of about £184m to the benefits of the policy.

69. Overall, the benefits are estimated to outweigh costs by 8:1, resulting in a large positive Net Present Value of about £2,950m. This indicates that the introduction of air quality requirements as described under option 2 may lead to welfare improvements for society.

70. We have run a sensitivity analysis on abatement costs, assuming a 25% increase in capex but keeping tariffs constant at central scenario levels. Modelling results suggest a 4% decrease of total renewable heat deployment in 2020 and an increase of CO2 emissions as a consequence.

71. However, if the UK is to meet its 2020 renewable energy target, the loss of renewable heat deployment has an opportunity cost attached to it. Taking this opportunity cost into account the total costs to society under the sensitivity analysis are higher than under the central scenario.