



**A RENEWABLE HEAT INCENTIVE FOR NORTHERN IRELAND
ADDENDUM**

27 January 2012

Submitted by:

Cambridge Economic Policy Associates Ltd and AEA Technology Limited



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Comment [IDM1]: Peter, we understand this is to be published. In some places, we have mentioned individual sites or consultees, to make the report clearer for you. Should we remove these for a version that is fit to be published?

Comment [PH2]: Agree with your comment Iain, would be preferable to have a 'publishable' copy and a 'clean' copy.

Comment [PH3]: Can delete this – project isn't EU funded this time round.

Comment [PH4]: As above

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EXECUTIVE SUMMARY

On 20 July 2011, DETI launched a public consultation on the development and implementation of a Northern Ireland Renewable Heat Incentive (RHI). The overall objective of the Northern Ireland RHI was to support the achievement of 10% renewable heat by 2020. The proposals outlined in the consultation were largely informed by CEPA and AEA's economic appraisal¹ of various options for incentivising the Northern Ireland renewable heat market.

The consultation closed on 3 October 2011. Seventy-eight responses were received; these can be found on DETI's website².

We understand from DETI that there was widespread support for the introduction of a Northern Ireland RHI, as well as an acknowledgement that it is important that a Northern Ireland approach is taken in relation to support for the renewable heat market. However, we also understand that there were a number of areas where consultees were not fully in agreement with the current DETI proposals, including:

- the proposed level of tariff rates (with evidence provided to suggest alternative pricing assumptions);
- the appropriateness of the existing banding; and
- the interaction between DETI policies on the extension of the gas network and renewable heat, specifically in relation to policy on supporting large industrial sites.

As a result, DETI asked CEPA and AEA to reconsider their assumptions, in the light of the new evidence presented. We were asked to revisit and, where appropriate, update existing cost assumptions and banding methodology and consider the resulting implications for tariffs and overall costs.

We have reviewed the new evidence, and updated our cost assumptions for biogas injection and for wood chip. We have also included cost assumptions for geothermal, which was not considered in our previous work. In addition, we have adjusted the tariff bandings for biomass and GSHPs. Following these changes, we have re-run our economic model with the new assumptions.

The high level results are shown in Table 1 below, which sets out the revised tariff levels and banding. We have shown the tariffs from our original report³ for ease of reference.

Table 1: Implications of updated assumptions for tariffs (all figures in p/kWh and based on quarterly payments)

Technology size band	Size range (kW) ⁴	Tariff in original report	Updated tariff ⁵	Notes
ASHP – Small	0-45	3.3	3.4	Increase due to

¹ CEPA/ AEA for DETI, *Renewable Heat Incentive For Northern Ireland*, June 2011, available at [http://www.detini.gov.uk/economic appraisal into the northern ireland rhi - june 2011.pdf](http://www.detini.gov.uk/economic%20appraisal%20into%20the%20northern%20ireland%20rhi%20-%20june%202011.pdf)

² www.detini.gov.uk

³ Table 5 in that report

⁴ The range should be read as including the lower end, but not the upper end. For example, the range 20-100 includes 20kW boilers but not 100kW boilers – the latter are covered by the 100-500 range.

⁵ Includes inflation, and effect of changes to technology costs and tariff bands

Technology size band	Size range (kW) ⁴	Tariff in original report	Updated tariff ⁵	Notes
				inflation
ASHP – Medium	45+	-		
Biogas injection – All	All	2.5	3.0	Change to assumption on gate fee
Biomass boilers – domestic	0-20	4.5	4.9	
Biomass boilers – small	20-100	4.5 (<45kW) 1.3 (45kW+)	4.7	Intermediate tariff based on 50kW boiler
Biomass boilers – medium	100-500	1.3		
Biomass boilers – large	500+	-		
GSHP – domestic	0-20	4.0	6.9	Change to the reference installation means a higher tariff, which is tiered
GSHP – small	20-100	4.0 (<45kW) 0.9 (45kW+)	3.6	Intermediate tariff based on 30kW pump
GSHP – large	100-500	0.9		
Geothermal	All	n/a	0.6	Indicative tariff only
Liquid biofuels – small	0-45	1.5		
Liquid biofuels – medium/large	45+	-		
Solar Thermal	All	8.5		

Comment [PH5]: Still concerned about not having a tariff for this sector given possible disadvantage in comparison to GB market although understand that the model provides a negative tariff. Some calculation attached for your consideration.

Comment [PH6]: How is this tiered? X p/kW for 1314 hours and then X???

As can be seen, the tariffs have changed for biomass, GSHPs and biogas injection. A new (indicative) tariff has been added for geothermal, although given the very small number of potential installations in Northern Ireland between now and 2020, some other form of support is likely to be more appropriate.

Comment [PH7]: ? i.e. capital grant/challenge fund?

Comparing the tariffs directly to those in Great Britain is difficult, since the tariff bands are different. However, in general our tariffs are lower. The main reason for this is as set out in our previous report – that is, the higher cost of oil heating in NI compared to gas heating which predominates in GB. Comparisons of specific tariffs are in Table 2 below.

Table 2: Comparison of NI and GB RHI rates⁶

Technology size band	Size range (kW)	Proposed NI tariff	Nearest GB equivalent
Biogas injection – All	All	3.0	6.5

⁶ Not all technologies are shown since in some cases there is not a GB equivalent.

Technology size band	Size range (kW)	Proposed NI tariff	Nearest GB equivalent
Biomass boilers – domestic	0-20	4.5	4.9
Biomass boilers – small	20-100	4.7	7.6 ⁷ for the first 1314 peak load hours and then 1.9
Biomass boilers – medium	100-500	1.3	4.7 ⁸ for the first 1314 peak load hours and then 1.9
Biomass boilers – large	500+	-	1.0
GSHP – small	20-100	3.6	4.3
GSHP – large	100-500	0.9	3.0
Geothermal	All	0.6	3.0 ⁹
Solar Thermal	All	8.5	

Comment [PH8]: Need this upfront

NOTE – Given the tariffs remain considerably lower than GB we are concerned that this might affect uptake as potential consumers are hesitant to install due to higher rates in GB, or ESCOs move business operations to GB where rates ‘appear’ more favourable. That being the case is it possible to briefly examine the level of tariffs with a 15% discount rate, rather than 12%, and the likely impact. Can this be quickly retrieved from the model?

<u>Technology size band</u>	<u>Size range (kW)</u>	<u>Proposed NI tariff with discount rate of 12%</u>	<u>Proposed NI tariff with discount rate of 15%</u>
<u>Biogas injection – All</u>	<u>All</u>	<u>3.0</u>	<u>2</u>
<u>Biomass boilers – domestic</u>	<u>0-20</u>	<u>4.5</u>	<u>2</u>
<u>Biomass boilers – small</u>	<u>20-100</u>	<u>4.7</u>	<u>2</u>
<u>Biomass boilers – medium</u>	<u>100-500</u>	<u>1.3</u>	<u>2</u>
<u>Biomass boilers – large</u>	<u>500+</u>	<u>-</u>	<u>2</u>
<u>GSHP – small</u>	<u>20-100</u>	<u>3.6</u>	<u>2</u>
<u>GSHP – large</u>	<u>100-500</u>	<u>0.9</u>	<u>2</u>
<u>Geothermal</u>	<u>All</u>	<u>0.6</u>	<u>2</u>

⁷ Tier 1 at 7.6p/kWh (for first 1314 kWh), then Tier 2 at 1.9p/kWh for remaining renewable heat.

⁸ Two tier tariff system applies to large commercial in GB.

⁹ Deep geothermal can receive the same tariff as large GSHPs.

<u>Technology size band</u>	<u>Size range (kW)</u>	<u>Proposed NI tariff with discount rate of 12%</u>	<u>Proposed NI tariff with discount rate of 15%</u>
<u>Solar Thermal</u>	<u>All</u>	<u>8.5</u>	

The high-level impact of these new tariffs, and other minor changes that DETI has asked us to make¹⁰, is shown in Table 3 below.

Table 3: Impact of RHI in 2020, including baseline and viable installation¹¹

	Renewable Heat delivered (% of total 2020 heat demand)	Lifetime cost in PV terms, compared to do nothing (£m)
Before changes	11.14%	334
After changes	10.92%	335
<u>With tariffs set at 15% rate of return</u>	<u>X%</u>	<u>£Xm</u>

In summary, the changes have a minor impact on both renewable heat deployed and on costs.

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¹⁰ Such as delaying ASHP and bioliquids tariffs until 2013

¹¹ Assuming long-term funding - £25m to 2014/15, with an additional £5m per year from 2015/16. This assumes no geothermal before 2020.

1. INTRODUCTION

CEPA and AEA Technology have been asked by the Department of Enterprise, Trade and Investment (DETI) to perform additional analysis on a possible Renewable Heat Incentive (RHI) for Northern Ireland. This follows our previous report, which was published alongside DETI's consultation on the RHI.

Since that report was published, further information has become available. The purpose of this addendum to our previous report is to consider that information, and other issues that have arisen as a result of DETI's consultation, and provide additional analysis on tariffs and the wider impacts of an RHI. Further details on the background to this project are in the next section.

1.1. Background and context

In this section we very briefly set out the context for the analysis discussed in later sections. We start with our previous report for DETI, which this work follows on from.

1.1.1. Previous report

Our previous report for DETI looked at “...*the most appropriate form of [an RHI] for Northern Ireland*”¹². It set out an RHI that while similar to the GB RHI in many ways, differed on the subsidy levels and on the technologies supported. We noted that previous work¹³ had shown that a GB RHI would be sub-optimal for Northern Ireland. In particular, it would not achieve the 10% renewable heat target, whereas our analysis suggested that the rates we proposed could achieve that target.

The report was published as part of DETI's consultation¹⁴ on the RHI. As part of the responses to that consultation, DETI has received additional material, which we now turn to.

1.1.2. New material received in response to consultation

We understand from DETI that there was widespread support for the introduction of a Northern Ireland RHI, as well as an acknowledgement that it is important that a Northern Ireland approach is taken in relation to support for the renewable heat market. However, we also understand that there were a number of areas where consultees were not fully in agreement with the current DETI proposals, including:

- the proposed level of tariff rates (with evidence provided to suggest alternative pricing assumptions);
- the appropriateness of the existing banding; and
- the interaction between DETI policies on the extension of the gas network and renewable heat, specifically in relation to policy on supporting large industrial sites.

¹² *ibid*, page 5.

¹³ AECOM/ Pöyry, 2010, *Assessment of the Potential Development of Renewable Heat in Northern Ireland: Final Report*

¹⁴ http://www.detini.gov.uk/consultation_on_the_development_of_the_northern_ireland_renewable_heat_incentive

In particular, responses were received on the technology costs and banding for biomass, biomethane, bioliquids, GSHPs and geothermal.

Technology costs are a major factor in determining the RHI tariffs that we suggested in our report. We have therefore been asked by DETI to review our assumptions on technology costs, in the light of the new information received, and update tariffs if appropriate. This and the other specific tasks assigned by DETI, are discussed below.

1.1.3. Terms of reference from DETI for extension

Our first task has been to update the technology costs, and where appropriate tariffs, for the following technologies: biomass, bioliquids, biomethane and ground source heat pumps. We have also been asked to consider what a tariff for geothermal might look like. Our results have been set out in a form agreed with DETI (see Annex A, for details of the tariffs, and Annex B for details of overall impact).

DETI has also asked us to consider at a high level the possible impact on gas demand of providing a tariff for large scale biomass and the potential for a shift to the use of biomass in the large industrial sector.

1.2. Structure of report

Following this introduction, our report is structured as follows:

- Section 2 outlines the methodology that we have used for this analysis;
- Section 3 sets out our results and conclusions;
- Annex A includes tables showing technology cost assumptions, and the breakdown of each tariff by capital, operating and fuel costs; and
- Annex B includes a table summarising key impacts of the policy, such as CO₂ emissions saved and renewable heat delivered per year.

2. METHODOLOGY

Much of our work for this report involves applying elements of our methodology from our previous report. We briefly summarise this below. Where the requirements involve a new methodology or approach, we have given more detail.

2.1. Technology costs and tariff bands

[Redacted text]

As well as revisiting technology costs, DETI has also asked us to revisit the banding for biomass and GSHPs. Specifically, it was felt that there needed to be finer-grained banding for both technologies. We have reviewed the views of consultees, and the GB approach, in coming to our recommendations.

2.2. Tariff setting

Changes to costs and tariff bands require us to recalculate tariffs for some technologies. Our basic methodology for doing so is as in our previous report. We briefly summarise it here. Further details can be found in Annex E of that report.

Our approach to setting the NI RHI tariffs can be summarised as: first, identify the required subsidy level, in pence per kWh that just covers the additional cost of a *reference* renewable heat installation compared to a conventional oil boiler. For example, suppose that over its lifetime, an oil boiler costs 5p per kWh of heat produced, and a reference biomass boiler of similar size costs 7p per kWh. The subsidy is therefore $7p - 5p = 2p$ per kWh.

This leads to two questions: (i) what is a reference installation; and (ii) how is the average lifetime cost of a boiler or renewable heat installation calculated?

Following the GB RHI approach, we say that the reference installation for a particular technology size is the one with the average¹⁵ cost for that technology size over all the sites where it could be installed.

To calculate the average lifetime cost, we calculate the annual operating and fuel cost, and add this to the annuitized cost of the upfront capital, installation and **barrier costs**. We then divide this cost per year by the average annual heat produced to obtain a figure for cost per unit of heat.

2.3. Delays to tariffs

At DETI's request, we have delayed the tariffs for ASHPs and bioliquids until 2013 (tariffs for other technologies start in 2012). We have also removed the small number of installations originally expect to take up renewable heat in the model in 2011. As will be seen in the next section, these changes have only a very small impact.

Comment [PH9]: Did AEA speak to anyone from the consultation? Rural Generation or Biomass NI?

Comment [PH10]: How is the barrier cost determined? Does it include the potential cost of a heat meter?

Comment [PH11]: Iain, as previously discussed. The DECC tariffs include an ongoing yearly barrier cost, ours only include an upfront cost. Why is this?

Not aware of all figures but large GSHP has upfront barrier of £6470 and ongoing of £66per annum and medium biomass (350kw ref technology) has a ongoing barrier cost of £969per annum.

¹⁵ More precisely, the median.

3. RESULTS

This section presents the results of the analysis that we performed, using the methodology from the previous section. To recap, DETI asked us to update technology costs and tariffs, and look at the impact on renewable heat delivered, carbon dioxide emissions, costs and gas demand.

3.1. Changes to banding

As noted in Section 3, we have updated the banding for biomass and ground source heat pumps (GSHPs). We propose the following new bands for both: a domestic band (0-20kW); a small (non-domestic) band (20-100kW); and a large band (100-500kW). In our results, we show an additional “above 500kW” band for biomass, but the subsidy level for this band is zero.

3.1.1. Biomass banding

The biomass bandings (less than 45kW and above 45kW) have been criticised by respondents to the consultation as being too broad. Respondents requested the same or similar biomass banding as in place in GB.

The GB biomass banding between small and medium non-domestic is set at 200kW. The rationale used for this banding is that that boilers above 200kW tend to predominantly run on wood chips compared to wood pellets and that load factors generally increase for larger boilers¹⁶. However, it should be recognised that in reality there is no specific point where the £/kW decrease dramatically. The net result of this is that any banding mechanism will result in ‘gaming’ where consumers look to undersize boilers where possible.

Recommendation:

Whilst many respondents would like to see the same tariffs as GB, the average boiler size in Northern Ireland is expected to be smaller than in GB. Therefore a tailored tariff to reflect the Northern Ireland market could be beneficial to consumers. We propose the banding in [Table 3.1](#) below.

Table 3.1: proposed biomass boiler bandings

Category	Band size	Modelling comments
Domestic	0-20kW	Based upon 11kW biomass boiler
Small biomass	20-100kW	Based upon 50kW size biomass boiler (original 20kW) ¹⁷ .
Larger biomass	100-500kW	Based upon 200kW boiler. This would encompass the majority of the ‘large commercial/public’
Very large biomass ¹⁸	500kW+	

¹⁶ AEA (2011) Review of technical information on renewable heat technologies

¹⁷ In reality 20kW is very small for a non-domestic boiler and many of the installations are likely to be larger i.e. 50kW+. In a very small office it would probably not be practical from a load factor perspective that biomass would be viable. It is also likely that small office premises may be connected to larger biomass boiler heating a either one larger building with several different businesses or via a small district heat network such as holiday lets/farm business.

Comment [PH12]: Don't want it to seem that bands are defined by sector. Wording along the lines of 'primarily for the domestic sector' may be better?

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Comment [PH13]: Probably don't need this column.

Deleted: Boundary

Comment [PH14]: Re footnote – the reduction of the tariff was more to do with the calculation of tariff rather than the banding, ie DECC setting tariff to incentivise 100% of potential rather than 50% like all other tariffs.

Comment [PH15]: Re footnote – “The price differential between heating oil and gas (for industrial consumers) used in the CEPA/ AEA modelling is between 1-2p/ kWh. While there is a higher cost to woodchips in NI, Table 3.3 suggests this is under 1p/ kWh. Based upon this, we have assumed that there should be no renewable heat incentive for large scale biomass in NI”

Is this not a bit simplistic in that ignores the initial capital costs, ongoing operating costs and barrier costs? The actual fuel price is only 1 element of the tariff.

Category	Band size	Modelling comments
		Regulations.

Comment [PH13]: Probably don't need this column.

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Comment [PH16]: What does this mean? Is it that EU wouldn't allow a large biomass tariff or the exclusion of one could leave NI industry uncompetitive?

3.1.2. Ground Source Heat Pump banding

Consultation responses have questioned the current tariff boundaries of less than and greater than 45kWh. The differences in tariff between the lower and upper bands have also been questioned as being too large (Geoserve). Such a dramatic step change in project costs does not exist and therefore the tariff boundaries need revising to reduce this significant difference.

Comment [IDM17]: Remove names before publication AGREE

One issue is that a 60kW installation will cost more per kW than a 200kW installation. The reasons for this are the use of smaller heat pump modules and that fixed drilling costs (that is, getting drilling contractors and rig set up on site) are not spread over a larger number of borehole. The step change between bands needs revisiting as it is quite significant in Northern Ireland at 3.1p/kWh compared to 1.2 p/kWh in GB. This issue has arisen largely from the size of the reference installation.

Recommendation:

Our recommendation is to introduce what is in effect a domestic tariff; this will be based upon the existing 11kW boiler size. Further, we recommend using a 30kW GSHP size for small commercial installations, instead of 11kW. We consider that it is more likely that small commercial installations will be by landlords installing heating systems to serve multiple small businesses, rather than each business in a building installing its own heating systems. We have therefore proposed a reference size which would cover the demand from two or three small businesses, rather than just one. The 30kW reference size will also act as an interim point between domestic and large commercial installations (reference size 200kW).

This gives us the proposed bandings in [Table 3.2](#) below.

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Table 3.2: Proposed GSHP bandings

Band	Band size	Reference size
Domestic	0-20kW	11kW
Small commercial	20-100kW	30kW (original 11kW)
Larger commercial	100kW +	200kW

Comment [PH18]: Delete column?

¹⁸ For large scale biomass consideration needs to be given to the revisions to the large scale biomass tariff made in GB. Due to state aid regulations enforced by the European Commission the GB large scale biomass tariff was revised down from 2.6p/kWh to 1.0p/kWh. For Northern Ireland the counterfactual is oil compared to gas in GB. The price differential between heating oil and gas (for industrial consumers) used in the CEPA/ AEA modelling is between 1-2p/kWh. While there is a higher cost to woodchips in NI, [Table 3.3](#) suggests this is under 1p/kWh. Based upon this, we have assumed that there should be no renewable heat incentive for large scale biomass in NI.

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3.2. Updated cost assumptions

In this section, we describe the new information received on technology and fuel costs, and what we have concluded as a result. Each technology that we have reviewed (biomass, biomethane, bioliquids, GSHPs and geothermal) is described below.

3.2.1. Biomass

Apart from concerns over bandings, which we addressed in the previous section, respondents' main concern was that the biomass fuel prices used for Northern Ireland were too low. In particular, it was raised several times that the local biomass price for Northern Ireland is higher than that for England. This is claimed to result from the lower levels of domestic biomass resource and the high demand encouraged by the Republic of Ireland (ROI) carbon tax of 15 €/tonne CO₂. One stakeholder Action Renewables claimed that biomass wood chip was 40% more expensive in Northern Ireland compared to GB. Following these concerns AEA have evaluated the prices provided to DETI and also undertaken additional analysis by reviewing publically available chip and pellet prices from distributors in Northern Ireland and England. The findings are presented in Table 3.3 below.

Table 3.3: Biomass chip and pellet prices evaluated in January 2012

	Sector	£/t	£/GJ	p/kWh
Wood chips	Domestic 20%MC- Northern Ireland	130	8.9	3.19
	Small/medium commercial 15%MC- Northern Ireland	125	7.9	2.85
	Small/medium commercial 15%MC (England)	85	5.4	1.94
Wood pellets	Average domestic Northern Ireland	223	13.0	4.69
	Small/medium commercial 9%MC- Northern Ireland	160	9.4	3.37
	Small/medium commercial 9%MC- England	190	11.1	4.00

The p/kWh figures are shown graphically in Figure 3.1 below. As is clear from this and from the table, prices for pellets are higher than prices for wood chips, across all customer groups.

Comment [IDM19]: Remove name before publication AGREE

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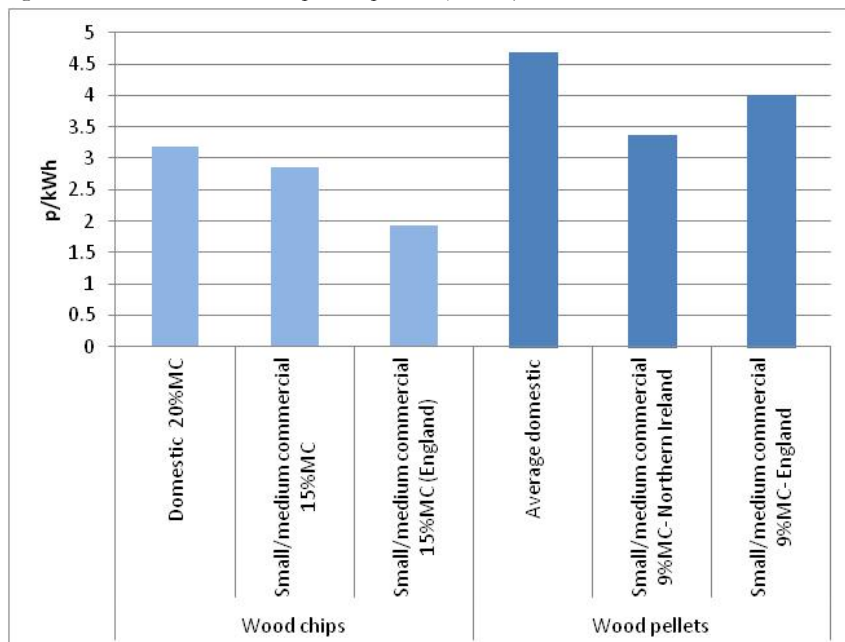
Comment [PH20]: How is this calculated?

Comment [PH21]: What about large commercial/industrial prices?

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Figure 3.1: Northern Ireland biomass prices in p/kWh (delivered)



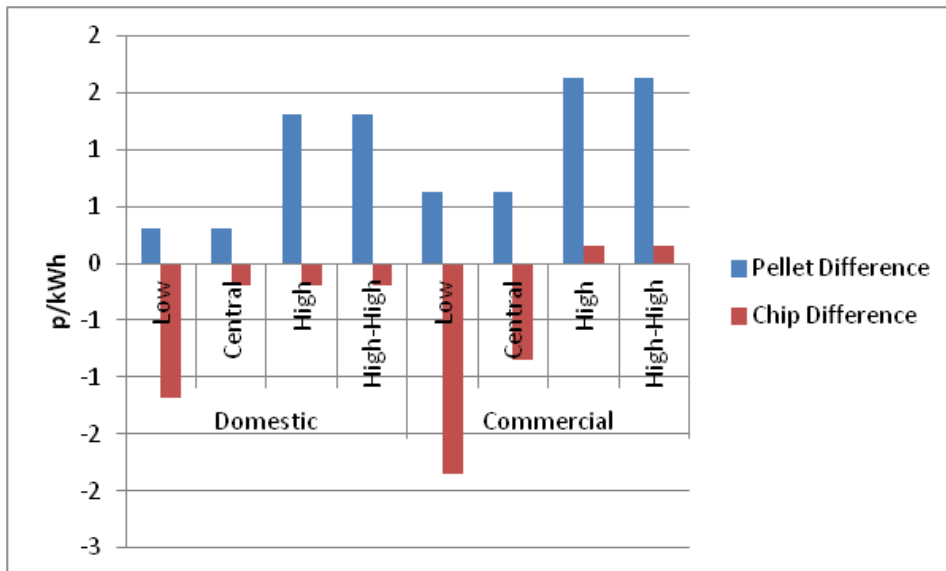
The analysis suggests that Northern Ireland prices are higher than in GB for wood chip. Wood pellet prices fluctuate dramatically depending upon location; however, it would appear that in general pellets prices may be marginally cheaper in Northern Ireland compared to England and certainly not more expensive. One of the reasons for this is the slightly more mature nature of the market in terms of suppliers and distributors in Northern Ireland such as Balcas.

Further analysis shown in [Figure 3.2](#) below of the difference between the prices compared to the prices in our original report suggests that as a general trend the pellet prices were about right or slightly generous whilst the chip prices were slightly under.

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Figure 3.2: Comparison of difference between fuel prices reviewed Jan 2012 and assumptions in previous report



The issue of fuel price inflation was also raised. This is highly uncertain due to a significant number of variables. However, respondents suggest that the inflation for biomass fuels through to 2020 was too low and that the ROI carbon tax of €15/t or potentially €30/t would significantly drive up the Northern Ireland biomass price.

On the first point, biomass inflation is unlikely to be as high as that of heating oil and therefore in the absence of better data the inflation rates remain as proposed. It is recommended that DETI reassess biomass prices at review points to determine whether the overall tariff level is still appropriate.

Second, on the ROI carbon tax, the UK also has a carbon price floor, expected to be set at £16/t from 2013¹⁹. Given this, the Northern Ireland market will not be experiencing an exceptional demand for biomass that is not occurring in GB. It should however be noted that the comparative £/MWh values used for heating oil²⁰ show no dramatic inflation on heating oil prices.

Recommendation

Our recommendation, therefore, is to use our existing central case for pellet prices (i.e. leave them unchanged), but to use our previous high case for chip prices. This gives the prices shown in [Table 3.4](#) below.

Comment [PH22]: The argument during the consultation process was given that NI would be competing with RoI and GB it would be disadvantaged and biomass would head south because of carbon tax and east because of early implementation of RHI. Is there no basis for these concerns? If not, may need more wording to explain fully.

Comment [PH23]: What are the high scenarios prices per kwh by sector/technology (to 4 decimal places)?

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¹⁹ Source: HM Treasury, 2011, *Carbon price floor consultation: the Government response*
http://www.hm-treasury.gov.uk/d/carbon_price_floor_consultation_govt_response.pdf

²⁰ See table C.3 in our previous report.

Table 3.4: Pellet and woodchips prices to 2040

Segment/ Scenario	2010	2015	2020	2025	2030	2035	2040
<i>Pellets</i>							
Domestic	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Commercial	0.04	0.04	0.05	0.05	0.05	0.05	0.05
Industrial	0.04	0.04	0.05	0.05	0.05	0.05	0.05
<i>Woodchips</i>							
Domestic	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Commercial	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Industrial	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Comment [PH24]: When setting tariffs are 2011 fuel prices used or the average price of fuel (and counterfactual) for the lifetime of the technology?

In fact, it turns out that the model uses a pellet boiler as the reference installation for all technology sizes (except large industrial). This means that it uses the (higher) pellet prices to determine tariffs, rather than the (lower) woodchip prices. This is likely to produce a higher tariff than using a woodchip boiler as a reference installation. However, since the pellet prices used for our current tariffs are the same as those for the previous tariffs, there is no change to tariffs as a result of fuel prices.

3.2.2. Biomethane

Following our review, we have updated our estimate of the annual operating cost to £350 per kW. It was previously £600 per kW. We have also changed our estimate of the efficiency to 85%. These changes were made following a review of additional evidence made available from SKM/Enviros²¹ in their report to DECC published May 2011. Finally, we have revisited our assumption on fuel input, and have assumed a 50:50 split between waste and fuel crops.

Recommendation

We recommend making the three changes to assumptions noted above, but keeping other figures the same as before.

3.2.3. Bioliquids

For this technology, AEA has re-considered both fuel prices and capital costs (capex).

The fuel price of 60 pence per litre (ppl) used in the original modelling aligns with updated figures provided during the consultation. This information indicated that through May 2010-May 2011 prices ranged between 45ppl and 65ppl.

On capital costs, the original assumption was a boiler cost of £220/kW for a 20kW domestic boiler running on B30 biofuel blend. This equates to a total capital cost of £4,392 installed. The

²¹ <http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/2711-SKM-enviros-report-rhi.pdf>

correspondence provided during the consultation does not suggest that any modifications to the current modelling values should be made.

Recommendation

Our recommendation, therefore, is to retain both the existing fuel prices and the existing capital cost figures.

3.2.4. Geothermal

DETI have been provided with cost and performance information by respondents to the consultation. This is generally the same information that has been provided to DECC and reviewed as part of the GB RHI.

The most comprehensive information relates to a deep geothermal scheme recently completed in Pullach-Im-Isartel, south of Munich, Germany. Cost and performance information provided by respondents to DETI and DECC has been consolidated into Table 3.5 below:

Table 3.5: Deep geothermal cost and performance information

CAPEX £/kW	OPEX £/kW	Size (kW)	Efficiency ²²	Lifetime	Load factor	CAPEX	Heat output MWh
3,415	39	5,000	1,500%	30	55%	10,000,000	24,090

Comment [PH25]: Is this figure correct?
3415 (capex) x 5000 (size) = 17,075,000

As highlighted to DETI by the consultation responses, other policy issues exist which would need to be overcome such as primary legislation defining the ownership of geothermal resources in Northern Ireland. Given the policy issues highlighted and the fact that deep geothermal is not an 'established' UK heating technology there is a risk that no project would be completed by 2020.

Other barriers to geothermal include the potential uses for the heat generated. For example, because of the relatively low temperatures in the ground underneath NI, the heat from geothermal is not suitable for high-temperature industrial uses. Use for small commercial premises or households would typically require some form of district heating system, which does not yet exist to any significant extent in NI. As the technology is largely dependent upon the presence of a district heating network we have included the costs for this within the capital costs.

Comment [PH26]: Should this be qualified to say "low temperatures at 2000m (i.e. 70-90c)". Evidence presented and Departmental research suggests 120c+ at 5000m – would this not satisfy larger commercial requirements?

An additional barrier facing Deep Geothermal is that the area with the greater resource; that is, the Rathlin basin, is not well aligned with areas of high heat density. A district heating network capital cost of £1,415/kW has therefore been assumed. The counterfactual is assumed to be domestic heating boilers as without the Deep Geothermal it would be unlikely that a district heating network would be constructed.

Comment [PH27]: Is this a standard figure for district heating? Does it not depend more on distance (km) rather than heat produced (kw)?

Putting these barriers aside, we have calculated an indicative tariff of 0.6p/kWh for geothermal. This is on the same basis as for other technologies.

²² Estimated based on a co-efficient of performance (CoP) of 15.

Given the small number of potential sites, the site-specific nature of many of the costs, and the significant uncertainties regarding geothermal in NI, we recommend that DETI revisits this tariff at the first review of the scheme. We also recommend that DETI considers carefully whether an RHI tariff is the best support option for geothermal (rather than, say, a capital grant). As mentioned above, the ability to utilise Deep Geothermal effectively is quite dependent upon district heating and this in itself is not commonplace in Northern Ireland.

3.3. Changes to tariffs

In summary, we propose changes to biomass, biomethane and GSHP, but not to bioliquids. We have proposed an indicative tariff for geothermal (but see the caveats above).

The implications of these changes on our recommended tariffs are shown in [Table 3.6](#) below.

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Table 3.6: Implications of updated assumptions for tariffs (all figures in p/ kWh)

Technology size band	Size range (kW) ²³	Tariff in original report	Updated tariff ²⁴	Notes
ASHP – Small	0-45	3.3	3.4	Increase due to inflation
ASHP – Medium	45+	-		
Biogas injection – All	All	2.5	3.0	Change to assumption on gate fee
Biomass boilers – domestic	0-20	4.5	4.9	
Biomass boilers – small	20-100	4.5 (<45kW) 1.3 (45kW+)	4.7	Intermediate tariff based on 50kW boiler
Biomass boilers – medium	100-500	1.3		
Biomass boilers – large	500+	-		
GSHP – domestic	0-20	4.0	6.9	Change to the reference installation means a higher tariff, which is tiered
GSHP – small	20-100	4.0 (<45kW) 0.9 (45kW+)	3.6	Intermediate tariff based on 30kW pump
GSHP – large	100-500	0.9		
Geothermal	All	n/a	0.6	Indicative tariff only
Liquid biofuels – small	0-45	1.5		
Liquid biofuels – medium/large	45+	-		
Solar Thermal	All	8.5		

²³ The range should be read as including the lower end, but not the upper end. For example, the range 20-100 includes 20kW boilers but not 100kW boilers – the latter are covered by the 100-500 range.

²⁴ Includes inflation, and effect of changes to technology costs and tariff bands

3.4. Implications for renewable heat delivered, cost and carbon emissions

In the work for our previous report, our model suggested that an NI RHI could deliver around 11.14% of NI's heat demand from renewables, at a cost of £334m in present value terms²⁵. We have re-run our economic model to show the impact of the changes discussed earlier in this section. The results are in [Error! Reference source not found.](#) below. At DETI's request, an annual breakdown of these figures is also provided (see Annex B).

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Table 3.7: Impact of RHI²⁶ in 2020, including baseline and viable installation, before and after changes

	Renewable Heat delivered (% of total 2020 heat demand)	Lifetime cost in PV terms, compared to do nothing (£m)
Before	11.14%	334
After	10.92%	335

The impact of each change on renewable heat delivered is shown in [Table 3.8](#) below.

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Table 3.8: Breakdown of factors driving change in level of renewable heat deployed

Factor	Effect on % of renewable heat delivered in 2020		Notes
	% of total heat	GWh	
<i>Heat delivered, before changes</i>	11.14%	1860	The value from our previous report.
Removal of installations in 2011	-0.04%	-7	Removed since the RHI did not exist in 2011.
Delay bioliquids and ASHP tariffs until 2013	-0.02%	-3	At DETI's request
Changes to banding and tariffs	-0.16%	-27	As in Table 3.6 .
<i>Heat delivered, after changes</i>	10.92%	1,824	

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In summary, the model outputs resulting from the revised inputs are very small (a 2% drop in renewable heat delivered), particularly given the extent of the uncertainties in our input assumptions. Those changes that did occur are largely due to a reduction in the number of GSHPs taken up by small rural non-domestic buildings (as might be expected, since the tariff for that segment has reduced slightly).

3.5. Implications of industrial biomass for the gas network

DETI has a stated objective [set out in statute²⁷, to promote the development and maintenance of an efficient, economic and coordinated gas industry in Northern Ireland. To this end, DETI has recently consulted²⁸ on the potential extension of the existing gas network.](#) It has therefore

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Comment [IDM28]: Peter –this is the phrase we used in our previous report. Let me know if still OK.

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²⁵ Source: CEPA/ AEA, 2011, op. cit., chapter 7

²⁶ Assumes long term funding of £25 m to 2014/15 and an additional £5m/ year from 2015/16

²⁷ Article 14 (1) of the Energy (Northern Ireland) Order 2003

²⁸ <http://www.deti.gov.uk/consultation-on-the-potential-for-extending-the-natural-gas-network-in-northern-ireland>

asked us to consider the implications for gas demand of the proposed changes to the RHI – in particular, support for large biomass boilers that might be used on industrial sites.

3.5.1. Industrial sites suitable for biomass

Our previous report looked at the potential for large industrial sites to switch to biomass. We classified the 15²⁹ such sites in Northern Ireland into three categories: “not suitable”, “less likely” and “potential”. This is shown in [Table 3.9](#) below, which is a copy of Table 2.11 in our previous report.

Table 3.9: Summary of industrial renewable heat potential in Northern Ireland

Category	Sites	Heat demand in GWh per year
Not suitable ³⁰		2,654
	<i>of which</i> <i>Quinn Cement</i>	
	<i>Lafarge Cement</i>	
	<i>Quinn Glass</i>	
Less Likely (near/on gas)		537
	<i>of which</i> <i>Bombardier Aerospace</i>	
	<i>Michelin Tyre plc</i>	
	<i>Armaghdown Creameries</i>	
	<i>Pritchitts</i>	
	<i>Gallaber Ltd</i>	
	<i>Hubtamaki (Lurgan) Ltd</i>	
	<i>Glanbia Cheese Ltd</i>	
	<i>Ulster Farm Byproducts Ltd</i>	
Potential sites		527
	<i>using coal</i> <i>Invista (Coal CHP)</i>	
	<i>using oil</i> ³¹ <i>Dalefarm Ltd</i>	
	<i>TMC Dairies</i>	
	<i>Moy Park Ltd - Dungannon</i>	
TOTAL		3,718

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Comment [PH29]: Do we need to expand to say that these sites are less likely because they are either on, or may soon be on, gas and therefore enjoying lower fuel costs (compared to oil), co2 reductions, invested heavily etc???

²⁹ The previous AECOM/ Pöyry report identified 17 such sites. Since that report, one site has closed and another (Balcas) is already using biomass.

³⁰ Because of their very high temperature requirement, which cannot be met by biomass.

³¹ Note that this was incorrectly labelled “using gas” in our previous report.

The question is then which of the sites in the “potential” or “less likely” categories might switch to biomass.

The factors that drive individual sites to take up biomass (or not) can be quite specific to that site. Our uptake model is designed to look at the decision that individual homes or businesses might make in choosing between an oil or gas boiler and renewable heat. In particular, our model looks at the relative costs of the two options. In any such decision, there are many factors that come into play, which might mean that for an individual home or business, our model’s conclusion is incorrect. However, when considering a large number of homes or businesses, we would expect those factors to tend to cancel out, and in this case our model’s conclusions would be expected to be reasonably representative of what might happen in reality.

The key phrase in the preceding paragraph is “...when considering a large number of homes or businesses”. When we consider a relatively small number of sites (such as the 16 large industrial sites), it is statistically less likely that the various factors specific to individual sites will cancel out. Our model is therefore likely to be further from reality in that case.

The best approach (which is outside the scope of this study) would be a full site-by-site analysis – and even this of course could not hope to predict accurately the individual commercial decisions of the firms. In this study, we have taken the approach of looking at the range of possible outcomes, on the spectrum from no sites adopting renewable heating to all possible sites adopting it, and considered the implications of both ends of that spectrum.

At the lower end of the uptake spectrum, no site switches to biomass. This might be because of concerns regarding the supply chain or wider business drivers that mean that a switch to biomass is not seen as a sufficient priority. Clearly, in this scenario, the impact is zero.

At the upper end, in theory every site in the “potential” or “less likely” categories could switch. In practice, this is very unlikely because of constraining factors such as the biomass supply chain, that many of those installations are likely to have installed gas boilers within the last ten years, meaning that they are less likely to be considering a boiler replacement of any type and so on. We also need to account for the fact that Invista is currently on coal rather than gas. But the industrial sites could, technically, produce around 1,064GWh of heat from biomass per year.

A more likely although still extreme scenario is that all the “potential” sites switch to biomass. In this case, industry would produce 527GWh of heat from biomass per year.

Now that we know the approximate scale of the possible shift to biomass, we can consider the possible impact on the gas network.

3.5.2. Implications for the gas network

We start by assuming that those sites in the “potential” category are unlikely to have the option of connecting to gas by 2020. In this case, there would be no impact on the gas network of these sites switching to biomass (and indeed our previous results assume that Invista, in particular, will switch). There may of course be impacts longer term if the gas network is rolled out to near these sites post-2020, but this is both beyond the scope of this project and sufficiently far in the future to be highly uncertain and so not amenable to analysis.

Comment [IDM30]: Could be sensitive? Peter, should we drop this?

Any impact on the gas network would come from those sites in the “less likely” category. These generate a total of 527 GWh per year. We start by comparing this to annual gas consumption in Northern Ireland, which in 2008/09 was 16,650 GWh³². However, the vast majority of this was for power generation - 4,161 GWh was distributed to non-power consumers³³.

The *potential* impact on non-power gas demand of a switch to industrial biomass is therefore up to 12.5%. The actual impact is likely to be significantly lower, as the decision to switch to biomass would be driven by a number of factors, of which the precise costs of biomass, gas and coal would be only one. For example, there are significant costs and risks associated with moving to a new system for generating heat on a well-established industrial site, not least the temporary disruption any move would cause.

As well as the impact on the gas network, we can ask what the impact would be on subsidy costs and renewable heat delivered. This is discussed in the next section.

3.5.3. Implications for cost

We do not propose any subsidy for large industrial biomass, based on the relative costs of oil and biomass. However, the case for such subsidy might change in future if those costs change. For example, if DETI were to move to the subsidy levels seen in GB (1p/kWh³⁴), the total annual subsidy to industrial sites would be as in [Table 3.10](#) below.

Table 3.10: Potential subsidy requirements from industrial biomass use

Scenario	Annual cost (£m)
No switching	0
All “potential” sites	5.27
All “potential” and “less likely” sites	10.64

For comparison purposes, the annual subsidy under the NI RHI is capped at £12m in 2014/15. Available funding would therefore not be a barrier to all industrial sites taking up biomass, but that take-up would significantly reduce the subsidy available to smaller businesses and to domestic consumers.

On the other hand, it would significantly help to achieve the renewable heat target. If all the “potential” sites above switched to biomass, this would deliver 527GWh at a cost (assuming GB subsidy rates) of just over £5m. By comparison, our preferred subsidy rates from our previous report delivered up to 580 GWh per year of renewable heat. This reinforces the point that renewable heat on industrial sites is significantly more cost-effective than that on smaller commercial, or domestic, sites.

³² Source: CER/ NIAUR (2010): Gas capacity statement

³³ *ibid*

³⁴ This is the current figure for the GB RHI for 1MWth and over.
<http://www.ofgem.gov.uk/e-serve/RHI/Documents1/RHI%20leaflet.pdf>

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ANNEX A: TARIFF TABLES

In this section we set out the technology assumptions, and tariffs, for each technology, in a format agreed with DETI. This includes those technologies where we do not consider that subsidy is required. In those cases, we have shown why the average cost of energy from the renewable heat technology is less than that from oil.

We do not show any tables for solar thermal. This is because the tariff for solar thermal was set on the same basis as the corresponding tariff for the GB RHI, i.e. at the cost of offshore wind, rather than using the same basis as for other technologies. See our previous report for more details.

Please note that in the tariff calculation tables, the figures are all on an annual basis except the final figure which for consistency with the GB RHI and our previous report is on the basis of quarterly payments. As in our previous report, we have converted to quarterly payments by multiplying the annual figure by 0.96. We have also increased all tariffs in line with 2011 inflation of 4.8%³⁵.

Note that figures have been rounded to the nearest pound (except where otherwise noted or for small sums). Totals may therefore not add exactly.

Air Source Heat Pumps – small

The tables below set out the technology costs for small (under 45kW) air source heat pumps, and compare them to an oil counterfactual. As for most renewable technologies we consider, the capital costs are relatively high, but the operating costs are in fact lower than the oil counterfactual.

Table A.1: Air Source Heat Pumps (small) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Air Source Heat Pump	650	3.88	260%	15%	14	20	14.87	605
Oil	183	9.41	93%	10.5%	20	15	5.11	0

The tables below reinforce the importance of capital costs, with the total difference in cost between technologies almost entirely driven by the capital cost.

³⁵ Source: December 2011 RPI figure, Office of National Statistics
<http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices/december-2011/stb---consumer-price-indices---november-2011.html>

Comment [PH31]: Fuel cost at 2011 or averaged over lifetime of technology?

Comment [PH32]: How is this calculated?

Comment [PH33]: Why do we not factor in ongoing barrier costs as per DECC?

Comment [PH34]: Does this include costs of heat meter?

Comment [PH35]: What is the background info for this data? On reflection it appears high as it provides a capital cost for a 20kw boiler as £3.6k. Just a comment but I have just had a gas boiler installed for half that amount – is an oil installation really that more expensive?

Comment [PH36]: Should this fuel cost not be consistent across all small scale tariffs? It differs for GSHP and Bioliquids.

Table A.2: Air Source Heat Pumps (small) – technology resource costs in £, per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised Upfront barrier costs
Air Source Heat Pump	1,218	54	1,050	81
Oil	538	188	1,004	0
Difference	681	-134	46	81
Sum of difference	673.			

Table A.3: Air Source Heat Pumps (small) – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	4.0
Operating costs	-0.7
Fuel costs	0.1
TOTAL	3.4
Convert to quarterly basis	3.3
Adjust for inflation	3.4

Note that figures may not add exactly due to rounding.

Air Source Heat Pumps – medium

The tables below show the technology costs for medium (above 45kW) ASHPs. As for the smaller heat pumps, capital costs are higher than the counterfactual oil boiler, but in this case operating costs are also higher.

Table A.4: Air Source Heat Pumps (medium) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)

Comment [PH37]: Using the tech assumptions I get an annual output of 18,396kwh.
 $681+81/18,396 = 4.14p$
 $-134/18,396 = -0.73p$
 $46/18,396 = 0.25p$
 Tariff = $4.14-0.73+0.25=3.66$
 Quarterly basis = 3.51
 Inflation = 3.7p
 Why the 0.3p difference? Are my sums wrong?

Comment [PH38]: Maybe need a footnote to say this is done by x.096 and an explanation as to why.

Air Source Heat Pump	446	3.45	400%	36%	200	20	13.73	3,951
Oil	68	1.47	89%	20%	360	15	5.05	0

The tables below show the impact of these technology costs. The key difference from the smaller heat pumps is the very substantial savings in annual fuel costs compared to an oil boiler. This saving is enough to outweigh the additional capital costs, and means that the technology is economic. This is driven by the higher efficiency of the larger ASHP (400%, compared with 260% for the sub-45kW boiler).

Table A.5: Air Source Heat Pumps (medium) – technology resource costs in £, per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised Upfront barrier costs
Air Source Heat Pump	11,942	690	21,653	529
Oil	3,594	529	35,827	0
Difference	8,348	161	-14,174	529
Sum of difference	-5,136			

Table A.6: Air Source Heat Pumps (medium) – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	No subsidy required
Operating costs	
Fuel costs	
TOTAL	
Convert to quarterly basis	

Ground Source Heat Pumps – domestic

The table below shows the technology cost assumptions for domestic GSHPs. The pattern is similar to that for small ASHPs – a relatively high capital cost but low operating costs.

Table A.7: Ground Source Heat Pumps (domestic) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Ground Source Heat Pump	940 ³⁶	4.94	325%	19%	11	20	16.7	605
Oil	183	9.41	93%	10.5%	20	15	5.4	0

This gives the relative resource costs in the table below. Again, capital cost dominates.

Table A.8: Ground Source Heat Pumps (domestic) – technology resource costs in £ per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised Upfront barrier costs
Ground Source Heat Pump	1,384.	54	941	81
Oil	538	188	1,062	0
Difference	847	-134	-121	81
Sum of difference	673			

Table A.9: Ground Source Heat Pumps (domestic) – tariff breakdown, in pence per kWh

Subsidy for	Amount
-------------	--------

³⁶ This is the figure for a rural installation, since our reference installation is in a rural area. The corresponding figure for an urban installation is £1,480.

Annualised capital and barrier costs	
Operating costs	-0.7
Fuel costs	-1.2
TOTAL	6.9
Convert to quarterly basis	6.6
Adjust for inflation	6.9

Comment [PH39]: Unsure how so high?
My calculations for GSHP ref technology show 18,308 kwh (11kw x 8760hrs) x load factor of 19%.
Annuitised capital and barrier costs are 928, 928/18308 = 5.07p
Spreadsheet attached to show further.

Note that figures may not add exactly due to rounding.

Ground Source Heat Pumps – small commercial

The picture for small commercial GSHPs is similar to that for the medium size ASHPs, as the table below shows. Capital and operating costs are higher, but fuel costs are lower because of the very high efficiency (360%).

Table A.10: Ground Source Heat Pumps (small commercial) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Ground Source Heat Pump	1,228	7.00	360%	29%	30	20	13.73	3,951
Oil	97	3.45	93%	17%	50	15	5.05	0

However, as the tables below show, this lower fuel cost is not enough to outweigh the high capital and operating costs, and so small commercial GSHPs require subsidy to be economic.

Table A.11: Ground Source Heat Pumps (small commercial) – technology resource costs in £, per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Upfront barrier costs

Ground Source Heat Pump	4,932	210	2,857	529
Oil	712	173	4,055	-
Difference	4,220	38	-1,198	529
Sum of difference	3,588			

Table A.12: Ground Source Heat Pumps (small commercial) – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	4.9
Operating costs	0.0
Fuel costs	-1.3
TOTAL	3.6
Convert to quarterly basis	3.5
Adjust for inflation	3.6

Note that figures may not add exactly due to rounding.

Ground Source Heat Pumps – larger commercial

The very largest ground source heat pumps do well on operating costs, and on fuel costs, but the capital cost is still very high compared to conventional oil boilers, as the table below shows.

Table A.13: Ground Source Heat Pumps (larger commercial) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Ground Source Heat Pump	900.	1.05	360%	36%	200	20	13.73	3,951
Oil	68	1.47	89%	20%	360	15	5.05	0

Comment [PH40]: Similar issue as above – attached spreadsheet refers. The ref installation, by my sums, has an annual output of 76212kwh. $(4220+529)/76212=6.23p$
Overall tariff closer to 4.8p?

Comment [PH41]: Same upfront barrier cost to a 30kw installation. Is this appropriate?

The implications of the table above is that the lower fuel costs of a larger GSHP almost outweigh the higher capital costs, leading to a low level of subsidy requirement, as the tables below show.

Table A.14: Ground Source Heat Pumps (larger commercial) – technology resource costs in £, per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised Upfront barrier costs
Ground Source Heat Pump	24,098	209	24,059.	529
Oil	3,594	529	35,827	-
Difference	20,504	-320	-11,768	529
Sum of difference	8,945			

Table A.15: Ground Source Heat Pumps (larger commercial) – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	2.5
Operating costs	-0.1
Fuel costs	-1.6
TOTAL	0.9
Convert to quarterly basis	0.9
Adjust for inflation	0.9

Note that figures may not add exactly due to rounding.

Comment [PH42]: As above, my calculations show a tariff breakdown as follows, working on the basis of 630720kwhrs;

- Capital / barrier costs = 3.33p
- Operating = -0.05p
- Fuel = -1.86p
- Total = 1.4p

Geothermal

The relative costs and characteristics of an indicative geothermal plant are shown below, compared to a notionally equivalent oil boiler (in fact, the combination of over a thousand typical domestic boilers).

Table A.16: Geothermal – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Geothermal	3,415	39	1,500%	55%	5,000	30	13.8	0
Oil	183	9.41	93%	10.5%	26,251 ³⁷	15	5.1	0

Comment [PH43]: Should this be blank?

Comment [PH44]: Re footnote – how many?

The most important factor to note in the table above is the extremely high efficiency (1,500%). This means that the annual electricity (fuel) cost for geothermal is very low, and the benefit of this low cost very nearly outweighs the high initial capital cost. This is illustrated in the next two tables.

Table A.17: Geothermal – technology resource costs in £, per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised Upfront barrier costs
Geothermal	2,119,753	195,000	221,634	98,591
Oil	705,490	247,114	1,317,802	-
Difference	1,414,263	-52,114	-1,096,167	98,591
Sum of difference	364,572			

Table A.18: Geothermal – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	6.4
Operating costs	-1.0
Fuel costs	-4.8

Comment [PH45]: Again re calculations as per spreadsheet.
 $(5000\text{kw} \times 8760\text{hrs}) \times \text{load factor of } 55\% = 24,090,000\text{kwhrs}$.
 $(1414262 + 98591) / 24,090,000 = 6.28\text{p}$
 $-52,114 / 24,090,000 = -0.21\text{p}$
 $-1,096,167 / 24,090,000 = -4.55\text{p}$
 Overall = $6.28 - 0.21 - 4.55 = 1.5\text{p}$

³⁷ This represents a large number of small domestic boilers (around 20kW each).

TOTAL	0.6
Convert to quarterly basis	0.5
Adjust for inflation	

Comment [PH46]: You will also see in attached spreadsheet that I have factored in a small commercial, large commercial and industrial counterfactual that produce tariffs of 2.8p, 4.6p and 5.3p.

Could it not be assumed that commercial heat could be displaced if the geothermal borehole was beyond 3km?

Bioliquids – small

The costs and characteristics for bioliquids, compared to an oil boiler, are shown below. Many of the figures are the same or very similar, reflecting the similar technology.

Table A.19: Bioliquids (small) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Liquid biofuels – small	220	9.41	93%	10.5%	20	15	5.14	908
Oil	183	9.41	93%	10.5%	20	15	5.11	0

The tables below illustrate the basic cost differences between the two boilers – a higher capital and upfront barrier cost and a slightly higher on-going fuel cost. These translate into a small subsidy requirement of 1.5p/kWh.

Table A.20: Bioliquids (small) – technology resource costs in £, per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised Upfront barrier costs
Liquid biofuels	645.	188	1,011	133
Oil	538	188	1,004	0
Difference	108	-	7	133
Sum of difference	247			

Table A.21: Bioliquids (small) – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	1.2
Operating costs	0
Fuel costs	0.3
TOTAL	1.5
Convert to quarterly basis	1.5
Adjust for inflation	1.5

Note that figures may not add exactly due to rounding.

Comment [PH47]: As before – see spreadsheet.

Biomass – domestic

The table below shows the relative costs of domestic biomass and oil boilers. Costs are higher across the board for biomass.

Table A.22: Biomass (domestic) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Biomass	633	19	85%	17.5%	12	20	5.61	908
Oil	183	9.41	93%	10.5%	20	15	5.11	0

The higher costs for capex, opex and fuel in the table above translate into a requirement for subsidy for all three, as shown in the two tables below.

Table A.23: Biomass (domestic) – technology resource costs in £ per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised Upfront barrier costs
Biomass	1,016	230	1,211	122

Oil	538	188	1,004	0
Difference	479	42	196	122
Sum of difference	838.55			

Table A.24: Biomass (domestic) – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	3.4
Operating costs	0.2
Fuel costs	1.2
TOTAL	4.8
Convert to quarterly basis	4.6
Adjust for inflation	4.9

Biomass – small commercial

The picture for small commercial biomass is slightly different to that for domestic, in that the fuel is marginally cheaper than oil, as shown in the table of costs below.

Table A.25: Biomass (small commercial) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Biomass	608	4.60	85%	17%	50	20	4.61	3,951
Oil	97	3.45	93%	17%	50	15	5.15	0

The slightly lower fuel cost is though outweighed by the significantly higher capital cost in particular, translating into a tariff almost identical to that for domestic biomass. This is shown in more detail in the two tables below.

Table A.26: Biomass (small commercial) – technology resource costs in £, per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised Upfront barrier costs
Biomass	4,073	230	4,059	529
Oil	712	173	4,129	-
Difference	3,360	58	-70	529
Sum of difference	3,877			

Table A.27: Biomass (small commercial) – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	4.9
Operating costs	0.1
Fuel costs	-0.3
TOTAL	4.7
Convert to quarterly basis	4.4
Adjust for inflation	4.7

Biomass – larger commercial

The picture for larger commercial biomass boilers is similar to that for smaller boilers, although the capital cost gap has narrowed somewhat. In addition, the higher load factor for a biomass boiler means that it can be of a smaller size, reducing the capital cost gap further.

Table A.28: Biomass (larger commercial) – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Biomass	486. ³⁸	4.60	81%	36%	200	20	4.5	5,364
Oil	68	1.47	89%	20%	360	15	5.01	0

The impact of these cost differences is illustrated in the tables below. As for most renewable technologies, most of the requirement for subsidy comes from the capital cost difference. Operating and fuel costs are similar for the technologies.

Table A.29: Biomass (larger commercial) – technology resource costs in £, per year

	Annuitised Capital cost at 12%	Annual operating costs	Annual fuel costs	Upfront barrier costs
Biomass	13,031.	920	35,016	718
Oil	3,594	529	35,501	-
Difference	9,437	391	-486	718
Sum of difference	10,061			

Table A.30: Biomass (larger commercial) – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	1.4
Operating costs	0.1
Fuel costs	0.2
TOTAL	1.3

³⁸ This is the figure for our reference installation, which is in a rural building. The corresponding figure for an urban installation is £508.80.

Convert to quarterly basis	1.3
Adjust for inflation	1.3

Large Biomass???

Is this not appropriate???

	<u>Capex</u> (£/kW)	<u>Opex</u> (£/kW/year)	<u>Efficiency</u> (%)	<u>Load Factor</u> (%)	<u>Size</u> (kW)	<u>Lifetime</u> (years)	<u>Fuel cost</u> (p/kWh)	<u>Upfront barrier costs</u> (£)
<u>Biomass</u>	<u>311</u>	<u>14.40</u>	<u>81%</u>	<u>82%</u>	<u>16,086</u>	<u>20</u>	<u>4.5</u>	<u>250,000</u> (roughly 5%)
<u>Oil</u>	<u>31.4</u>	<u>0.2</u>	<u>89%</u>	<u>82%</u>	<u>16,089</u>	<u>20</u>	<u>5.01</u>	<u>0</u>

Comment [PH48]: My own calculations for a 500+ tariff based on previous assumptions for comment.

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	<u>Annuitised Capital cost</u> <u>at 12%</u>	<u>Annual operating costs</u>	<u>Annual fuel costs</u>	<u>Annuitised Upfront barrier costs</u>
<u>Biomass</u>	<u>712,833</u>	<u>231,638</u>	<u>6,419,386</u>	<u>33,470</u>
<u>Oil</u>	<u>67,622</u>	<u>3,217</u>	<u>6,491,514</u>	<u>=</u>
<u>Difference</u>	<u>645,211</u>	<u>228,421</u>	<u>-72,128</u>	<u>33,470</u>
<u>Sum of difference</u>	<u>834,974</u>			

Given an annual output of 115,548,955KWhrs (i.e. [size]x [8760 hours per year] x [load factor] from table above) the resulting subsidy is 0.7/KWh (i.e. £834,974/115MWh).

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<u>Subsidy for</u>	<u>Amount</u>
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Annualised capital and barrier costs	0.59
Operating costs	0.20
Fuel costs	-0.06
TOTAL	0.7
Convert to quarterly basis	0.7
Adjust for inflation	0.7

Biogas (biomethane)

The table below shows the technology costs for the production of biomethane for injection into the gas grid. One point to note is that fuel costs are shown as negative. This is because some of the fuel for biomethane production is waste, which has a negative cost (a “gate fee”).

Also, the counterfactual for biogas is conventional wholesale gas. The viability of biomethane is therefore assessed based on its cost per kWh against the 2.9p per kWh we assume for wholesale gas prices.

Table A.31: Biomethane – technology parameters

	Capex (£/kW)	Opex (£/kW/year)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)
Biomethane	4,600	350	85%	93%	1,000	20	-4.1	0
Wholesale gas	-	-	-	-	-	-	2.9	

Comment [PH49]: The opex for this tariff for the GB RHI is £600 – why is the opex so much lower for NI?

The tariff cost for biomethane is shown in the table below. Note that the fuel cost figure is higher than might be expected from the figures in the previous table (a fuel cost difference of 4.1+2.9=7.0p/kWh). This is because the subsidy figure is per unit of heat produced, while the fuel cost is per unit of heat in the fuel. There are losses in converting from the fuel to heat (as shown by the efficiency factor) which means that the subsidy figure per unit of heat produced is higher than the difference in the cost of the input fuel.

Table A.32: Biomethane – tariff breakdown, in pence per kWh

Subsidy for	Amount
Annualised capital and barrier costs	6.7
Operating costs	4.3
Fuel costs	-8.1
TOTAL	3.0
Convert to quarterly basis	2.9
Adjust for inflation	3.0

Comment [PH50]: Need a breakdown for Solar Thermal.

ANNEX B: HIGH LEVEL IMPACT OF POLICY

The tables in this annex show the high level impact, by year, of the RHI on key measures such as renewable heat delivered, carbon emissions reduced and subsidy paid. The tables assume a rising level of funding to 2020 (“Funding 2”, from our previous report).

We start by showing how the table would have looked based on the tariff levels in our previous report.

Table B.1: Overall impact of previously proposed RHI rates

Year	Total CO ₂ emissions displaced (millions of tonnes)	Additional renewable heat resource (GWh)	Number of installations	Subsidies paid (£m, 2010 prices) ³⁹
2012	0.01	31	721	0.98
2013	0.02	84	2,230	2.43
2014	0.03	156	4,190	4.36
2015	0.05	242	6,814	6.89
2016	0.07	334	9,557	9.53
2017	0.09	438	12,946	12.75
2018	0.12	558	17,173	16.73
2019	0.16	701	22,496	21.68
2020	0.20	871	29,248	27.94
2021	0.20	871	29,248	27.94
2022	0.20	871	29,248	27.94
2023	0.20	871	29,248	27.94
2024	0.20	871	29,248	27.94

³⁹ Note that, as we stated in our previous report: “...deployment constraints, and the fact that the rates used in the RHI options set out above may not be sufficient to incentivise all the potential for each technology, mean that not all available funding will be taken up. In practice of course, the ability to deploy renewable heat could increase, given a long-term, credible, funding stream, and so our results need to be considered with this in mind” (CEPA/ AEA, 2011, section 7.6.1)

Year	Total CO ₂ emissions displaced (millions of tonnes)	Additional renewable heat resource (GWh)	Number of installations	Subsidies paid (£m, 2010 prices) ³⁹
2025	0.20	871	29,248	27.94
2026	0.20	871	29,248	27.94
2027	0.20	871	29,248	27.94
2028	0.21	871	29,248	27.80
2029	0.21	871	29,248	27.66
2030	0.21	871	29,248	27.53
2031	0.22	871	29,248	27.39
2032	0.22	840	28,527	26.28
2033	0.22	787	27,018	24.83
2034	0.23	716	25,057	22.90
2035	0.23	629	22,434	20.37
2036	0.24	537	19,690	17.86
2037	0.24	433	16,302	14.78
2038	0.24	313	12,074	10.94
2039	0.25	171	6,752	6.12
2040	0.25	0	0	0

Table B.2 below shows the impact of the changes described in this report.

Table B.2: Overall impact of RHI given changes

Year	Total CO ₂ emissions displaced (millions of tonnes)	Additional renewable heat resource (GWh)	Number of installations	Subsidies paid (£m, 2010 prices)
2012	0.01	31	721	0.89
2013	0.02	74	1,741	2.16
2014	0.05	155	4,190	4.22
2015	0.08	242	6,814	6.97
2016	0.11	334	9,557	9.70
2017	0.14	436	12,905	13.01
2018	0.18	551	17,057	17.03
2019	0.22	682	22,263	21.98
2020	0.26	842	29,015	28.39
2021	0.26	842	29,015	28.39
2022	0.26	842	29,015	28.39
2023	0.26	842	29,015	28.39
2024	0.26	842	29,015	28.39
2025	0.26	842	29,015	28.39
2026	0.27	842	29,015	28.39
2027	0.27	842	29,015	28.39

Year	Total CO ₂ emissions displaced (millions of tonnes)	Additional renewable heat resource (GWh)	Number of installations	Subsidies paid (£m, 2010 prices)
2028	0.27	842	29,015	28.39
2029	0.27	842	29,015	28.13
2030	0.28	842	29,015	28.00
2031	0.28	842	29,015	27.87
2032	0.28	811	28,294	26.84
2033	0.28	768	27,274	25.45
2034	0.29	687	24,824	23.52
2035	0.29	600	22,201	20.77
2036	0.29	508	19,457	18.17
2037	0.29	406	16,110	14.99
2038	0.30	291	11,957	11.10
2039	0.30	160	6,752	6.28
2040	0.30	-	-	-

Apart from differences in 2013 (due to a delay in ASHPs and bioliquids) the major differences are in carbon saved (more with the updated tariffs, which will be due to increased displacement of oil boilers). Other changes are less than 5%.