Review of the biomass tariff structure for the Northern Ireland RHI Scheme

Final Report

Report for the Department for the Economy

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1 Introduction and Background

1.1 This report

Ricardo Energy & Environment (Ricardo) was contracted by the Department for the Economy (the Department or DfE) to undertake a review of the tariff structures for small and medium sized solid biomass boilers and combined heat and power (CHP) plants under the Northern Ireland Non-Domestic Renewable Heat Incentive Scheme (the Scheme or NI RHI). This report describes the review, its outcomes and recommendations to the Department.

Sections 2 and 3 of this report describe our review of the current NI RHI solid biomass tariff and the derivation of an alternative set of tariffs based on updated assumptions. These tariffs, and variations of them, have been tested on the existing whole population of NI RHI small and medium sized solid biomass installations in order to assess the impacts on projected financial returns to participants and the overall Scheme cost to government.

Section 4 of the report provides a summary of the review of the CHP tariff in the context of two prospective installations, the developers of which applied for RHI preliminary accreditation prior to the Scheme's closure in February 2016. Details of the review have been reported to the Department as a confidential addendum to this main project report, the reason being that it contains detailed technical and financial information concerning these CHP plants that is commercially sensitive.

1.2 The Northern Ireland Non-Domestic RHI

The Non-Domestic Renewable Heat Incentive Scheme was introduced in Northern Ireland in November 2012 through the Renewable Heat Incentive Scheme Regulations (Northern Ireland) 2012, following the introduction of a parallel scheme in the rest of the UK. The NI RHI is a financial incentive scheme designed to increase the uptake of renewable heat technologies in non-domestic applications; a similar Renewable Heat Incentive Scheme for domestic properties was introduced in Northern Ireland in December 2014.

The owners of NI RHI accredited installations receive a payment for every kilowatt-hour of eligible heat energy produced by various specified eligible technologies for a period of twenty years from the date of accreditation. The payments are determined by tariffs set out in the NI RHI Regulations, which are subject to RPI[1] adjustment at the 1st April each year.

The original 2012 Regulations have been amended four times, with amendments to the tariffs in 2015 and 2017 and the introduction of a suspension to new applicants on 29 February 2016.

The 2015 amendment regulations introduced a tiered tariff structure for biomass installations for new entrants from 18 November 2015 to manage the costs of the Scheme to government. The 2016 suspension and 2017 tariff amendment were subsequently introduced because it had become apparent that there would still be insufficient funds available for meeting the total costs of periodic payments for all eligible installations accredited and those likely to be accredited under the 2012 Regulations. The 2017 regulations extended the tiered tariff structure to all small and medium sized biomass installations going forward irrespective of their accreditation date.

The 2015 amendment regulations also introduced a specific biomass CHP tariff from 18 November 2015; prior to which CHP was included under the general tariffs for solid biomass installations. Further detail on this is provided in section 4 of this report.

1.3 Objectives of this study

As defined in the Department's specification for the work, the key objectives of this study include the following:

(a) A Comprehensive Review of each of the elements of the 2017-18 tariff structure for medium biomass boilers, as set out below, as the basis for a set of recommendations on the most appropriate structure for the remainder of the lifetime of the scheme:

[1] The 12-month increase in the general index of retail prices for all items to the previous December, as published by ONS.

(i) Medium Biomass Tier 1 Tariff (6.7p per kWh)
   a. Cost of Boiler - including potential use of data from applications to the RHI Scheme;
   b. Upfront barrier costs; and
   c. Rate of Return - including appropriateness of the 12% rate.

(ii) Medium Biomass Tier 1 Usage limit (15% load factor)[2] - including potential increase to 35%, in order to match the rest of the UK.

(iii) Medium Biomass Tier 2 Tariff (1.5p per kWh)
   a. Operating costs;
   b. Fuel costs; and
   c. Ongoing barrier costs.

(iv) Medium Biomass Upper Usage Cap (400,000kWh) - including whether it should vary by sector.

(b) A Comprehensive Review of each of the elements of the tariff for CHP plants, as set out below, as the basis for a set of recommendations on the most appropriate structure for the remainder of the lifetime of the scheme:

(i) CHP Tariff (3.5p per kWh)
   a. Capital costs;
   b. Size;
   c. Efficiency;
   d. Investment timescales;
   e. Operating costs;
   f. Fuel costs;
   g. Income from electricity (incorporating impact of Climate Change Levy, Renewable Obligation Certificates etc.);
   h. Duration of tariff; and
   i. Rate of return - including appropriateness of the 12% rate.

(c) A Comprehensive Review of other factors impacting on both medium biomass and CHP plant tariffs as the basis for a set of recommendations on the most appropriate structure for the remainder of the lifetime of the scheme:

(i) Inflationary uplift (RPI)
   a. Consideration of whether this should apply to all elements of tariff or just operating costs;
   b. RPI versus CPI; and
   c. Inflationary uplift versus annual review of market conditions; and
   d. Alternative approaches to remain within uncertain budget for the scheme.

(ii) Other factors
   a. Reference fossil fuel - should this remain oil or also include LPG;
   b. Efficiency - including impact of high load factors over time;
   c. Risks - including the potential for behavioral change by participants in response to any change in the tariff structure. Attrition rate - due to installation owners leaving and being removed from scheme, informed by separate work on inspections[3];
   d. Load factor; and
   e. Lifespan - including impact of high load factor.

[2] Tier 1 threshold set at 1,314 hours which is equivalent to 15% of the total amount of hours in a year.

[3] A number of Non-Domestic RHI installations to be inspected by the end of 2017 to support enforcement action against those not operating in line with regulations.

2 Biomass Tariff Review

2.1 Methodology summary

Our review of the solid biomass tariff has been undertaken in the following stages:

A. Review of the methodology and assumptions for the derivation of the original biomass tariffs and how they have developed to date.

B. Review and analysis of the small and medium biomass installation level data held by the Department, which includes capital costs and installation capacity, as provided by participants in their original applications, and eligible heat generated and associated incentive payments made.

C. Preparation of a revised set of assumptions based on data available, including: the installation level data described in B.; from recent NI RHI site inspections commissioned by the Department; and other sources.

D. Derivation of "base-case" tariffs from these assumptions that would be appropriate for current conditions if the RHI Scheme were starting today.

E. Tests to determine the sensitivity of the derived tariffs to varying key assumptions.

F. Application of the derived tariffs to the actual population of Northern Ireland biomass installations to determine the impact on the internal rate of return (IRR) for each installation and the total cost to government.

G. Tests of the sensitivity of the results to certain assumptions and options for implementing new tariffs.

These stages are described in the following sections.

Unless otherwise stated, all monetary values in this report are expressed in 2016 prices; i.e. in 2016 real terms.

2.2 Origins of the current solid biomass tariffs

The biomass tariffs that have applied over the course of the Northern Ireland RHI Scheme are shown in Figure 2.1 by capacity[4] band. The values are in nominal terms and are adjusted each year by the 12-month RPI change to the previous December and then rounded to the nearest tenth of a penny.

2.2.1 Tier 1

The 2017/18 Medium Biomass Tier 1 tariff (for installations in the range 20 kW_{th} up to but not including 200 kW_{th}) is 6.7 p/kWh. This is the RPI adjusted equivalent of the 6.5 p/kWh as set out in Table 1 of Schedule 3A of the 2017 Regulations. That in turn is equivalent to the original 5.9 p/kWh medium biomass tariff in Schedule 3 of the 2012 Regulations adjusted for RPI.

The original 5.9 p/kWh originates from the modelling work undertaken for the Department of Enterprise, Trade and Investment (DETI) (now DfE) by Cambridge Economic Policy Associates Ltd (CEPA), with technical support from AEA Technology Ltd. The outputs of that work comprised two reports:

- *Renewable Heat Incentive for Northern Ireland, Final Report*; 28 June 2011 (CEPA 2011); and
- *Renewable Heat Incentive for Northern Ireland, Addendum*; 16 February 2012 (CEPA 2012).

The Addendum report was produced to take account of responses to DETI's July 2011 consultation on the NI RHI[5]. That report proposed revised bandings for biomass with revised tariffs, the latter being due to the use of different reference installations in accordance with the revised size bands together with updated assumptions for capital costs. CEPA also included on-going barrier costs, which were stated to follow the approach and costs used for the GB RHI; upfront barrier costs had already been included in the analysis for the June 2011 report.

[4] Capacity refers to the manufacturer's stated full load thermal (heat) output of the plant in kW.

[5] *Consultation: The Development of the Northern Ireland Renewable Heat Incentive*; July 2011, DETI.

Figure 2.1: Northern Ireland non-domestic RHI biomass tariff history, p/kWh by capacity band

Year	2012	2013	2014	2015	2016
Annual inflation, Dec to Dec (RPI all items)	*1.0309*	*1.0267*	*1.0162*	*1.0120*	*1.0249*

		1 Nov 12 to 31 Mar 13		1 Apr 13 to 31 Mar 14		1 Apr 14 to 31 Mar 15		1 Apr 15 to 31 Mar 16		1 Apr 16 to 31 Mar 17	
	Band, kWth	*Tier 1*	*Tier 2*	*Tier 1*	*Tier 2*	*Tier 1*	*Tier 2*	*Tier 1*	*Tier 2*	*Tier 1*	*Tier 2*
Installations accredited on or before 18/11/2015	< 20	6.2	n/a	6.4	n/a	6.6	n/a	6.7	n/a	6.8	n/a
	20 to < 100	5.9	n/a	6.1	n/a	6.3	n/a	6.4	n/a	6.5	n/a
	100 to < 1,000	1.5	n/a	1.5	n/a	1.5	n/a	1.5	n/a	1.5	n/a

		19 Nov 15 to 31 Mar 16		1 Apr 16 to 31 Mar 17	
	Band, kWth	*Tier 1*	*Tier 2*	*Tier 1*	*Tier 2*
Installations accredited after 18/11/2015	< 20	6.7	1.5	6.8	1.5
	20 to < 200	6.4	1.5	6.5	1.5
	200 to < 1,000	1.5	1.5	1.5	1.5

		1 Apr 17 to 31 Mar 18	
	Band, kWth	*Tier 1*	*Tier 2*
All installations	< 20	7.0	1.5
	20 to < 200	6.7	1.5
	200 to < 1,000	1.5	1.5

Tables A.25, A.26 and A.27 of the Addendum report set out the key assumptions and the derivation of the 5.9 p/kWh tariff for the 20 to <100 kW capacity band[6]. However, it has become apparent that there are several errors in those tables, such that the resulting tariff of 5.9 p/kWh cannot be derived as is indicated. CEPA's spreadsheet, which has been made available to us by the Department, differs from the report tables and is internally consistent. The derivation of the 20 to <100 kW tariff, in line with the CEPA spreadsheet, is presented as Figure 2.2 below in a similar format to the Addendum report tables.

Figure 2.2: Original CEPA tariff derivation for biomass boilers in the range 20 to <100 kW

(Monetary values are in 2010 real terms, unless otherwise stated.)

Technology parameters

	Capex (£/kW)	Opex (£/kW pa)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)	Ongoing barrier costs (£ pa)
Biomass	608	4.60	85%	17%	50	20	4.56 [a]	5,364	818
Oil	97	3.45	93%	17%	50	15	5.10 [a]	0	0

a In their analysis, CEPA took account of assumed fuel cost inflation; the figures shown are the effective single values (in 2010 prices).

Annualised technology resource costs in £ per year

	Annuitised capital cost at 12%	Annual operating costs	Annual fuel costs	Annuitised upfront barrier costs	Ongoing barrier costs
Biomass	3,636 [b]	230	4,015	641 [c]	818
Oil	634 [b]	173	4,090	-	-
Difference	3,002	58	-75	641	818
Sum of differences	4,444				

b The capital costs were annuitised by increasing the standard annuity factor calculated for 12% discount rate over 20 years by an additional 12%, implying the assumption that the initial capital investment is made in Year 1 of the 20 years following accreditation to the NI RHI, rather than the previous year (Year 0).

c The upfront barrier costs were also annuitised in the same way, unlike in the derivation of GB RHI tariffs where no return on these costs was assumed and the annualisation was achieved by dividing by 20.

Biomass (small commercial) – tariff breakdown, in pence per kWh

Subsidy for:	Amount	Ricardo Comments
Annualised capital costs	4.008	See b above
Annualised barrier costs	0.856	See c above
Operating costs	0.077	
Ongoing barrier costs	1.092	
Fuel costs	-0.100	See a above
TOTAL	5.933	In 2010 prices
Converted to quarterly basis	5.683	Multiplier of 0.958 for quarterly payments
Adjusted for inflation and rounded	5.9	Exact inflator used by CEPA unclear

The basic technical assumptions in CEPA's modelling are clear. The area of greatest uncertainty has been that of barrier costs, both upfront and ongoing – specifically what they include and how the costs were derived. This is considered within section 2.4, *Review of Assumptions*.

[6] Note that the CEPA tables refer to 'small commercial', whereas this is '*Medium Biomass*' in the Regulations

2.2.2 Tier 2

We understand that the 1.5 p/kWh Tier 2 tariff that was first introduced for installations accredited after 18 November 2015 was set on the basis of operating costs described by a CAFRE paper[7] on heat requirements in poultry rearing, and the prevailing GB RHI tariff at the time the policy was being developed in spring 2015. Between 1 April and 30 June 2015, the GB Tier 2 tariff for installations less than 200 kW was 1.56 p/kWh[8]. From 1 October 2015 this fell to 1.11 p/kWh, but was not reflected in the NI Tier 2. Given that counterfactual fuels in Northern Ireland (mainly kerosene and LPG) are costlier than the standard GB natural gas counterfactual could imply that the 1.5 p/kWh in Northern Ireland was over-generous.

2.2.3 The 400,000 kWh annual cap

With the November 2015 introduction of Tier 2, an annual cap of 400,000 kWh was also set, meaning that any eligible heat generated by an installation above this figure during the installation's RHI year receives no incentive payment. We understand that the cap was set by consideration of typical installations of 99 kW_{th} with high load factors; the cap is equivalent to a 46% load factor for a boiler of this capacity. Furthermore, this is at the upper end of a range implied by the CAFRE paper.

2.2.4 State Aid approval

State Aid approval for the Northern Ireland RHI Scheme was granted by the European Commission on 12 June 2012[9]. Paragraph 63 of the approval states:

> *As regards the discount rate of 12% applied in the calculations of levelised production costs for biomass, biogas and ground source heat production, the Commission notes that this is the same rate used in the mainland UK scheme. Under the assessment of that scheme, the UK authorities submitted a detailed report from an independent consultant which concluded that the necessary rate of return to incentivise renewable heat production ranges between 8 and 22%. The chosen rate of 12% is at the lower end of that range and it can be considered reasonable.*

The original tariff derivations undertaken by CEPA were all in real (2010) price terms. Consequently, our work has been done on the basis of the 12% IRR being a real IRR, and similarly the 8% to 22% range is on a real basis.

2.3 Analysis of RHI installation data

The Department provided Ricardo with an MS Excel file containing anonymised details of all NI RHI small and medium biomass boiler installations as of September 2017. The file lists 2,077 installations of which 1,969 have recorded heat data. We undertook a range of analysis to gain an initial overview of the data; a sense of the impact of alternative tariff structures; and how it could form the basis of the planned cash flow analysis.

The charts in the following sections present capital costs, load factors[10] and average annual incentive payments based on what has been paid to date. For each of these parameters, separate charts show installations accredited prior to 18th November 2015 and on or after 18th November 2015, at which point the tiered tariff was introduced for new entrants to the Scheme, with the 20-99kW size band expanded to 20-199kW. The y-axis scales are set such that a few extreme outliers are excluded.

2.3.1 Capital costs

The capital cost data are those provided by the RHI participants in their original applications as **'direct capital costs'** (Figures 2.3.and 2.4). These costs should be for the core biomass installation only, excluding heat distribution pipework, heat emitters and civil works. Whilst applicants were given guidance as to which items to include (and which to exclude), it has been observed from site inspections that participants, or their agents, sometimes have given values that included associated items that should have been excluded, or have only provided rough estimates.

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[7] *Environmental Control in Poultry (Broiler) units*, College of Agriculture, Food and Rural Enterprise (CAFRE), 16 July 2015

[8] https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi/contacts-guidance-and-resources/tariffs-and-payments-non-domestic-rhi

[9] http://ec.europa.eu/competition/state_aid/cases/244651/244651_1375577_58_1.pdf

[10] The load factor, expressed as a percentage, is the actual heat generated in a year (kWh) divided by the product of the boiler capacity (kW) and 8,760 hours, being the total number of hours in a year.

Applicants were also asked to provide a figure for **'indirect costs'** (Figures 2.5.and 2.6), which should include items such as planning costs and other costs not attributable directly to the purchase or construction of the physical plant. In principle therefore, these should represent upfront barrier costs (see section 2.4.5). However, as with direct capital costs, we believe that the actual figures provided are inconsistent in what they cover.

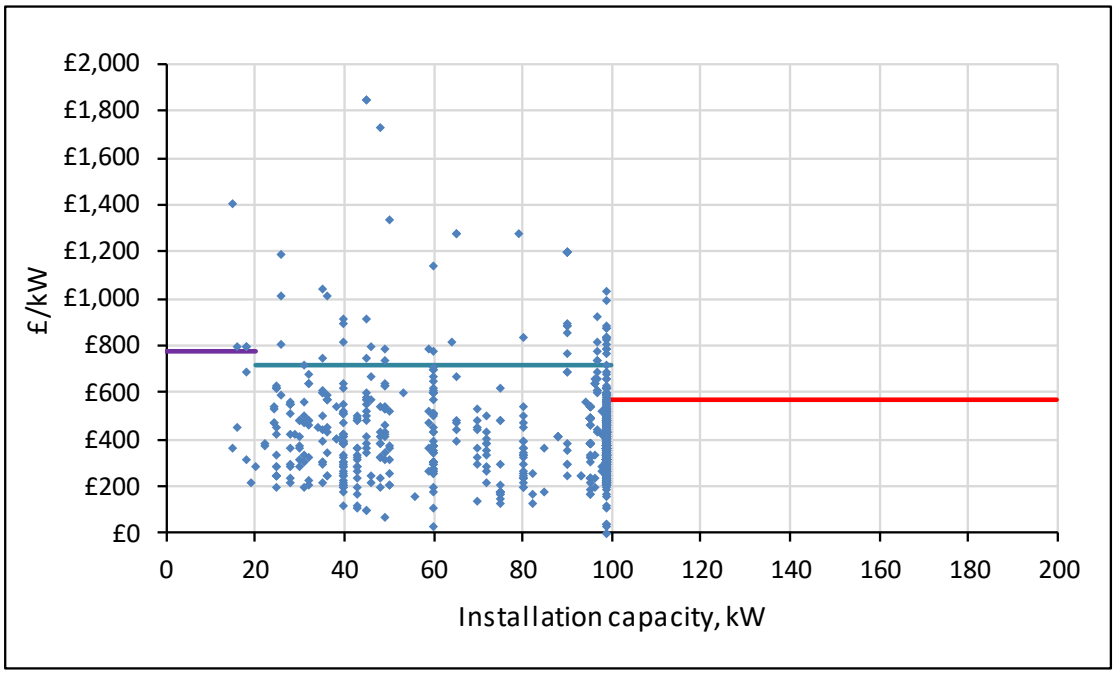
Unfortunately, the application process did not require evidence to support the costs stated. As well as what has been observed from inspections of specific installations, the range of capital cost per kW values determined from application forms gives rise to concerns as to the quality of some of the data provided by applicants. Nevertheless, calculated median values appear realistic – see section 2.4.3.

In Figures 2.3 and 2.4, the original reference capital costs assumed for the CEPA 2012 report, adjusted to 2016 prices, are shown as:

	2016 prices	Capacity band	CEPA 2010 prices
	£779/kWh	0 to <20 kW	£662/kWh
	£715/kWh	20 to <100 kW	£608/kWh
	£572/kWh	100 to <1,000 kW	£486/kWh

The capital costs have proved significantly lower than those originally assumed. For the <20 kW range, the median of application form direct costs per kW is 87% of the equivalent assumed for the original tariff derivation. For the 20 to <100 kW range, the median is around 48% of the originally assumed value, and 42% for the 100 to <1,000 kW range (see also section 2.4.3).

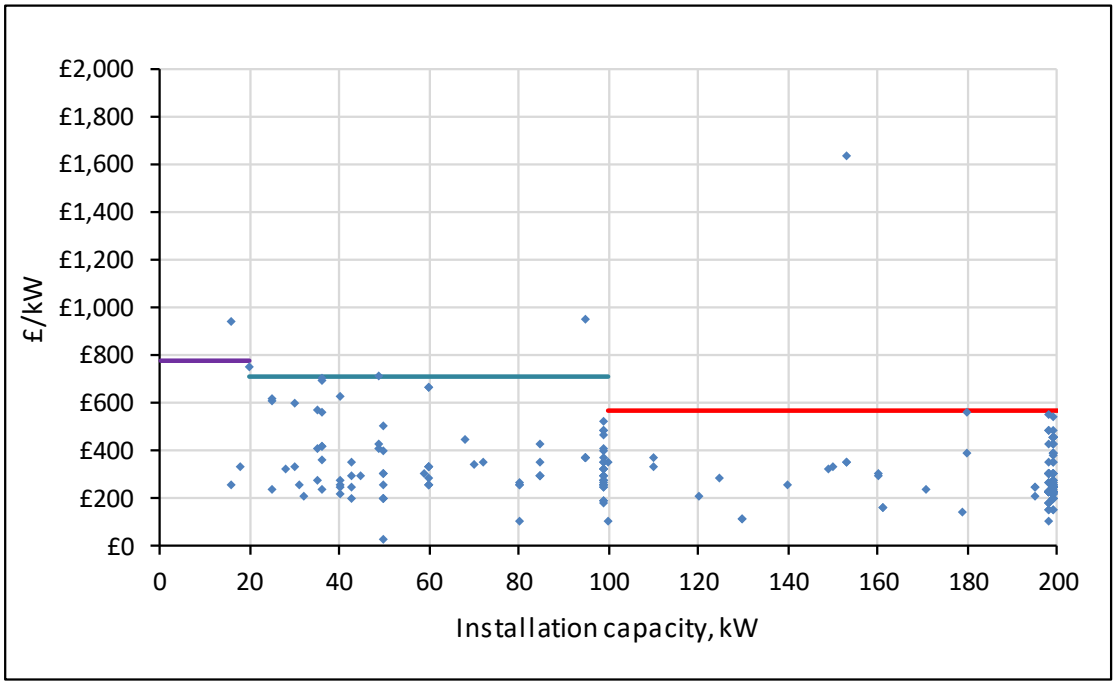
Figure 2.3: Direct capital costs - installations accredited before 18 Nov 2015
(Mean £395/kW, median £362/kW, 2016 prices)



The implication of the actual capital costs being significantly lower than those assumed in deriving the original tariffs is that, for future long-term tariffs, the component of Tier 1 related to capital cost should be significantly lower than that of the original tariffs.

Both Figure 2.3 and 2.4 show the tendency of most installations to be sized at the upper end of the capacity band: 99 kW up to 18 November 2015 and 199 kW subsequently. Together with multiple installations on the same site, this we believe is largely a reflection of boilers being sized to maximise incentive payments, rather than being matched to expected heat demands. In this respect, boilers can be oversized, giving a higher kWh threshold between Tiers 1 and 2 than would otherwise be the case, or undersized (with fossil fuel top-up) to keep within the band with a higher tariff.

Figure 2.4: Direct capital costs - installations accredited on or after 18 Nov 2015
(Mean £282/kW, median £244/kW, 2016 prices)



Figures 2.5 and 2.6 show significant ranges for the indirect costs submitted by participants, with many at zero up to levels exceeding what would be expected for the direct costs.

Figure 2.5: Indirect costs - installations accredited before 18 Nov 2015
(Mean £61/kW, median £21/kW, 2016 prices)

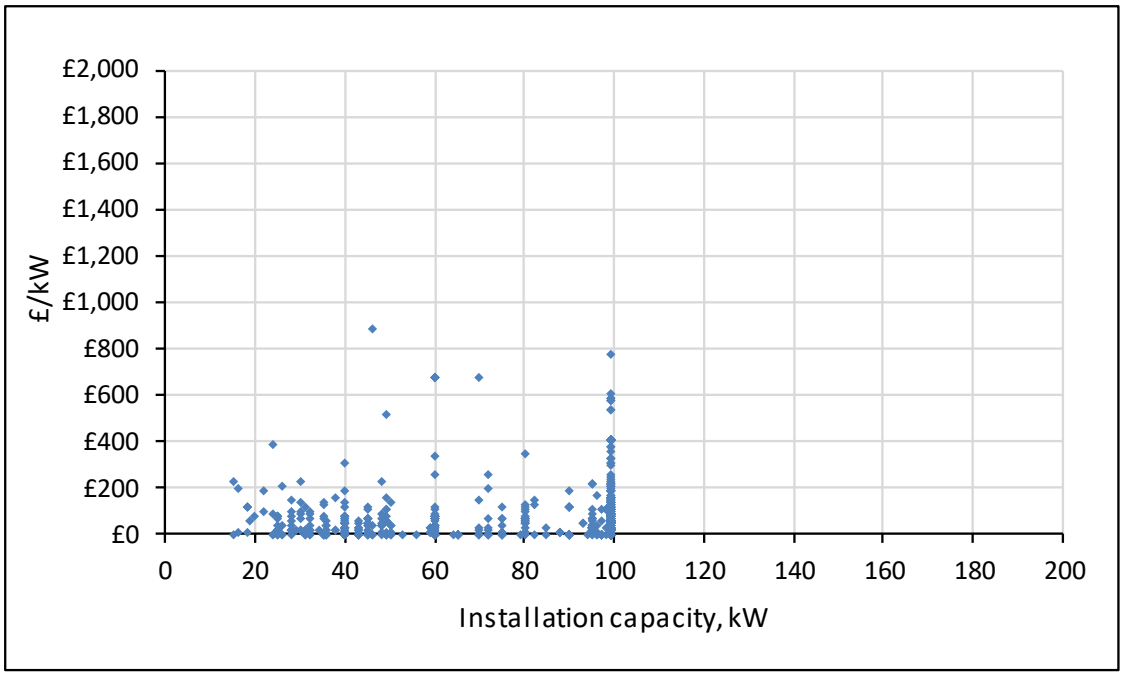
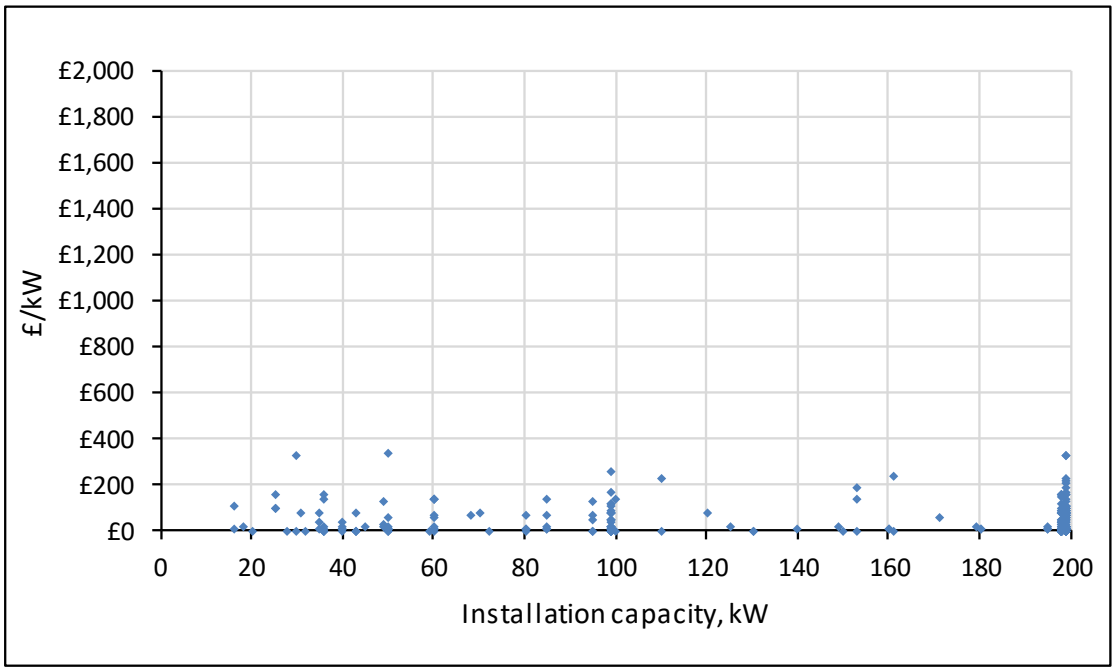


Figure 2.6: Indirect costs - installations accredited on or after 18 Nov 2015
(Mean £73/kW, median £10/kW, 2016 prices)

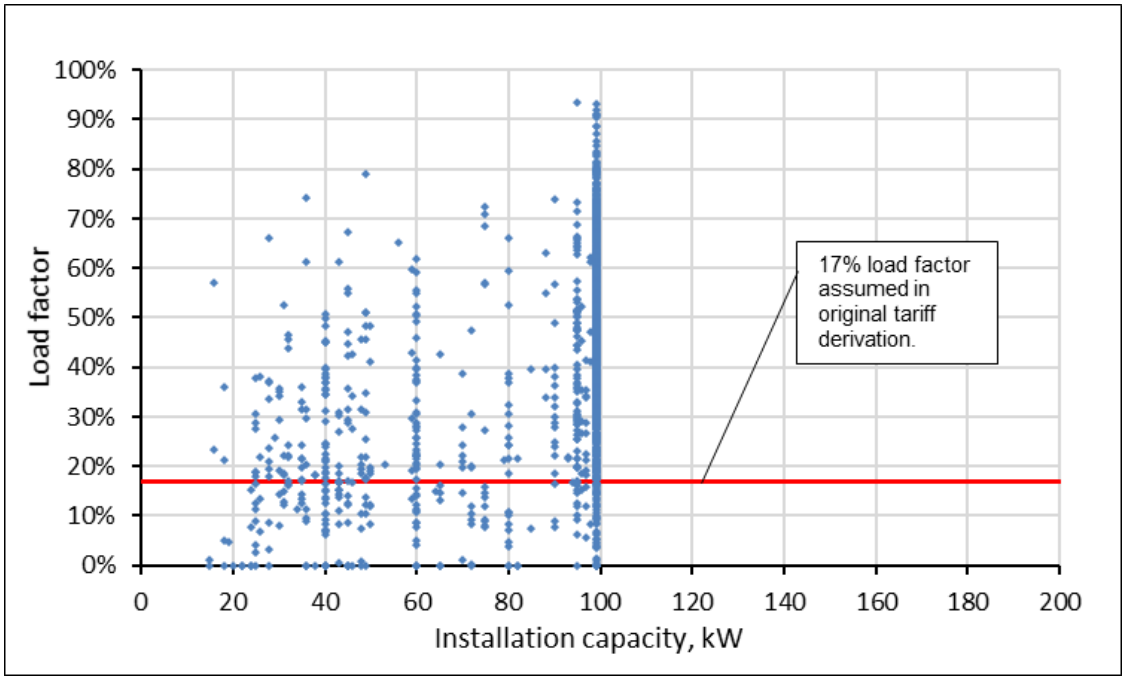


Given the uncertainty over the indirect costs data and that in principle the RHI is intended to compensate for the capital investment in the core biomass installation, for the purposes of this review we have not included the indirect cost data in any of the analysis, but rather have assumed the upfront barrier costs that we have derived as set out in section 2.4.5.

2.3.2 Load factor

The actual average load factors achieved by installations is shown in Figures 2.7 and 2.8. The original tariffs were determined assuming a typical load factor of 17%, which is reasonable for normal space heating applications providing thermal comfort for people in buildings.

Figure 2.7: Load factor - installations accredited before 18 Nov 2015
(Mean 43%, median 43%)

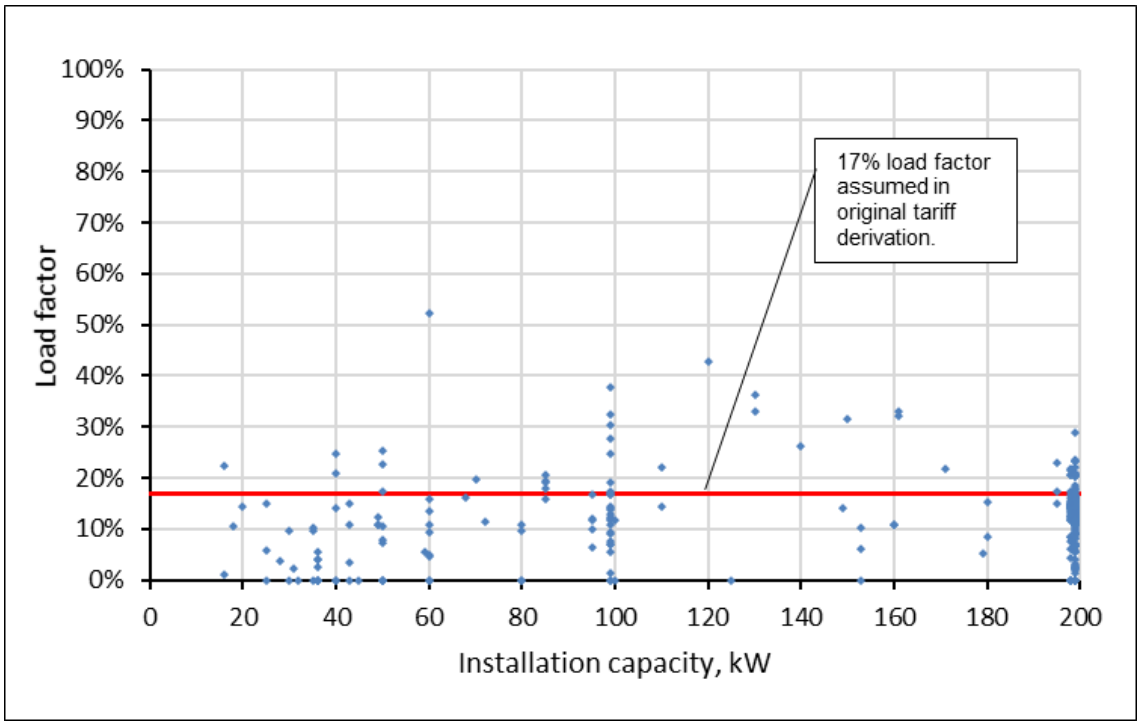


For process loads such as poultry raising, mushroom farming and materials drying, higher load factors are inevitable, though this eventuality was overlooked in the original derivation of the biomass tariffs in that tiering was not considered necessary. As well as providing excessive returns where load factors are naturally and justifiably high, the lack of tiering gave a direct incentive to increase installation load factors through inefficiency and deliberate wastage of heat.

Low load factors, perhaps below 10%, suggest possible boiler over-sizing or problematic systems.

The load factor data is derived from participant's heat meter readings submitted to Ofgem. There is therefore a high level of confidence in the data, though there could be cases of meter failure or of participants making systematic errors in taking readings and submitting their data on-line to Ofgem.

Figure 2.8: Load factor - installations accredited on or after 18 Nov 2015
(Mean 13%, median 12%)



2.3.3 Annual incentive payments per kW of capacity

The actual annual average incentive payments per kW of capacity to date are plotted against capacity in Figures 2.9 and 2.10. For a 99 kW boiler the originally expected level of incentive at 17% load factor is equivalent to around £100 per kW pa, based on the current Tier 1 tariff of 6.7 p/kWh. This is shown by the red line in Figures 2.9 and 2.10. Below 20 kW, the amount is slightly more as the current Tier 1 is 7.0 p/kWh.

The difference between installations accredited before and after 18 November 2015 is stark. Many accredited prior to the November 2015 tariff change have received a much higher level of incentive per kW of capacity than originally anticipated due to higher load factors. After the tariff change, the trend was for lower load factors, sometimes through boiler oversizing.

Figure 2.9: Annual average incentive payments - installations accredited before 18 Nov15
(Mean £227/kW/yr, median £226/kW)

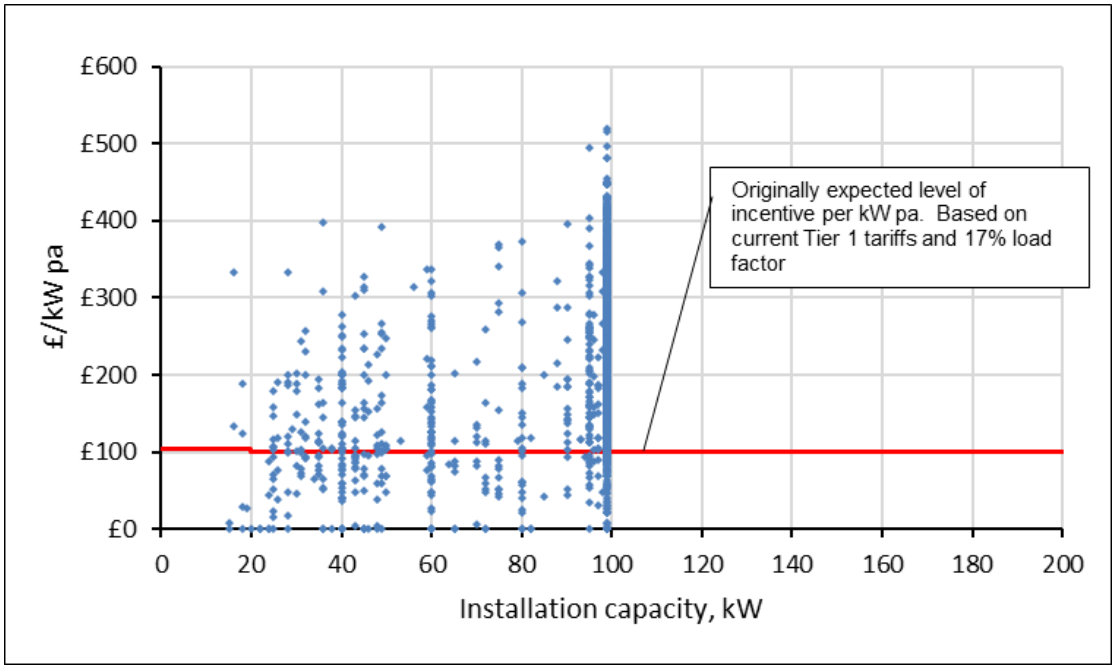
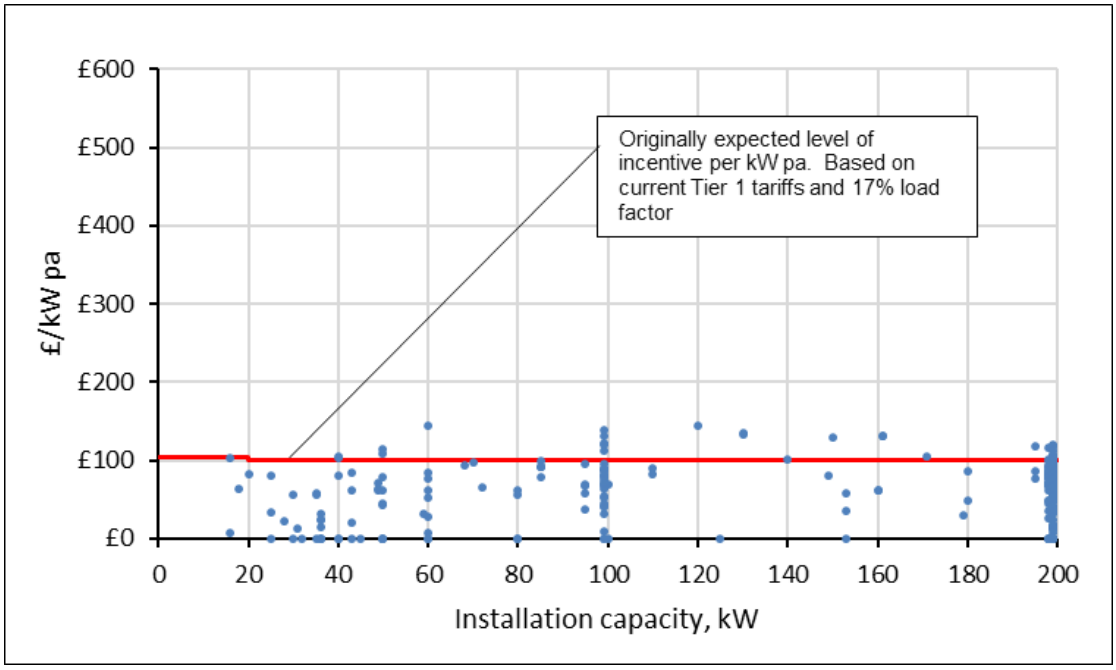


Figure 2.10: Average incentive payments, £/kWh pa - installations accredited on or after 18 Nov 15
(Mean £68/kW pa, median £75/kW pa)



2.4 Review of assumptions

In section 2.3 we reviewed the actual installation data in respect of two critical parameters that affect the return on investment of supported installations under a particular tariff structure; capital costs and load factor. The following sections expand this by reviewing the original assumptions made for these and other parameters and, given current knowledge, recommend a set of 'base-case' assumptions that as far as possible are representative of the available information. The aim is to produce assumptions that are typical of the population that they are intended to characterise. However, with over 2,000 NI RHI biomass installations there will always be variations around what is considered 'typical'.

2.4.1 Data sources

In reviewing the assumptions used in the original CEPA work and in determining recommended revised assumptions for deriving the new base-case tariffs, the following sources have been drawn upon:

- Data from NI RHI participants' application forms and heat data submissions for each installation, which have been provided by the Department (see section 2.3).
- Data from the Department on the capital costs of 285 domestic biomass boilers, between 1.5 and 19 kW, from the Northern Ireland Domestic RHI scheme.
- Data assumptions for previous Department for Energy and Climate Change (DECC) work, which came from sources, including in particular the Bio-Energy Capital Grants scheme and discussions with equipment suppliers.
- Sweett: *'Research on the Costs and Performance of Heating and Cooling Technologies',* for DECC Feb 2013.
- *'Spon's Mechanical and Electrical Services Price Book 2018', Taylor and Francis.*
- Department for Business, Energy and Industrial Strategy (BEIS) *'Non-Domestic RHI and domestic RHI installation cost estimate: October 2015',* published as part of the GB RHI March 2016 consultation[11]. This is the outcome in spreadsheet form of DECC statistical analysis of GB RHI data; amongst other technologies, it provides median and mean costs per kW of solid biomass installations for each of the GB RHI capacity bands. Like the capital cost data for NI RHI installations that the Department holds, this data is based on RHI participants' responses in their original applications to Ofgem for accreditation.
- Responses to recent DECC/BEIS consultations.
- In relation to barrier costs, the GB RHI Impact Assessment and the Enviros report *Barriers to Renewable Heat, Part 2: Demand Side.*
- Oil and LPG suppliers in Northern Ireland for current prices of candidate counterfactual fuels.
- Historic kerosene prices in Northern Ireland from the Consumer Council NI, who kindly provided data available on their web-site directly to us in the form of an Excel spreadsheet.
- Phase 1 of the NI RHI Inspection Programme, which Ricardo has been undertaking for the Department. This has provided:
    - validated capital costs from installer invoices. Participants were not required to provide supporting evidence for the figures they provided in their applications and it has become clear that some misunderstood exactly what was being asked of them;
    - actual costs of equipment servicing and maintenance;
    - historic and current prices for biomass fuels;
    - some data on prices paid for LPG and oils; and
    - biomass boiler efficiencies, although these depend on fuel calorific value assumptions.

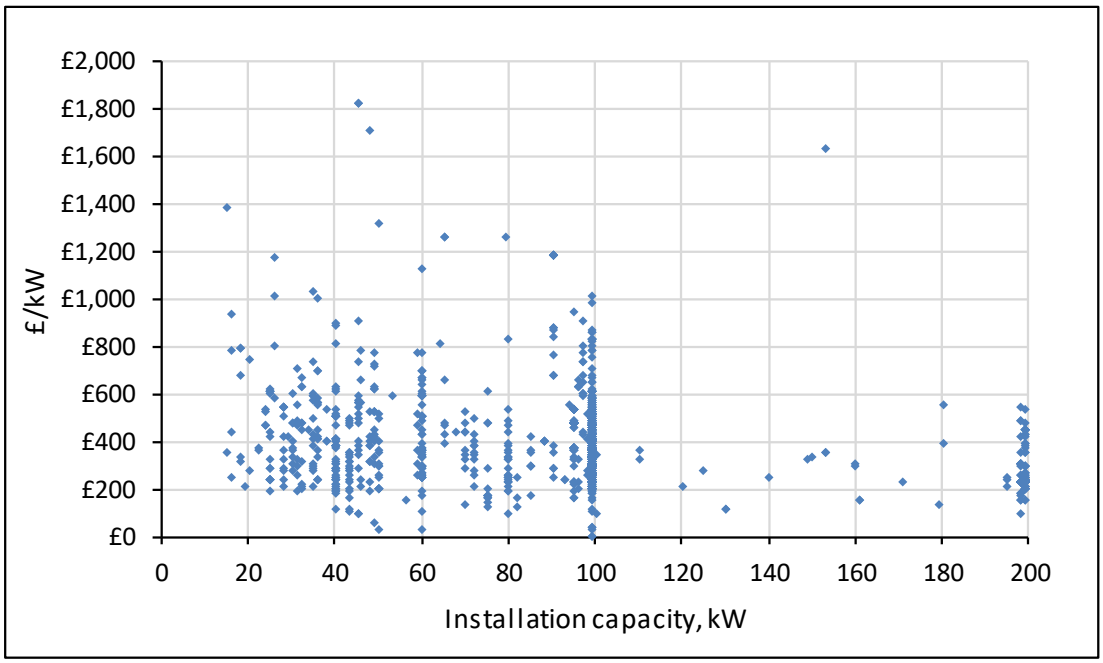
In principle, the site inspection data has provided the most accurate and up to date capital and operating costs, fuel prices and efficiencies for biomass boilers. However, the 63 installations inspected to date represent only 3% of the biomass installations on the Scheme. We have mainly used this data as a check against the other sources listed above to finalise the assumptions used. Details on the selection of the proposed values of each variable are provided in the following sections.

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

2.4.2 Capacity bandings

The direct capital costs provided by participants in their RHI application forms expressed as £ per kW of heat capacity are plotted as Figure 2.11. There is a large spread of costs per kW and with this scatter there is no obvious trend of cost per kW with capacity.

Figure 2.11: Installation direct capital costs (£/kW, 2016 prices)



For the following analysis, we have excluded the bottom and top 10% of capital costs to remove outliers. Examining the mean and median costs for different boiler capacity ranges indicates a more significant difference in cost per kW between the ranges 0 to <20 kW and 20 to <100 kW than between the ranges 0 to <50 kW and 50 to <100 kW. Consequently, we recommend retaining the current capacity range of <20 kW for small installations rather than expanding this to <50 kW or some other value. Furthermore, the <20 kW range has a much higher proportion of installations at the median capacity than for the <50 kW range. We have also examined the impact of splitting the 20 to <100 kW band into two at a number of capacity values, but our analysis has shown that this provides no overall advantage and adds complexity.

Table 2.1 summarises the application data by band. Note that for simplicity, we also refer to the 0 to <20 kW, 20 to <100 kW and 100 to <200 kW bands as 0-19 kW, 20-99 kW and 100-199 kW respectively, and similarly for any other bands.

The mean and median cost per kW for the 100-199 kW range is significantly lower than for <100 kW boilers so we propose splitting the current medium installation band into 20-99 kW and 100-199 kW ranges. We have also assigned the median capacity within each band as that band's reference capacity; i.e. 17 kW, 99 kW and 199 kW respectively.

Regarding data from inspections, since 63 installations only have been inspected to date the sample is too small to support a similar analysis of appropriate bandings.

Table 2.1: Mean and median biomass installation capital costs by capacity range, from application data (2016 prices).

Min capacity kW	0	20	100
Max capacity kW	**19**	**99**	**199**
Mean installation capacity, kW	16.9	88.1	192.7
Median installation capacity (reference capacity), kW	17	99	199
Number of installations in range	12	1,864	201
Number of reference capacity installations in range	9[12]	1,334	134
Mean installation capex in 10-90th percentile cost for reference capacity, £	£10,351	£35,783	£50,375
Median installation capex in 10-90th percentile cost range for reference capacity, £	£11,616[13]	£35,873	£48,000
Mean installation capex in 10-90th percentile cost for reference capacity, £/kW	£609	£361	£253
Median installation capex in 10-90th percentile cost for reference capacity, £/kW	£683	£362	£241

2.4.3 Biomass installation capital costs

Of the 63 biomass boiler installations inspected to date, none were <20kW, 56 were single boiler installations between 20 and 99 kW (47 being 99 kW) and five were 100-199 kW installations, of which three comprised single 199 kW boilers, two comprised 2 x 99 kW boilers (198 kW), one 2 x 80 kW boilers (160 kW) and one 990 kW boiler. Table 2.2 summarises the analysis of the inspection data in the two bands.

Table 2.2: Capital costs for inspected biomass installations (£, 2016 prices)

Min capacity kW	20	100
Max capacity kW	**99**	**199**
Median installation capacity (reference capacity), kW	99	199
Number of inspected installations in band	56	6
Number of inspected reference capacity installations	47	5[14]
Mean installation capex in 10-90th percentile cost for reference capacity	£32,891	£48,000
Median installation capex in 10-90th percentile cost range for reference capacity	£34,028	£48,000
Mean installation capex in 10-90th percentile cost range for reference capacity £/kW	£332	£241
Median installation capex in 10-90th percentile cost range for reference capacity £/kW	£344	£241

The median cost for inspected 99 kW boilers is broadly consistent with the median cost from application forms (Table 2.1); we consequently have used that derived from application forms for the 20-99 kW band (£35,873 = £362 /kW).

The median cost for 199 kW installations derived from site inspections of £48,000 (£241 /kW) is the same as the median of costs derived from the application form data for the 100-199 kW range (Table 2.1), and we have therefore used this value.

[12] There are actually no 17 kW boilers, but nine 16 kW or 18 kW boilers.

[13] There are no 17 kW boilers so the median capital cost is based on the median £/kW for 16 kW and 18 kW.

[14] 198 kW included as they are essentially the same as 199 kW.

We have also received data from the Department on the capital costs of 285 domestic biomass boilers, between 1.5 and 19 kW, from the Northern Ireland Domestic RHI scheme in the Excel file <*NI Domestic RHI Scheme Capital Costs for Ricardo.xls*>. The median capital cost for the entire sample is £387 /kW, and the median cost for each of the boiler sizes between 15 and 19 kW are as shown in Table 2.3.

Table 2.3: Median capital costs for 15-19 kW domestic biomass boilers.

Capacity, kW	15	16	17	18	19
No. of boilers	51	10	3	97	1
Median capital cost, £/kW	£349	£369	£356	£401	£400

These costs are lower than those stated in the non-domestic RHI application forms for <20 kW installations. However, we are concerned that deriving the RHI tariffs for the <20 kW band based on these domestic figures rather than the non-domestic costs would not be a consistent approach. Whilst we do not know the reasons for the differences, this might reflect greater price sensitivity amongst domestic consumers.

As no installations of less than 20 kW have been inspected, we propose using the median of capital costs provided on application forms of £11,616 (£683 /kW).

Table 2.4 summarises the proposed capital cost assumptions for tariff derivation.

Table 2.4: Proposed installation capital cost assumptions by band (2016 prices)

Min capacity kW	0	20	100
Max capacity kW	19	99	199
Reference installation capacity, kW	17	99	199
Median installation capex for reference capacity, £	£11,616	£35,873	£48,000
Median installation capex for reference capacity, £/kW	£683	£362	£241

2.4.4 Biomass installation servicing & maintenance costs

We use the term “servicing & maintenance” rather than “operation & maintenance” to make a distinction between the activities undertaken by professional maintenance contractors (often the installer organisation) and those normally undertaken by the boiler owner, namely regular boiler cleaning and ash removal. The latter are included within ongoing barrier costs (see section 2.4.5). The servicing & maintenance costs assumed in the CEPA 2012 report (referred to as Opex) on a £/kW pa basis are as set out in Table 2.5, with the equivalent annual costs for the new reference capacities.

Table 2.5: Servicing & maintenance costs for reference installations based on CEPA 2012 £/kW pa costs (2016 prices)

Min capacity kW	0	20
Max capacity kW	19	99
New reference installation capacity, kW	17	99
CEPA 2012 servicing & maintenance cost, £/kW pa	£22.36	£5.42
Servicing & maintenance, £ pa equivalent for new reference capacity	£380	£537

Servicing & maintenance costs obtained from site inspections show significant variability. Generally, wood pellet boilers require a service every 2,000 hours of full load equivalent operation or annually, whichever is the sooner. In addition, there will be call-outs for faults. Where there are multiple boilers on a site, the participant can reduce the cost of each boiler’s servicing by having multiple boilers serviced at the same time. Whilst there will be at a minimum an annual service, boilers with higher load factors will have additional servicing and maintenance costs that will tend to rise in proportion to heat generation. At the same time, the cost of a service for a small boiler will not be significantly less than that for a larger boiler since the costs are mainly determined by the contractor’s time charges.

The servicing & maintenance costs derived from site inspection data are set out in Table 2.6.

Table 2.6: Servicing & maintenance costs for reference installations derived from recent RHI inspections

Min capacity kW	20	100
Max capacity kW	**99**	**199**
Reference installation capacity, kW	99	199
Median servicing & maintenance, £ pa	£735	£600
Median servicing & maintenance, £/kW	£7.42	£3.02
Median servicing & maintenance, p/kWh	0.21	0.22

We consider that for the 20-99 kW band, the median figure of 0.21 p/kWh derived from the inspections to be realistic. Considering the much higher load factors of the inspected installations compared with that assumed for the CEPA 2012 reference boiler, the lower p/kWh figure is not inconsistent.

Although the number of 199 kW boilers inspected is relatively small, the p/kWh maintenance cost at 0.22 p/kWh is close to that for 99 kW boilers and we believe it reasonable to use this value as the basis for the tariff derivation. Generally, the cost of a service for a 199 kW boiler will be similar to that for a 99 kW boiler, any difference in annual costs or costs per kW will depend on the load factor. The lower annual cost of the 199 kW boilers is due to lower load factors and so greater time between services, which for most boilers are specified to be every 2,000 hours of full load equivalent operation or annually, whichever is sooner.

For the 0-19 kW band, the CEPA 2012 £/kW pa figure is equivalent to £380 pa for the 17 kW reference boiler and, at the median load factor of installations within the band, a servicing & maintenance cost of 1.08 p/kWh, which we believe to be realistic at this capacity.

The assumed p/kWh values in Table 2.7 have been used in deriving the proposed new biomass tariffs.

Table 2.7: Servicing & maintenance cost assumptions for biomass installations

Min capacity kW	0	20	100
Max capacity kW	**19**	**99**	**199**
Reference installation capacity, kW	17	99	199
Median annual heat output, kWh pa	35,262	432,905	242,212
Load factor	23.7%	49.9%	13.9%
Servicing & maintenance, p/kWh	1.08	0.21	0.22
Servicing & maintenance, £ pa	£380	£893	£536
Servicing & maintenance, £/kW pa	£22.36	£9.02	£2.69

2.4.5 Barrier costs

Although we have not been able to determine explicitly how the upfront and ongoing barrier costs used by CEPA were calculated, it appears that this drew upon previous work that informed the GB RHI tariff derivations. From the NERA report *The UK Supply Curve for Renewable Heat and Design of the Renewable Heat Incentive*, it is clear that the barrier costs originate from work undertaken by Enviros for the Department for Business, Enterprise and Regulatory Reform (BERR) (as it was then) in 2008, the relevant report being *Barriers to Renewable Heat, Part 2: Demand Side*.

Our understanding is that the CEPA work underlying the report *Renewable Heat Incentive for Northern Ireland, Final Report; 28 June 2011* included account of 'upfront' barrier costs only. However, there is no quantification of these costs or the rationale behind them. The CEPA Addendum Report and associated spreadsheets provide the following:

Ongoing barrier costs: £818 pa
The source for the ongoing barrier costs is given by CEPA as the GB RHI impact assessment (IA), and can be found in the table at Annex 3, page 35 of *DECC Impact Assessment No: DECC 0057, dated 10/10/2011*[15], where it is stated to be £828 pa. As seen in Figure 2.2, in CEPA's spreadsheet, £818 pa was used, although the £828 figure is stated in Table A.25 of the CEPA addendum report. There is insufficient detail in the GB IA to determine how this figure was built up, though there are indications of ongoing administrative costs that applicants would have in respect of participating in the RHI, specifically the requirement to take and submit heat meter readings.

Upfront barrier costs: £5,364
There is no reference for this figure given by CEPA. The GB IA also has values for biomass installation upfront barrier costs, but there is no obvious match with the CEPA value of £5,364. The GB IA value is £6,965 for biomass boilers in the <200 kW band and the reference boiler capacity is 107 kW, though it is not a simple matter that scaling has been employed for the 50 kW reference boiler used in the CEPA Addendum work.

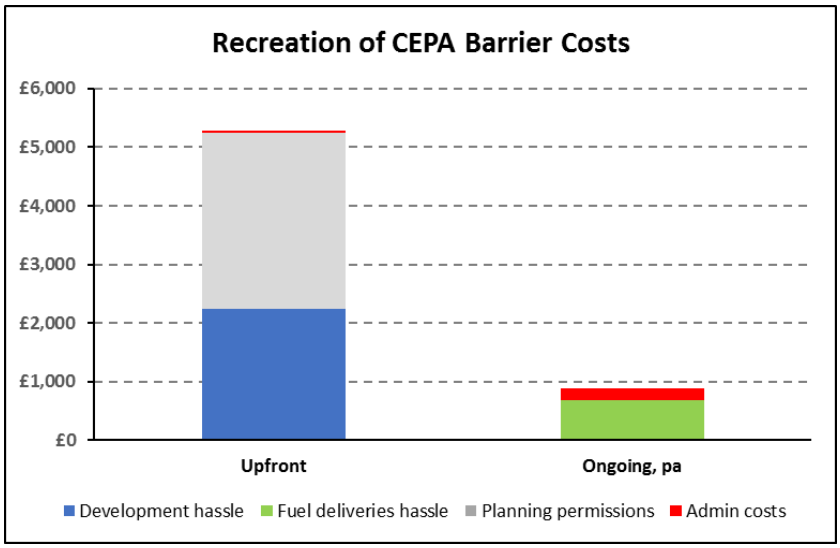
We have reviewed the Enviros 2008 report, which provides assumptions for the additional effort (staff or consultancy time) that organisations adopting renewable heat technologies would need to expend compared with conventional fossil fuel systems. The amount of effort is presented against three high level deployment scenarios for renewable heat in the UK. From these assumptions, we have built up figures for both ongoing and upfront barrier costs in an attempt to replicate the CEPA values. This is set out in Table 2.8 and Figure 2.12 below. The day rates used in the Enviros work are not explicit. We cannot be sure what rates and days lie behind the CEPA figures, but we are reasonably confident that the estimates in Table 2.8 cover all the cost elements included and were considered additional to similar cost items that would arise for a fossil fuel boiler solution.

Table 2.8: Recreation of CEPA biomass barrier costs

Upfront	Days	Rate £/day	Cost, £	Comments
Development hassle	5	£450	£2,250.00	Derived from Enviros, 2008
Planning permissions	3	£1,000	£3,000.00	Derived from Enviros, 2008
Admin			£26.21	From GB RHI IA
Total			**£5,276.21**	
		CEPA value:	*£5,364.00*	
		Difference:	*£87.79*	
Ongoing, pa	**Days**	**Rate £/day**	**Cost pa, £**	**Comments**
Fuel deliveries hassle	1.5	£450	£675.00	Derived from Enviros, 2008
Admin			£206.88	From GB RHI IA
Total			**£881.88**	
		CEPA value:	*£818.00*	
		Difference:	*-£63.88*	

[15] http://www.legislation.gov.uk/ukia/2011/332/pdfs/ukia_20110332_en.pdf

Figure 2.12: Recreation of CEPA biomass barrier costs



Having understood as far as possible how the CEPA barrier costs were derived, we have considered whether:

- each individual cost item is justifiable as additional to that for a conventional boiler;
- there are any other cost items that should be included;
- the time costs (rates) are appropriate; and
- the amount of time for each item is appropriate.

From our experience of projects and that which we have observed from both the NI RHI Site Inspection Programme and RHI audits carried out for Ofgem in Northern Ireland and GB, our views are:

- The planning permissions cost assumed in Enviros (2008) is overstated for most situations. Biomass installations at the scale deployed under the NI RHI rarely need planning permission, but may well need building control approval, but we understand that this is no different than for any new boiler installation.
- Most sites in Northern Ireland would otherwise have oil or LPG deliveries, so we are unconvinced that biomass deliveries (mainly bulk wood pellets or chip) warrant the assignment of a 'hassle' cost. Furthermore, agricultural sites will also be receiving deliveries of a very similar nature in respect of animal feed. There will be a difference in the case of small boilers where the biomass fuel is likely to be bagged wood pellets, which must be manually emptied into the boiler's hopper.
- We have difficulties with the inclusion in incentive payments of some compensation for participants' time in taking and submitting heat meter readings, since this is something that should be carried out for any energy plant as part of good energy management practice. We recommend therefore that no administrative element be included in ongoing barrier costs.
- Administrative costs for making the original application are arguably an upfront barrier so we have included allowance for this, including for the preparation of metering reports and schematics by consultants.

Tables 2.9 and 2.10 set out our recommended barrier cost assumptions respectively for the capacity ranges <20 kW and 20 to <200 kW. The hourly rates used have been sourced from the NISRA *Northern Ireland Annual Survey of Hours and Earnings Bulletin, October 2017* [16]. The variable costs in the two tables are based on the assumption of a 15% load factor.

[16] https://www.nisra.gov.uk/sites/nisra.gov.uk/files/publications/4xu-NI-ASHE-Bulletin-2017.PDF and https://www.nisra.gov.uk/sites/nisra.gov.uk/files/publications/4xt-ASHE2017F4.xlsx

Table 2.9: Recommended barrier costs for installations <20 kWth

Upfront	Hours	Rate per hour	Cost	Comments
Development hassle	20	£18.97	£379.32	Research time, etc. for participant. Few participants have used consultants, relying on the installer to include such support in their price.
Regulatory approvals	0	£100.00	£0.00	Assumed none required at this scale
Administration	5	£11.01	£55.07	Upfront application time for participant
Metering report and schematics			£0.00	Rarely required at this scale
Total			**£434.38**	
Ongoing, pa	**Hours**	**Rate per hour**	**Cost**	**Comments**
Fuel deliveries hassle	16.25	£9.02	£146.55	Deliveries of bagged pellets: assumes 30 mins each for 6.5 deliveries pa. Manual filling of boiler hopper: 1 bag per week at an average of 15 mins.
Ash clearance and cleaning	13	£9.02	£117.24	Assumes 15 mins a week for boiler clean and ash removal.
Additional insurance premium			£100.00	Higher value asset than fossil installation and higher perceived risk.
Total			**£363.79**	

Table 2.10: Recommended barrier costs for installations 20 to <200 kWth

Upfront	Hours	Rate per hour	Cost	Comments
Development hassle	30	£18.97	£568.97	Research time, etc. for participant. Few participants have used consultants, relying on the installer to include such support in their price.
Regulatory approvals	0.8	£100.00	£80.00	Generally, no more than would be required for new fossil boiler, though may need larger or new boiler house. Assumed consultancy cost of 8 hours for 10% of installations.
Administration	8	£11.01	£88.11	Upfront application time for participant
Metering report and schematics			£250.00	A typical price from a consultant is £500, but not all installations need a metering report; assumed 50% do.
Total			**£987.08**	
Ongoing, pa	**Hours**	**Rate per hour**	**Cost**	**Comments**
Fuel deliveries hassle	0	£10.81	£0.00	Bulk deliveries of pellets/chip generally do not need attendance of site staff
Ash clearance and cleaning	52	£9.02	£468.96	Assumes 1 hr a week for boiler clean and ash removal.
Additional insurance premium			£150.00	Higher value asset than fossil installation and higher perceived risk.
Total			**£618.96**	

The additional insurance premium is a fixed annual value, irrespective of plant usage, so has been treated accordingly in the derivation of the tariffs.

2.4.6 Biomass and counterfactual fuels

Of the 63 inspected installations (35 sites), 45 (27 sites) use wood pellets so we propose to assume pellets to be the biomass fuel in deriving tariffs since it predominates. Furthermore, wood pellets are

more expensive than wood chips on a kWh for kWh basis, so using wood pellets increases this element of the tariff over an assumption of wood chips.

Most poultry rearing sites use LPG as a standby and top-up fuel, whereas the remainder, if they have this facility, tend to use kerosene, which is cheaper than LPG. Assuming LPG is used where the real counterfactual is kerosene would under-estimate the required level of incentive so we propose to assume kerosene as the counterfactual fuel. This means that for installations where the alternative fuel is actually LPG the use of kerosene as the counterfactual will over-estimate the required level of incentive.

2.4.7 Fuel prices

CEPA's modelling employed fuel price inflation over 20 years from 2012, all expressed in 2010 prices. For 2012, the following fuel prices were assumed:

Wood pellets: 4.39 p/kWh

Counterfactual oil: 4.86 p/kWh

However as described in section 2.2.1, Figure 2.2, the effective prices used in deriving the original tariff were:

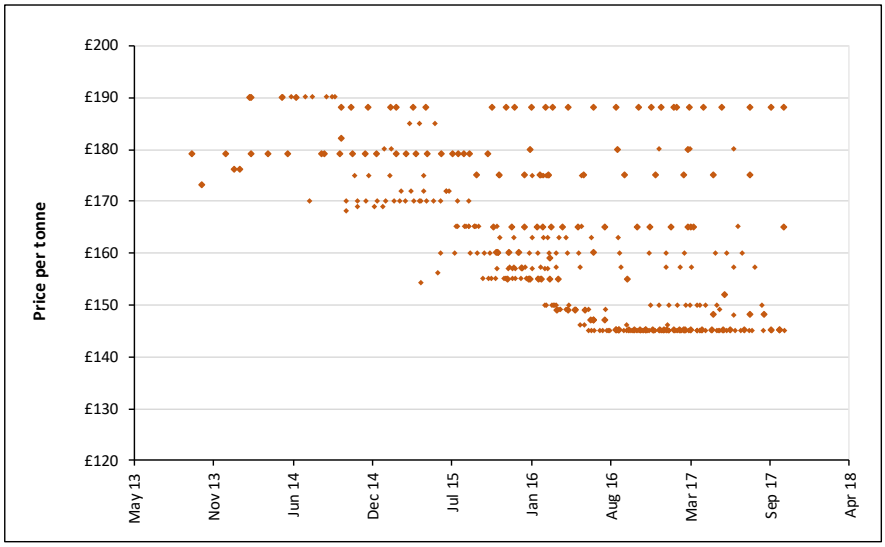
Wood pellets: 4.56 p/kWh

Counterfactual oil: 5.10 p/kWh

2.4.7.1 Wood pellets

From around July 2016 to October 2017, bulk supply wood pellet prices in Northern Ireland of around £145 to £150 per tonne (delivered) have been achievable for consumers seeking competitive prices. As shown in Figure 2.13, prices have fallen over the last few years from around £185 to £190 per tonne in early to mid-2014. For deriving the base-case tariffs for >20 kW installations, we have assumed a cost of £150 /tonne, which is equivalent to 3.26 p/kWh, based on an assumed net calorific value (NCV) of 4,600 kWh/tonne[17].

Figure 2.13: Bulk wood pellet prices, Northern Ireland, Sep 2013 to Oct 2017



Source: NI RHI Phase 1 Inspections – data from 23 sites

As already noted, no <20 kW installations have been inspected, but these would typically employ bagged pellets (rather than bulk), which are significantly more expensive. We have observed costs during 2017 of £180 to £220 /tonne (equivalent to 3.91 to 4.78 p/kWh) for bagged pellets. We have therefore assumed a price at the middle of this range of 4.35 p/kWh (around £200 /tonne).

2.4.7.2 Kerosene

Regarding kerosene, for the <20 kW band's 17 kW counterfactual reference installation, which would consume in the order of 2,500 litres pa, we have reviewed prices from the Consumer Council NI's

[17] 4,600 kWh/tonne is the minimum allowable NCV under the ENplus quality certification scheme for wood pellets (http://www.enplus-pellets.eu/wp-content/uploads/2016/03/ENplusHandbook_part3_V3.0_PelletQuality_EPCinternational.pdf)

website[18]. This provides current and historic domestic kerosene prices for 300, 500 and 900 litre deliveries ('drops'). We have assumed 900 litre deliveries for the 17 kW installation (around 3 pa) for which the average price in Northern Ireland at 16/11/2017 was 43.0 p/litre (NCV basis)[19]

From undertaking a 'secret shopper' exercise with local oil suppliers on 15/11/2017, we concluded that at that time kerosene in Northern Ireland was around 40.43 p/litre for the supply of quantities suitable for the reference installations of 99 kW and 199 kW. This is equivalent to 4.14 p/kWh (NCV).

2.4.7.3 Summary of fuel price assumptions

As at November 2017, bulk wood pellets are about 20% cheaper per kWh than kerosene for comparable quantities. Bagged pellets are slightly cheaper than kerosene. The fuel price assumptions used in deriving the base-case tariffs are summarised in Table 2.11. These are, of course, a snapshot at a particular point in time; dealing with the volatility of fuel prices is a significant issue for the tariffs going forward.

Table 2.11: Fuel price assumptions

Min capacity kW	0	20	100
Max capacity kW	**20**	**99**	**199**
Reference installation capacity kW	17	99	199
Wood pellets £/tonne	£197	£150	£150
Kerosene p/litre	43.00	40.43	40.43
Wood pellets p/kWh NCV	4.35	3.26	3.26
Kerosene p/kWh NCV	4.41	4.14	4.14

2.4.8 Boiler efficiencies

2.4.8.1 Biomass

The medians of the efficiencies stated in the participants' RHI application forms are as shown in Table 2.12.

Table 2.12: Installation biomass efficiencies from RHI application forms

Min capacity kW	0	20	100
Max capacity kW	**20**	**99**	**199**
Reference Installation capacity kW	17	99	199
Median installation efficiency %NCV	93.0%	93.0%	91.3%

These values are very likely to be based on the respective manufacturers' specifications, but they compare well with the efficiencies provided in the Sweett *Report on the costs and performance of heating and cooling technologies*, 2013 for DECC. Figure 3.5iii of this report gives 92% for <100 kW and 91% for >100 kW boilers. Data from the RHI site inspections is also consistent with the Sweett figures, which we therefore have adopted (Table 2.13).

2.4.8.2 Kerosene

The efficiencies assumed for oil boilers in CEPA 2012 show little difference with the Sweett report figures for biomass boiler efficiencies and for simplicity we have assumed the same values for both fuels (Table 2.13).

[18] http://www.consumercouncil.org.uk/energy/home-heating-oil/

[19] The net calorific value of kerosene is 9.76 kWh/litre (Digest of UK Energy Statistics, 2016)

2.4.8.3 Summary of biomass and kerosene boiler efficiency assumptions

Table 2.13: Biomass and kerosene boiler efficiency assumptions

Min capacity kW	0	20	100
Max capacity kW	**20**	**99**	**199**
Reference installation capacity kW	17	99	199
Reference efficiency for wood pellets %NCV	92.0%	92.0%	91.0%
Reference efficiency for kerosene %NCV	92.0%	92.0%	91.0%

2.4.9 Biomass and kerosene boiler lifetimes

The lifetimes assumed in the 2012 CEPA report were 20 and 15 years for biomass and oil boilers respectively. We consider that 15 years for oil boilers is low and have raised this to 20 years.

2.4.10 Kerosene boiler capital and maintenance costs

2.4.10.1 Capital costs

The capital costs for oil boilers assumed in CEPA 2012 and inflated to 2016 real terms are as shown in Table 2.14.

Table 2.14: Oil boiler capital costs assumed by in CEPA 2012 (2016 prices)

Min banding capacity kW	0	20	100
Max banding capacity kW	**19**	**99**	**199**
Reference counterfactual boiler capacity kW	17	99	199
Assumed kerosene boiler capex for reference capacity, £/kW	£215	£114	£80
Assumed kerosene boiler capex for reference capacity	£3,655	£11,286	£15,920

The capital costs for oil boilers implied in the latest edition of *Spon's Mechanical and Electrical Services Handbook*, which is a widely used reference for costing, are as shown below.

Table 2.15: Oil boiler capital costs implied by Spon's Handbook

Min banding capacity kW	0	20	100
Max banding capacity kW	**19**	**99**	**199**
Reference counterfactual boiler capacity kW	17	99	199
Assumed kerosene boiler capex for reference capacity, £/kW	£113	£113	£65
Assumed kerosene boiler capex for reference capacity	£1,918	£11,205	£12,998

The Spon's values are very close to those assumed in CEPA 2012 adjusted to 2016 prices for the 99 kW and 199 kW boilers. However, on a £/kW basis, the cost implied by Spon's for a 17 kW boiler is equal to that of a 99 kW boiler and much lower than that assumed in the CEPA report. This is somewhat surprising, but could be due to the smaller boilers being manufactured in much greater numbers (due to domestic demand) offsetting the economies of scale inherent in a larger installation. Nevertheless, we propose to retain the assumptions in CEPA 2012 adjusted to 2016 prices (Table 2.14).

2.4.10.2 Servicing and maintenance costs

The servicing and maintenance costs for oil boilers assumed in CEPA 2012 and inflated to 2016 real terms are as shown in Table 2.16 below. This implies that a 199 kW installation costs less to maintain in absolute terms than a 99 kW installation, which we do not believe is realistic. The absolute cost will be similar to or more than the 99 kW installation.

Table 2.16: Oil boiler maintenance costs – CEPA, 2012 in 2016 prices

Min banding capacity kW	0	20	100
Max banding capacity kW	19	99	199
Reference counterfactual boiler capacity kW	17	99	199
Servicing and maintenance costs, £/kW pa	£11.07	£4.06	£1.73
Servicing and maintenance costs, £ pa	£188	£402	£344

The estimated operating and maintenance costs quoted on various websites[20] for servicing oil boilers were approximately as follows.

Table 2.17: Oil boiler estimated annual servicing costs

Min banding capacity kW	0	20	100
Max banding capacity kW	19	99	199
Reference counterfactual boiler capacity kW	17	99	199
Servicing costs, £/kW pa	£7.35	£1.41	£0.70
Servicing costs, £ pa	£125	£140	£140
Servicing and maintenance costs, £ pa	£175	£196	£196
Median annual heat output, kWh/Yr	35,262	432,905	242,212
Servicing and maintenance costs, p/kWh	0.50	0.05	0.08

These sites also recommend annual servicing which implies these are typical annual costs. Servicing costs will include replacement of 'consumable' components such as the oil filter, but not other parts that may need replacement. To account for this, we have conservatively increased the servicing only values in Table 2.17 by 40% to £175, £196 and £196 pa respectively to give estimated annual servicing **and** maintenance costs. We believe that the costs shown in Table 2.17 are more realistic than those derived from CEPA 2012, and so these are used in the tariff derivation.

2.4.11 Summary of assumptions

Table 2.18: Summary of assumptions

Min banding capacity kW	0	20	100
Max banding capacity kW	19	99	199
Reference biomass boiler capacity, kW	17	99	199
Reference counterfactual boiler capacity, kW	17	99	199
Median biomass boiler capex for reference capacity, £	£11,616	£35,873	£48,000
Median biomass boiler capex for reference capacity, £/kW	£683	£362	£241
Biomass boiler maintenance for reference capacity, p/kWh	1.08	0.21	0.22
Biomass boiler barrier costs upfront, £	£434	£987	£987
Biomass barrier costs ongoing, fixed, £ pa	£100	£150	£150
Biomass boiler barrier costs ongoing, variable, £ pa	£264	£469	£469
Wood pellet price, p/kWh (NCV)	4.35	3.26	3.26
Biomass boiler efficiency, % (NCV)	92.0%	92.0%	91.0%
Kerosene boiler capex for reference capacity, £	£3,655	£11,286	£15,920
Kerosene boiler maintenance for reference capacity, p/kWh	0.50	0.05	0.08

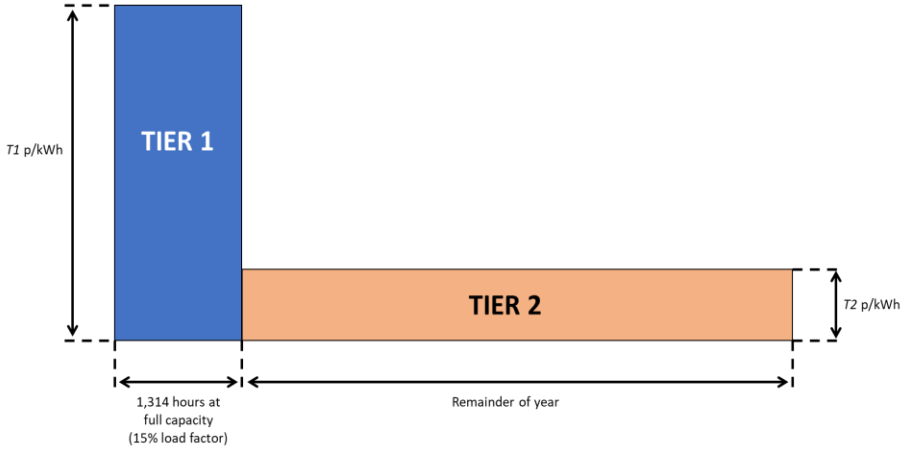
[20] http://www.wheildons.co.uk/light-commercial-boiler-servicing
http://www.andersheating.co.uk/prices_gasboilerservice.pdf

Min banding capacity kW	0	20	100
Max banding capacity kW	**19**	**99**	**199**
Kerosene boiler efficiency, % (NCV)	92.0%	92.0%	91.0%
Kerosene price, p/kWh (NCV)	4.41	4.14	4.14
Annual heat consistent with reference capacity, 15% load factor, kWh	22,353	130,175	261,665
Biomass boiler lifetime, years	20	20	20
Kerosene boiler lifetime, years	20	20	20

2.5 Calculation of base-case tariffs

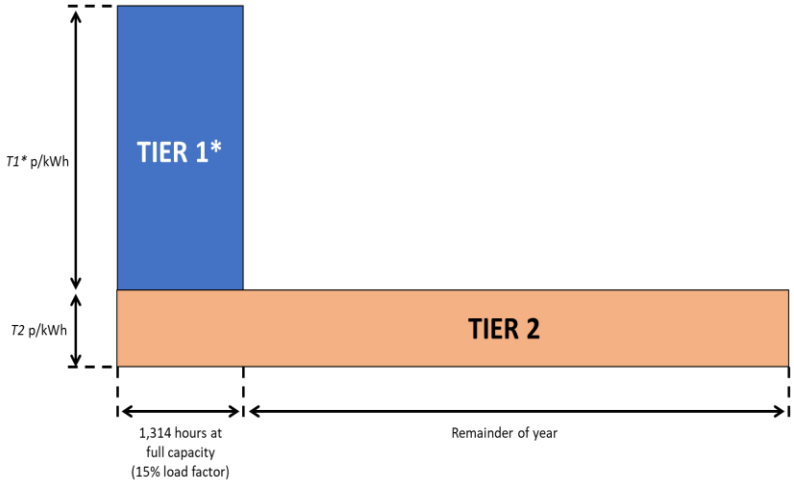
In both the GB and NI RHI Schemes, Tier 1 applies to eligible heat up to the annual load factor threshold (currently 15% for biomass under the NI RHI) from which point Tier 2 applies up to any overall cap (currently 400,000 kWh under the NI RHI). This is illustrated in Figure 2.14 (ignoring any cap).

Figure 2.14: Standard tariff tiering model



Where the total ongoing cost per kWh of heat for operating the biomass installation (wood pellets, maintenance and variable ongoing barrier costs) exceeds that for the counterfactual kerosene boiler (kerosene and maintenance) then the principle of the Tier 2 tariff (*T2*) is that it bridges the gap to encourage the biomass installation to be used rather than the kerosene boiler. At the same time, the Tier 1 tariff (*T1*) should enable the installation to make a 12% return on the total marginal capital cost (biomass boiler capital less the avoided capital cost of the equivalent kerosene boiler) and compensate for the additional up-front barrier costs of biomass, though not providing any financial return on this element. Tier 1 also includes an element equal to Tier 2 to cover the marginal operating costs.

Figure 2.15: Alternative tariff tiering model



An alternative, and more transparent way of presenting this is to split Tier 1 into its two elements as shown in Figure 2.15 such that Tier 1* (*T1**) only covers the upfront capital and barrier costs and Tier 2 the marginal operating costs for all heat (subject to any cap).

Hence T1* = T1 – T2.

In the rest of this report we will mainly present T1, T1* and T2.

We have calculated the base-case tiered tariffs required for the reference installations for the three size bands and the assumptions set out in Table 2.18 to achieve a real terms IRR of 12%, which is consistent with the original intent of the Scheme and the EU State Aid approval. The 15% load factor (1,314 hours pa) tier threshold has been retained.

On this basis, the tariffs required to achieve an IRR of 12% are calculated for each of the three capacity bands as shown in Tables 2.19 to 2.21. We refer to this set of tariffs as the **base-case**. The tariffs are summarised in Table 2.22.

Table 2.19, A to D: Base-case tariff derivation for 0 to 19 kW capacity band

A Technology parameters

	Capex (£/kW)	Maint'nce (p/kWh)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)	Fixed ongoing barrier costs (£ pa)	Variable ongoing barrier costs (£ pa)
Biomass	683	1.08	92%	15%	17	20	4.35	434	100	264
Kerosene	215	0.50	92%	15%	17	20	4.41	-	-	-

B Capex and heat output

	Capex (£)	Modelled annual heat output (kWh/Year)
Biomass	11,616	22,338
Kerosene	3,655	22,338

C Annualised technology resource costs in £ per year

	Annuitised capital cost at 12%	Annual servicing & maint' costs	Annual fuel costs	Annualised upfront barrier costs	Fixed ongoing barrier costs	Variable ongoing barrier costs
Biomass	£1,555	£241	£1,056	£22	£100	£264
Kerosene	£489	£111	£1,070	-	-	-
Difference	£1,066	£130	-£15	£22	£100	£264
Sum of differences	£1,567					

D Biomass, 0 to 19 kW band – tariff breakdown, in pence per kWh

Incentive for:	Amount p/kWh heat
Marginal annualised capital costs	4.77
Annualised upfront barrier costs	0.10
Fixed ongoing barrier costs	0.45
Tier 1* tariff	**5.32**

Marginal fuel costs	-0.07
Marginal servicing & maintenance costs	0.58
Variable ongoing barrier costs	1.18
Tier 2 tariff	**1.70**

Tier 1 tariff	**7.01**

Table 2.20, A to D: Base-case tariff derivation for 20 to 99 kW capacity band

A Technology parameters

	Capex (£/kW)	Maint'nce (p/kWh)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)	Fixed ongoing barrier costs (£ pa)	Variable ongoing barrier costs (£ pa)
Biomass	362	0.21	92%	15%	99	20	3.26	987	150	469
Kerosene	114	0.05	92%	15%	99	20	4.14	-	-	-

B Capex and heat output

	Capex (£)	Modelled annual heat output (kWh/Year)
Biomass	35,873	130,175
Kerosene	11,286	130,175

C Annualised technology resource costs in £ per year

	Annuitised capital cost at 12%	Annual servicing & maint' costs	Annual fuel costs	Annualised upfront barrier costs	Fixed ongoing barrier costs	Variable ongoing barrier costs
Biomass	£4,803	£268	£4,614	£49	£150	£469
Kerosene	£1,511	£59	£5,863	-	-	-
Difference	£3,292	£210	-£1,250	£49	£150	£469
Sum of differences	£2,920					

D Biomass, 20 to 99 kW band – tariff breakdown, in pence per kWh

Incentive for:	Amount p/kWh heat
Marginal annualised capital costs	2.53
Annualised upfront barrier costs	0.04
Fixed ongoing barrier costs	0.12
Tier 1* tariff	**2.68**

Marginal fuel costs	-0.96
Marginal servicing & maintenance costs	0.16
Variable ongoing barrier costs	0.36
Tier 2 tariff	**-0.44**

Tier 1 tariff	**2.24**

Table 2.21, A to D: Base-case tariff derivation for 100 to 199 kW capacity band

A Technology parameters

	Capex (£/kW)	Maint'nce (p/kWh)	Efficiency (%)	Load Factor (%)	Size (kW)	Lifetime (years)	Fuel cost (p/kWh)	Upfront barrier costs (£)	Fixed ongoing barrier costs (£ pa)	Variable ongoing barrier costs (£ pa)
Biomass	241	0.22	91%	15%	199	20	3.26	987	150	469
Kerosene	80	0.08	91%	15%	199	20	4.14	-	-	-

B Capex and heat output

	Capex (£)	Modelled annual heat output (kWh/Year)
Biomass	48,000	261,665
Kerosene	15,920	261,665

C Annualised technology resource costs in £ per year

	Annuitised capital cost at 12%	Annual servicing & maint' costs	Annual fuel costs	Annualised upfront barrier costs	Fixed ongoing barrier costs	Variable ongoing barrier costs
Biomass	£6,426	£579	£9,376	£49	£150	£469
Kerosene	£2,131	£212	£11,916	-	-	-
Difference	£4,295	£368	-£2,539	£49	£150	£469
Sum of differences	£2,791					

D Biomass, 100 to 199 kW band – tariff breakdown, in pence per kWh

Incentive for:	Amount p/kWh heat
Marginal annualised capital costs	1.64
Annualised upfront barrier costs	0.02
Fixed ongoing barrier costs	0.06
Tier 1* tariff	**1.72**
Marginal fuel costs	-0.97
Marginal servicing & maintenance costs	0.14
Variable ongoing barrier costs	0.18
Tier 2 tariff	**-0.65**
Tier 1 tariff	**1.07**

Table 2.22: Base-case tariffs, to one decimal place

Capacity band	Tier 1, p/kWh	Tier 1*, p/kWh	Tier 2, p/kWh
0 to 19 kW	7.0	5.3	1.7
20 to 99 kW	2.2	2.7	-0.4
100 to 199 kW	1.1	1.7	-0.7

The Tier 2 tariffs for the two higher bands are negative due to the current relative prices of wood pellets and kerosene, i.e. kerosene being more expensive than wood pellets on an energy basis. The volatility of energy prices and the difference between them means that in principle the Tier 2 value should change with the market and move from being positive to negative when kerosene is sufficiently more expensive than wood pellets. Whilst negative tariffs may be valid economically, there are obvious practical implications, which are considered in later sections of this report.

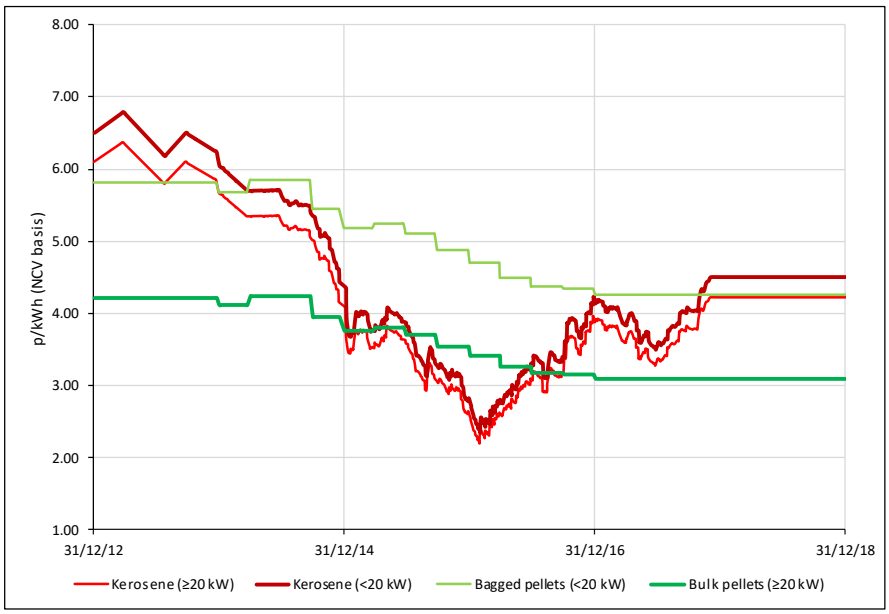
2.6 Tariff sensitivity analysis

2.6.1 Historic fuel prices

Historic prices for kerosene and wood pellets in Northern Ireland have been obtained up to December 2017 and assumed to be constant in real terms thereafter, as illustrated in Figure 2.16. Commercial kerosene prices in November 2017, for volumes suitable for a 99 kW boiler at a 15% load factor, were obtained via a telephone survey of oil suppliers in Northern Ireland. Current and historic domestic kerosene prices for 900 litre deliveries have been sourced from the Consumer Council oil price archive[21]. At our request, the Consumer Council helpfully provided us with the data we required in spreadsheet form.

The commercial prices, based on higher volumes, were naturally lower than those for domestic use. Consequently, for the ≥20 kW bands, the historic 900 litre delivery prices were scaled such that the November 2017 price matched the commercial price determined from the telephone survey. For the <20 kW band, the Consumer Council 900 litre domestic prices have been used directly, albeit adjusted to 2016 prices, as the volumes are similar to domestic use.

Figure 2.16 Historic kerosene and wood pellet prices in Northern Ireland (2016 prices)



Historic wood pellet prices have been obtained from the inspections of biomass boiler installations. To produce the bulk wood pellet prices (in 2016 real terms) shown in Figure 2.16, we have taken median values for data points within each quarter and interpolated between quarters where necessary. Few data points were available for 2013, so we have lower confidence in the corresponding prices than those from around mid-2014 where we estimate the price was around £190 /tonne (4.13 p/kWh nominal) and from late 2014 started to fall. We have also examined the following information sources of historic wood pellet prices, which indicate that pellet prices were relatively stable or rising between during 2013 and early 2014.

1. The CEPA 2012 report, Table 3.3 of which indicates that bulk pellet prices obtained in a market survey in January 2012 were around (3.37p/kWh), which is significantly lower than those observed during mid-2014.
2. Weekly bio-energy newsletters from EnAgri received by Ricardo from January to November 2014 indicate that in the UK and the EU, bulk pellet prices were fairly constant between January 2013 and summer 2014. However, information from the Wood Pellet Association of Canada[22] indicates that prices rose in North America and a report by the Biomass Trade Centre '*Wood fuel prices – Report no. 6*' indicates they rose in Ireland during this period.
3. An article by a pellet supplier[23] indicates European pellet prices were rising in 2013 and 2014.

[21] http://www.consumercouncil.org.uk/energy/home-heating-oil/oil-price-archive
[22] https://www.pellet.org/wpac-news/global-pellet-market-outlook-in-2017
[23] http://www.forever-fuels.com/future-prospects-wood-pellet-prices-and-availability

Based on the information available to us, we believe that the peak price in 2014 was around 4.13 p/kWh, and from early 2013 it seems likely that the price had been increasing to this peak. We have therefore assumed that between January 2013 and late 2014 wood pellet prices were at 4.01 p/kWh (nominal).

The historic fuel prices we have constructed have been used in the cash flows for the scenarios described in section 2.7.

2.6.2 Sensitivity tests undertaken

We have undertaken sensitivity tests affecting Tier 1* and Tier 2, compared with the base-case tariffs presented in Table 2.19 to 2.22, by adjusting specific input assumptions for each test. Tables 2.23 and 2.24 set out the sensitivities that respectively affect Tier 1* and Tier 2. The high and low sensitivities compared with the base-case have been selected on the basis of our judgement of the reasonable possible variation in actual values compared with the assumptions set out in Table 2.18.

Table 2.23: Sensitivity tests affecting Tier 1*

Sensitivity parameter	Code	Value/adjustment by capacity band		
		0 to 19 kW	20 to 99 kW	100 to 199 kW
Reference biomass boiler capex, upper quartile	C	£14,349	£40,998	£50,000
Reference biomass boiler capex, lower quartile	D	£6,000	£30,748	£45,000
Upfront barrier costs	E	+ 100%	+ 100%	+ 100%

Table 2.24: Sensitivity tests affecting Tier 2

Sensitivity parameter	Code	Value/adjustment by capacity band		
		0 to 19 kW	20 to 99 kW	100 to 199 kW
Fuel price differential between biomass and counterfactual	B	Zero	Zero	Zero
Fuel price differential between biomass and kerosene, minimum between 2013 - 2017	F	-0.96 p/kWh	-2.16 p/kWh	-2.16 p/kWh
Fuel price differential between biomass and kerosene, maximum between 2013 - 2017	G	2.37 p/kWh	1.21 p/kWh	1.21 p/kWh
Servicing and maintenance cost differential between biomass and counterfactual	H & I	± 30%	± 30%	± 30%
Ongoing barrier costs	J & K	± 20%	± 20%	± 20%

The tariffs resulting from each of these sensitivities are set out in Table 2.25, overleaf. Each sensitivity is assigned a reference letter, with the base-case (i.e. the unadjusted calculated tariff) being 'A'.

Due to the volatility of fuel prices, sensitivity B, which assumes that wood pellet and kerosene prices are equal, is important. One option for the implementation of tariffs from April 2019 is to exclude differences in fuel prices such that Tier 2 just covers the ongoing barrier costs and the marginal servicing & maintenance costs between biomass and kerosene plant. This avoids negative Tariff 2 values (and for Tariff F a negative Tier 1 value for the 100 to 199 kW band) where the cost of biomass is lower than that for kerosene by an amount greater than the sum of the ongoing barrier and marginal servicing & maintenance costs. Table 2.25 therefore also presents the resulting tariffs for relevant sensitivities based on Tariff B. These are labelled BC, BD, etc. in accordance with the sensitivities applied.

A further tariff variant that is part-way between Tariffs A and B has also been considered. For this "hybrid" tariff, the negative Tier 2 values of Tariff A have simply been set to zero, with consequential changes to the corresponding Tier 1 values (which become the unchanged Tier 1* values). This is denoted "Tariff Hy", and is also included in Table 2.25 below.

Table 2.25: Base-case tariff and sensitivities

Sensitivity reference	Sensitivity description	0 to 19 kW			20 to 99 kW			100 to 199 kW		
		Tier1	Tier1*	Tier2	Tier1	Tier1*	Tier2	Tier1	Tier1*	Tier2
A	**Base-case**	**7.0**	**5.3**	**1.7**	**2.2**	**2.7**	**-0.4**	**1.1**	**1.7**	**-0.7**
B	No fuel price differential	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3
C	Upper quartile biomass capex	8.6	6.9	1.7	2.8	3.2	-0.4	1.2	1.8	-0.7
D	Lower quartile biomass capex	3.6	1.9	1.7	1.7	2.2	-0.4	0.9	1.6	-0.7
E	Up front and fixed and ongoing barrier costs doubled	7.6	5.9	1.7	2.4	2.8	-0.4	1.1	1.8	-0.7
F	Min (most -ve) marginal wood pellet price	6.0	5.3	0.7	0.9	2.7	-1.8	-0.3	1.7	-2.1
G	Max marginal wood pellet price	9.6	5.3	4.3	4.5	2.7	1.8	3.4	1.7	1.7
H	Marginal maintenance +30%	7.2	5.3	1.9	2.3	2.7	-0.4	1.1	1.7	-0.6
I	Marginal maintenance -30%	6.8	5.3	1.5	2.2	2.7	-0.5	1.0	1.7	-0.7
J	Variable ongoing barrier costs +20%	7.2	5.3	1.9	2.3	2.7	-0.4	1.1	1.7	-0.6
K	Variable ongoing barrier costs -20%	6.8	5.3	1.5	2.2	2.7	-0.5	1.0	1.7	-0.7
Sensitivities on B, Base-case – with no fuel price differential										
B	**Base-case (no fuel price differential)**	**7.1**	**5.3**	**1.8**	**3.2**	**2.7**	**0.5**	**2.0**	**1.7**	**0.3**
BC	Upper quartile biomass capex	8.7	6.9	1.8	3.7	3.2	0.5	2.1	1.8	0.3
BD	Lower quartile biomass capex	3.7	1.9	1.8	2.7	2.2	0.5	1.9	1.6	0.3
BE	Up front and fixed ongoing barrier cost doubled	7.6	5.9	1.8	3.4	2.8	0.5	2.1	1.8	0.3
BH	Marginal maintenance +30%	7.2	5.3	1.9	3.3	2.7	0.6	2.1	1.7	0.4
BI	Marginal maintenance -30%	6.9	5.3	1.6	3.2	2.7	0.5	2.0	1.7	0.3
BJ	Variable ongoing barrier costs +20%	7.3	5.3	2.0	3.3	2.7	0.6	2.1	1.7	0.4
BK	Variable ongoing barrier costs -20%	6.8	5.3	1.5	3.1	2.7	0.4	2.0	1.7	0.3
Variant of Tariff A Base-case – negative Tier 2 values set to zero										
Hy	**Base-case – hybrid tariff**	**7.0**	**5.3**	**1.7**	**2.7**	**2.7**	**0.0**	**1.7**	**1.7**	**0.0**

2.7 Impact of tariffs on the installation population

2.7.1 Scenario approach and cash flow methodology

This section examines the impact of applying the base-case tariffs and their sensitivity variants (as set out in Table 2.25) to the complete population of 2,031 small and medium biomass installations (which excludes cancelled and rejected installations). There are some installations that have yet to be fully accredited and for which there is no heat data. For each of these a 15% load factor has been applied to estimate their annual heat generation.

The tariffs can be applied to the population in different ways, and we refer to these as **scenarios**. For each scenario, the following have been determined.

- The number of installations that are projected to achieve an IRR of less than 8%.
- The number of installations that are projected to achieve an IRR between 8 and 22%, inclusive.
- The number of installations that are projected to achieve an IRR of greater than 22%.
- The projected total Scheme cost to government.

These have been calculated via a cash flow model, which for each installation takes account of the following:

- The installation's direct capital cost as provided by the participant in their original application minus the equivalent counterfactual boiler's capital cost.
- The assumed up-front biomass boiler barrier cost. As explained in section 2.5, Tier 1 is designed to provide no return on the up-front barrier cost element. To be consistent with this approach, in the cash flow the up-front barrier cost is spread equally over the 20 years of operation rather than being counted alongside the capital cost in year zero.
- Future annual eligible heat use is assumed to be the same as the historic average. For installations with no heat data, a 15% load factor has been used to calculate the assumed annual heat use from the accreditation date and incentive payments calculated on that basis.
- Marginal biomass fuel costs to date based on historic wood pellet and kerosene prices. Going forward, a fixed value for this is used, based on recent/current conditions (see Figure 2.16)
- Marginal ongoing costs for servicing and maintenance, plus on-going barrier costs.
- Boiler efficiencies are taken as those assumed for the tariff derivation (section 2.4.8.3)
- Depending on the scenario: actual incentive payments made to date; projected payments until the end of March 2019 under the current tariffs; future payments to the end of the installation's 20-year term in the RHI under the calculated tariffs.
- Historic cash flows, as appropriate, are inflated to 2016 values[24] so that the entire cash flow and results are expressed in 2016 real terms.

2.7.2 Reference scenarios

For reference purposes, a number of scenarios have been modelled as follows:

Scenario 1: Original tariffs levels and structure
This assumes that the tariff levels and structure in place at the time of accreditation for each installation are retained and inflated accordingly. In other words, the scenario assumes that the April 2017 tariffs were not introduced and individual installations continue to receive their original tariffs for their entire 20-year period from accreditation.

Scenario 2: Continuation of 2017/18 tariffs
This assumes the actual tariffs for each installation to date and then the current 2017/18 tariffs, including 400,000 kWh pa cap, continue with appropriate inflation adjustment to the end of each installation's 20-year period from accreditation.

Scenario 3: Cease RHI payments from 1 April 2019
This is as per Scenario 2, but assumes that no further RHI payments are made from 1 April 2019.

[24] Using: https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/chaw/mm23

The outcomes of these three scenarios are summarised in Table 2.26.

Table 2.26: Outcomes of Scenarios 1 to 3

Scenario		No. of installations			Scheme cost (2016 real terms)			
		IRR < 8%	8% ≤ IRR ≤ 22%	IRR > 22%	To Oct '17	Oct 17 to 31 Mar '19	From 1 Apr '19	Total
1	Original tariffs levels and structure	47	126	1,858	£89 m	£66 m	£692 m	£847 m
2	Continuation of 2017/18 tariffs	51	142	1,838	£79 m	£34 m	£337 m	£451 m
3	Cease RHI payments from 1 April '19	297	215	1,519	£79 m	£34 m	£0 m	£114 m

For the purposes of comparison, the same scenarios, but assuming that all installations start afresh in the RHI from 1 April 2019 (i.e. are accredited on 31 March 2019 for 20 years) have also been modelled:

Scenario 1(4): NI RHI starts afresh on the 2012 tariff[25] from 1 April 2019

Scenario 2(4): NI RHI starts afresh on the 2017 tariff from 1 April 2019

Scenario 3(4): NI RHI starts afresh from 1 April 2019 with zero RHI support

In addition, the following scenarios have been modelled using the main newly calculated tariffs (from Table 2.25):

Scenario 4A: NI RHI starts afresh with new Tariff A from 1 April 2019
This scenario applies the new calculated base-case tariff (Tariff A) to the population of installations, assuming that they are all accredited on 31 March 2019 and that energy prices and boiler efficiencies are equal to those assumed in developing the tariffs. No annual heat cap has been applied due to the negative Tier 2 values.

The purpose of this scenario is to test the validity of the base-case tariff against the population of installations.

Scenario 4B: NI RHI starts afresh with new Tariff B
This scenario applies the new calculated base-case tariff omitting any fuel cost differential (Tariff B) to the population of installations, assuming that they are all accredited on 31 March 2019 and that energy prices and boiler efficiencies are equal to those assumed in developing the tariffs. A 400,000 kWh pa cap is included.

Tariff B omits the fuel price differential that has biomass at a lower cost than kerosene and which gives rise to negative Tier 2 rates in Tariff A.

Scenario 4Hy: NI RHI starts afresh with new Tariff Hy
This scenario applies the new calculated base-case tariff with negative Tier 2 values set to zero (and Tier 1 adjusted accordingly) to the population of installations, assuming that they are all accredited on 31 March 2019 and that energy prices and boiler efficiencies are equal to those assumed in developing the tariffs. A 400,000 kWh pa cap is included, but in practice makes no difference to the outcomes.

The outcomes of these six 'start afresh' scenarios are set out in Table 2.27 below. The outcomes for Scenarios 1(4) and 2(4) differ only slightly in their IRR distributions from their respective parent scenarios. Scenario 3(4) confirms that most installations need a level of support to make them cost-effective, although Scenario 3 shows that around 1,734 (85%) will have already received sufficient NI RHI support by April 2019 to achieve at least an 8% IRR.

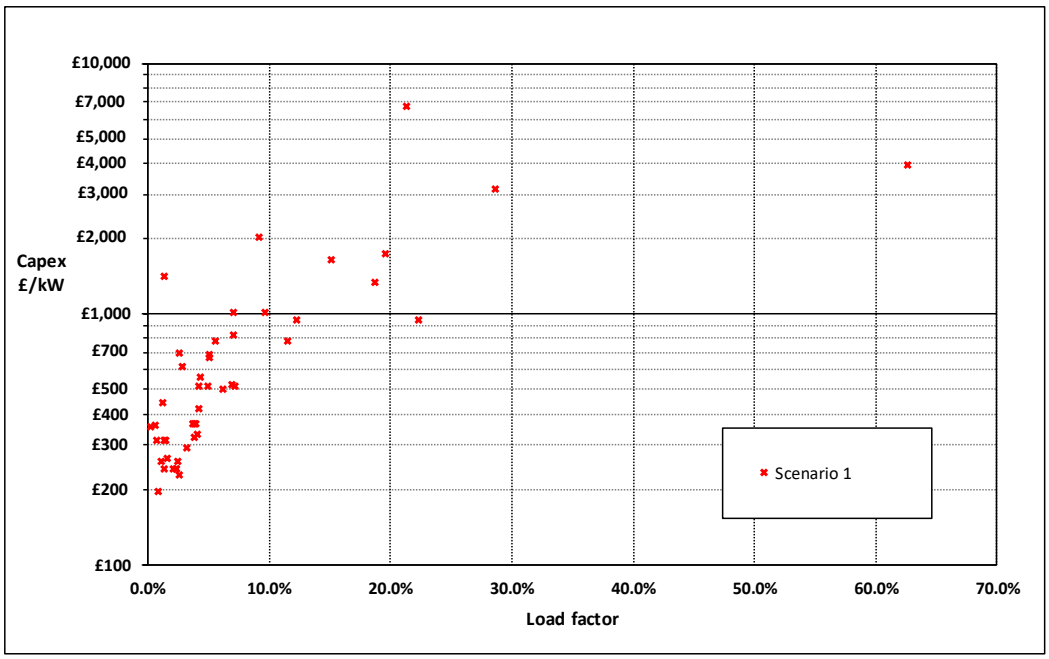
[25] For simplicity, the 2012 tariff is used for all installations rather than a mixture of the 2012 and 2015 tariffs.

Table 2.27: Outcomes of 'start afresh' scenarios

Scenario		No. of installations			Scheme cost (2016 real terms)			
		IRR < 8%	8% ≤ IRR ≤ 22%	IRR > 22%	To Oct '17	Oct 17 to 31 Mar '19	From 1 Apr '19	Total
1(4)	Scenario 1, but starts afresh	41	115	1,875	n/a	n/a	£853 m	£853 m
2(4)	Scenario 2, but starts afresh	46	144	1,841	n/a	n/a	£417 m	£417 m
3(4)	Scenario 3, but starts afresh	1,213	665	153	n/a	n/a	£0 m	£0 m
4A	NI RHI starts afresh with Tariff A, no cap	364	1,182	485	n/a	n/a	£67 m	£67 m
4B	NI RHI starts afresh with Tariff B, with 400 MWh cap	165	490	1,376	n/a	n/a	£180 m	£180 m
4Hy	NI RHI starts afresh with Tariff Hy, with 400 MWh cap	227	780	1,024	n/a	n/a	£125 m	£125 m

The modelling demonstrates that continuation of the original tariffs as they applied to installations at their point of accreditation (Scenario 1) would have meant a total Scheme cost of around £847 million (2016 real terms). Furthermore, around 90% of installations would have been over-compensated, assuming this is represented by an IRR of over 22%. Nevertheless, 47 installations exhibit IRRs of less than 8%. Examining the detail of these sites shows that they have a low load factor, high capital cost, or both as can be seen in Figure 2.17.

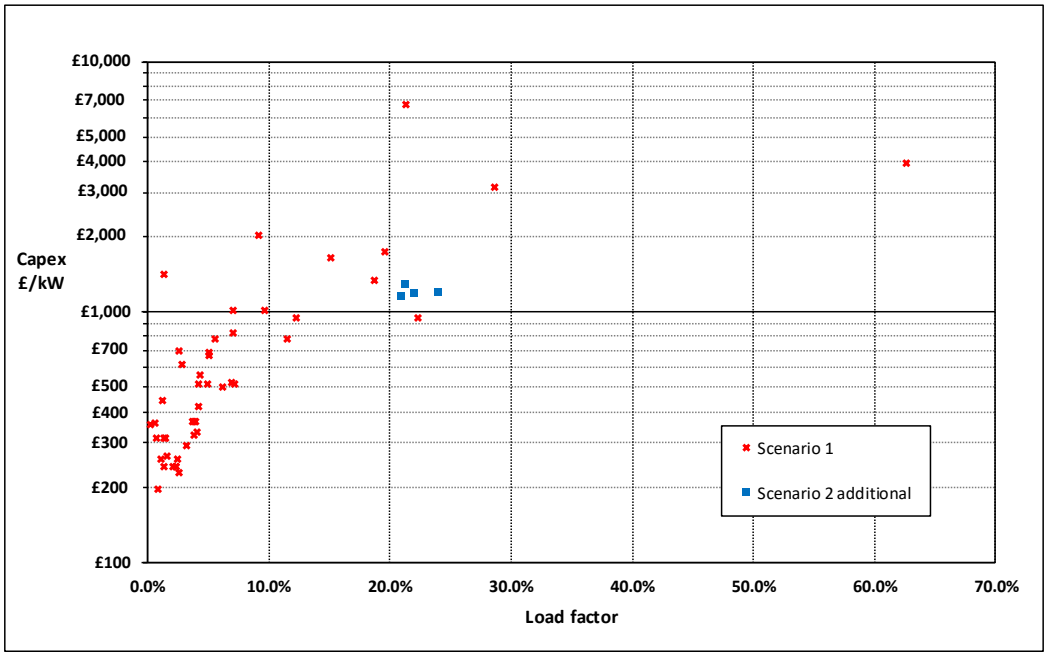
Figure 2.17: Capital cost per kW plotted against load factor for Scenario 1 - Installations with IRRs <8%



Load factors are based on actual heat metered and claimed by the participants and, unless there are meter faults or misreadings, are likely to be reliable. As already remarked, we believe that some participants misunderstood the application form instructions and may well have included wider costs not directly associated with the actual biomass boiler installation; the apparent high capital costs of some installations may therefore not reflect the scope intended.

Compared with Scenario 1, continuation of the current tariffs (Scenario 2) makes only a limited difference to the number of installations falling into each IRR range, but reduces the total Scheme cost from around £846 million to £451 million, and causes only an additional four installations to fall below an IRR of 8%. These are included in Figure 2.18 alongside those under Scenario 1. The four all have reasonable load factors, but apparently high capital costs.

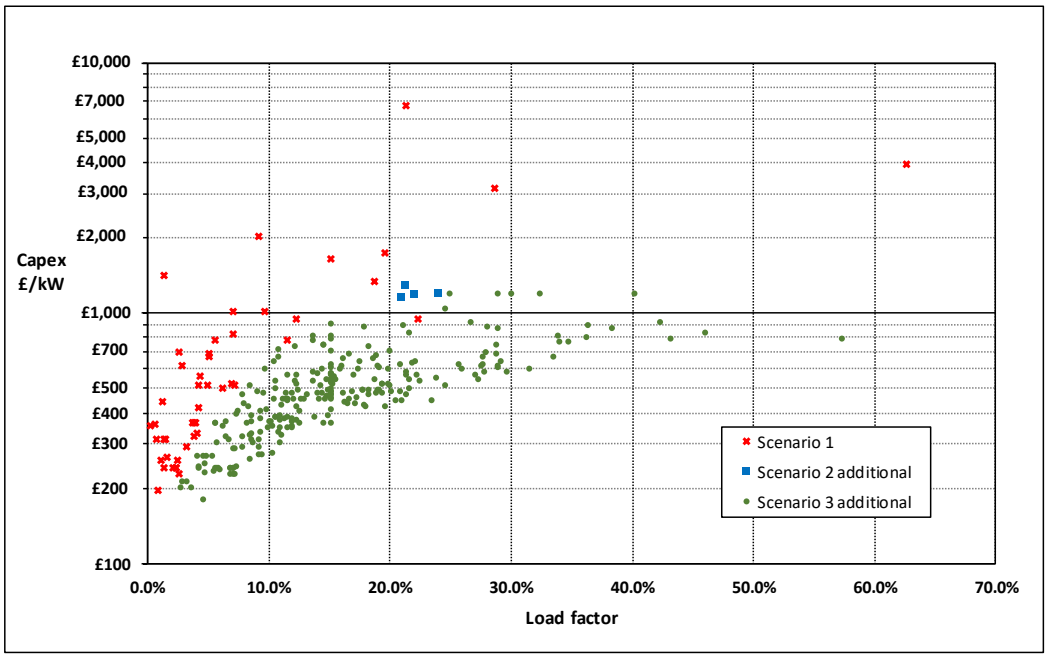
Figure 2.18: Capital cost per kW plotted against load factor for Scenarios 1 and 2 - Installations with IRRs <8%



Although the introduction by the Department of the revised tariffs from 1 April 2017 should produce a significant reduction in overall Scheme costs, the results of Scenario 2 indicate that continuation of the existing tariffs would still result in over-compensation of around 90% of Schemes.

It is revealing to see that if incentive payments ceased entirely from 1st April 2019 (Scenario 3) then around 1,519 installations (75%) would still achieve an IRR of 22% or more. Not unexpectedly, at the same time the number failing to achieve 8% would increase, to 297. The additional 246 installations with IRRs falling below 8% are shown in Figure 2.19 as green points. Whilst many still exhibit high capital costs and/or low load factors, those with more typical values were mainly accredited immediately before the November 2015 tariff change or suspension of the Scheme at the end of February 2016 and so would receive incentive payments for a limited period under this scenario.

Figure 2.19: Capital cost per kW plotted against load factor for Scenarios 1, 2 and 3 - Installations with IRRs <8%



Scenario 4A applies the new calculated base-case tariff (Tariff A) to the population of installations, assuming that they are all accredited on 31 March 2019. A cap is not applied as there are negative Tier 2 values under Tariff A. Tariff A takes account of the higher price of kerosene relative to biomass, which is currently sufficient to make Tier 2 negative for the two bands covering the capacity range 20 to 199 kW. This balances the benefit that the participant would gain from the lower fuel price compared with the counterfactual; it is worth noting that other fossil fuels commonly used for heating in Northern Ireland, gas-oil and LPG, are more expensive than kerosene on an energy basis.

Scenario 4A gives an outcome that is much more in line with the original intentions of the Scheme, with around 58% of the installations falling into the 8-22% IRR range. Nevertheless, there are still a significant number of installations above and below this range. Figure 2.20 shows the capital cost per kW plotted against load factor for the 485 installations with an IRR greater than 22% under Scenario 4A and Figure 2.21 shows the corresponding distribution of IRRs. At least some of the particularly high IRRs, we believe, are the result of anomalies in the data set.

Figure 2.20: Capital cost per kW plotted against load factor for Scenario 4A - Installations with IRRs >22%

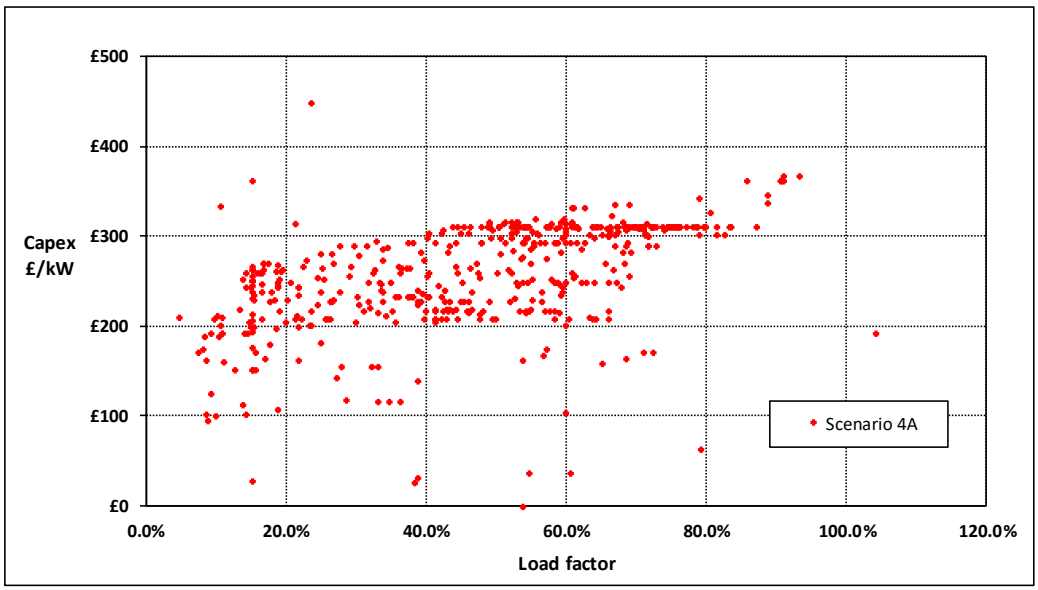


Figure 2.21: Internal Rates of Return above 22% for installations under Scenario 4A

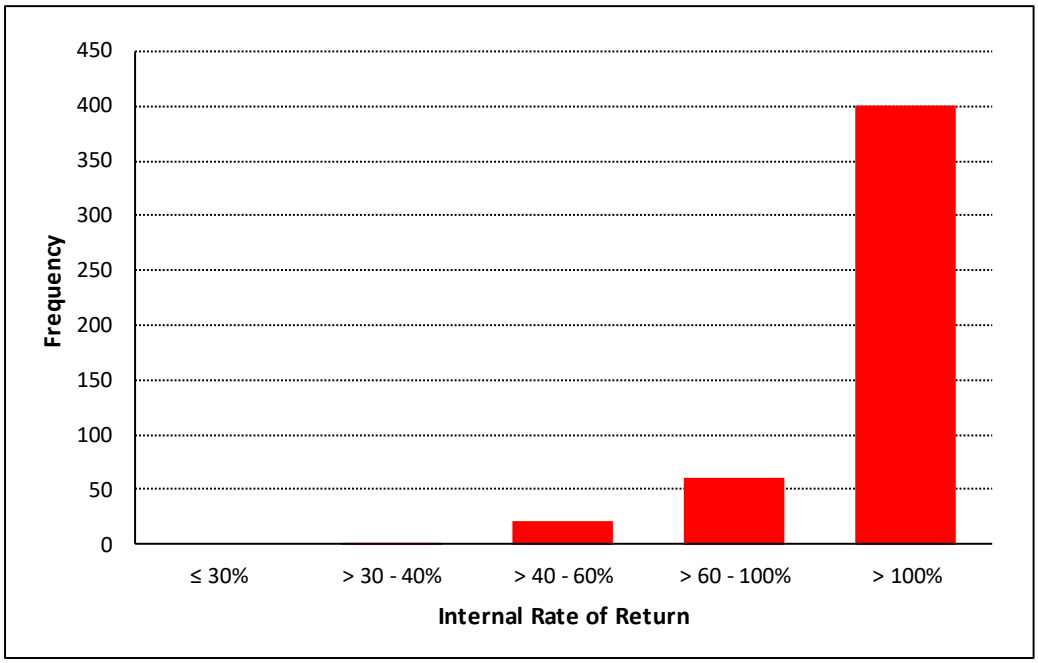
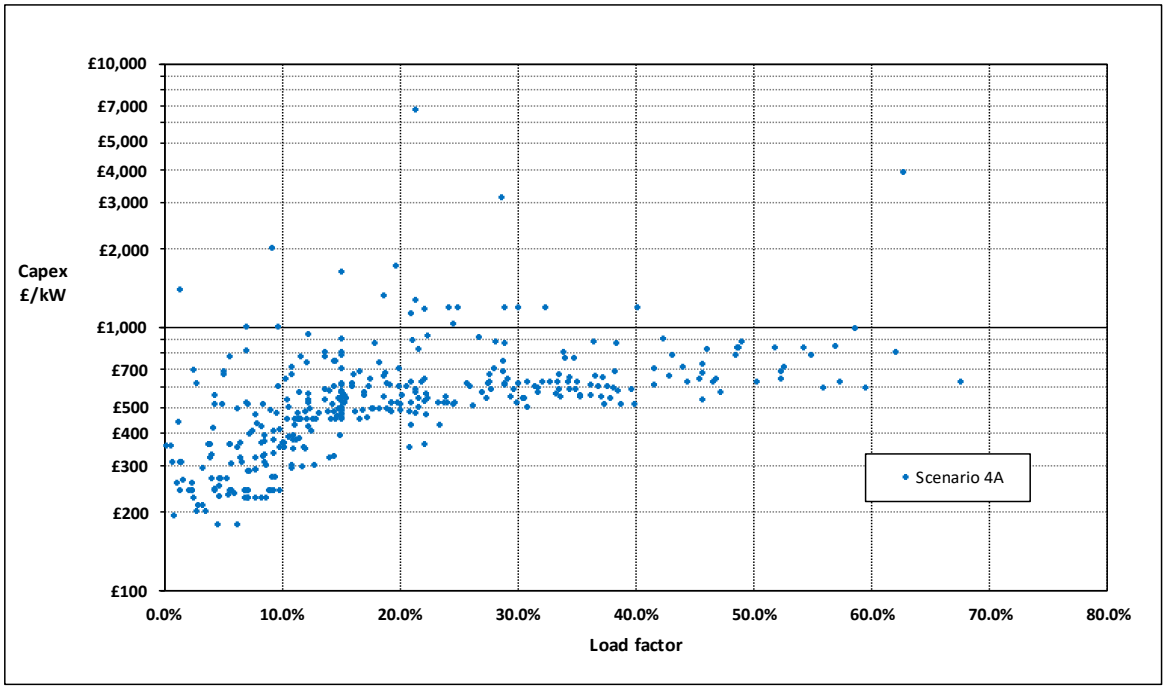


Figure 2.22 shows the capital cost per kW plotted against load factor for the 364 installations with an IRR less than 8% under Scenario 4A. The distribution of points includes a concentration of installations with load factors from 20% to 60% and capital costs between £500 /kW and £700 /kW, where the higher load factors would usually be expected to off-set the higher capital costs. This is an effect of the negative Tier 2 tariffs, where increasing load factor actually reduces the incentive payment income. The distribution of installations with IRRs >22% in Figure 2.20 also exhibits a distorted pattern for the same reason.

Figure 2.22: Capital cost per kW plotted against load factor for Scenario 4A - Installations with IRRs <8%



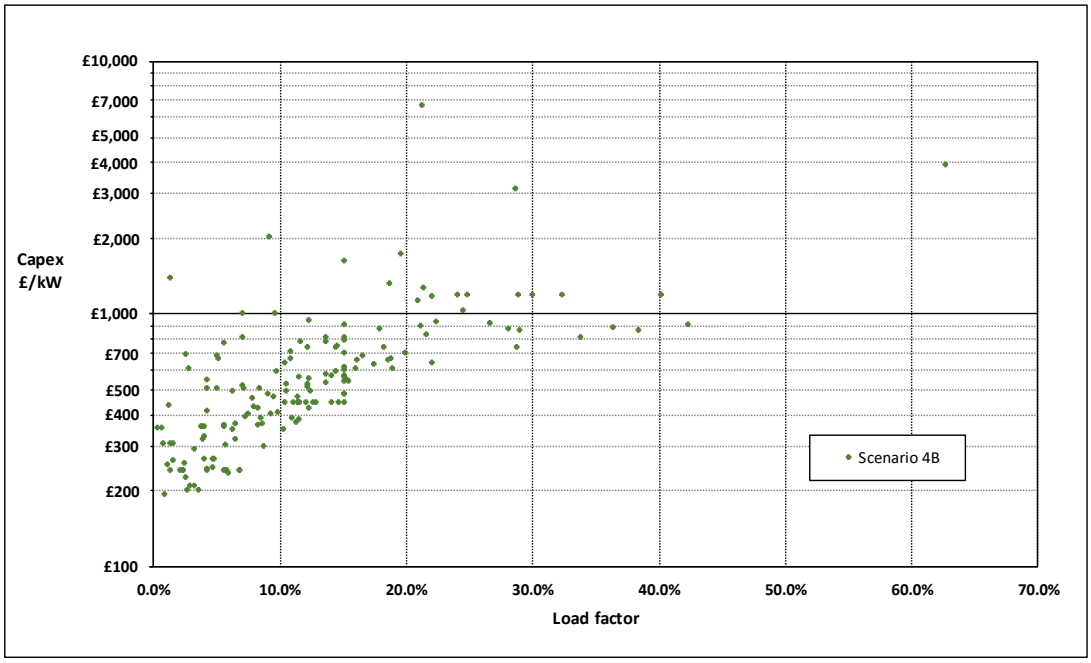
In terms of the distribution of installations between the three IRR ranges (364 <8%; 1,182 8% to 22%; and 485 >22%), Scenario 4A demonstrates that, in principle, the base-case Tariff A provides an appropriate set of incentive rates based on current circumstances.

Whilst negative Tier 2 tariffs moving forward may in theory bring the NI RHI back closer to its original intentions, there are of course practical, political and possibly legal difficulties in such a course. Not least, negative Tier 2 tariffs would have a profound impact on participant behaviour, particularly where load factors would normally exceed the 15% Tier 1 to Tier 2 threshold.

Scenario 4B is the same as 4A, but with Tariff B applied; i.e. the base-case tariff but omitting any account of difference in the biomass and counterfactual fuel prices. This removes the negative tariffs and shifts the balance of installations strongly towards achieving higher returns. Scenario 4B includes an annual heat cap of 400,000 kWh. The scenario also assumes that the current low cost of wood pellets relative to kerosene continues. As shown in Figure 2.16 in section 2.6.1, over the period of the NI RHI to date the cost per kWh of bulk wood pellets has been less than that of kerosene for around three and a half years out of five, which has been to the benefit of participants. A tariff that takes no account of the fuel price differential is likely therefore to be more generous on average over the remaining years of the Scheme than one that takes account of a snap-shot of fuel prices at a point in time.

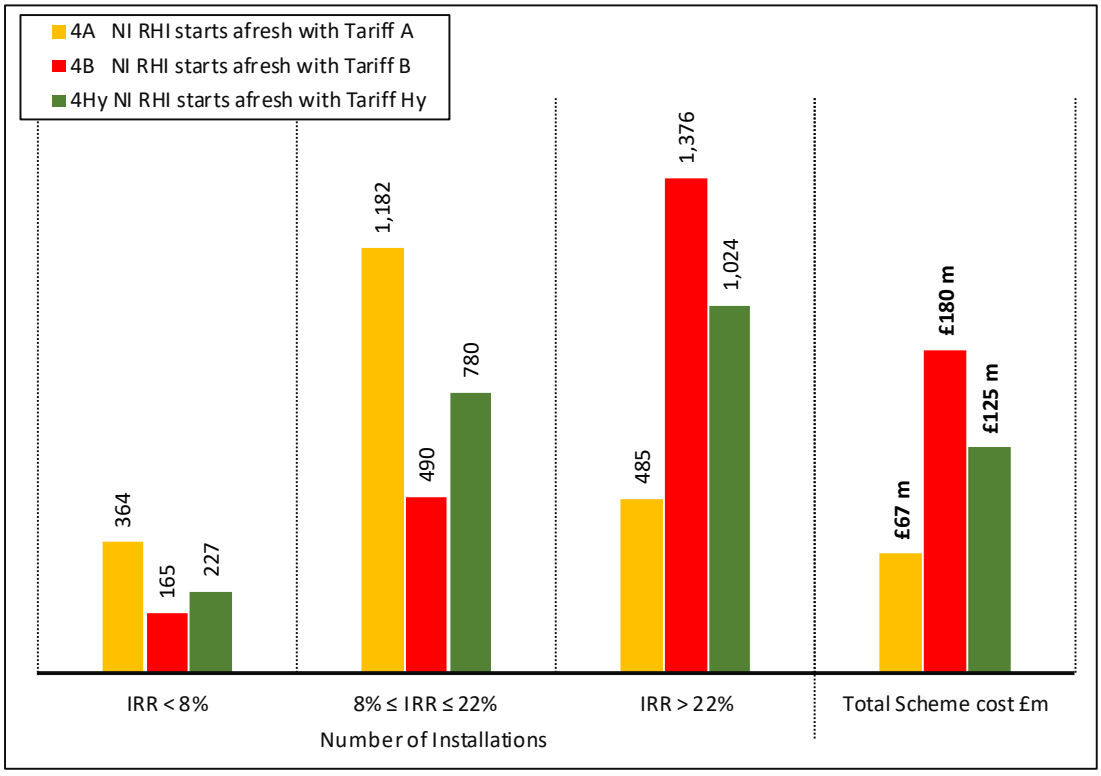
Figure 2.23 shows the plot of capital cost per kW against load factor for the 165 installations with IRRs under 8% under Scenario 4B. The shape of the distribution does not exhibit the distortion of Scenario 4A (Figure 2.22).

Figure 2.23: Capital cost per kW plotted against load factor for Scenario 4B installations with IRRs <8%



Whilst limiting the number of installations failing to achieve an 8% IRR, Scenario 4B results in around 68% of installation having IRRs above 22% and so Tariff B appears to be over-generous. Scenario 4Hy provides a more balanced distribution of installations across the three IRR categories, albeit still with around 50% achieving IRRs above 22% as shown in Figure 2.24.

Figure 2.24: Distribution of IRRs and total Scheme costs for Scenarios 4A, 4B and 4Hy



The scenarios examined so far have considered for the full 20 years:

Scenario 1. Continuation of the original tariffs

Scenario 2. Continuation of the current tariffs (i.e. no further change)

Scenario 3. Ceasing payments altogether from April 2019

Scenario 4. Starting the NI RHI afresh with the three principal tariffs derived in sections 2.5 and 2.6, and the equivalents of Scenarios 1, 2 and 3.

The Department's intention is to introduce a new tariff from 1 April 2019; in the meantime, the current tariffs will continue to apply. In the following section we examine the impact of introducing revised tariffs from 1 April 2019 to the end of the remainder of each installation's 20-year period, including actual history to date and estimates to 31 March 2019.

2.7.3 Scenarios: actual tariffs to April 2019 followed by new tariffs options

To examine the impact of revised biomass tariffs being introduced from April 2019, we have applied the new base-case tariffs and their sensitivity variants (as set out in Table 2.25) to the population of installations from 1 April 2019. These scenarios employ historic actual data, the current (April 2017) tariffs to 1 April 2019, and then the new base-case tariffs and each of the variants to the end of each installation's 20-year term in the Scheme from its actual accreditation date. The assumption that future annual heat use is the same as the historic average is maintained, but the 400,000 kW annual cap is not applied for Tariff A and its variants due to the negative Tier 2 values.

The scenarios are each given the prefix 5 followed by the applicable tariff reference letters as shown with their outcomes in Table 2.28 below. The scenario results are divided into those with tariffs including and those excluding fuel price differentials, plus the hybrid Tariff Hy.

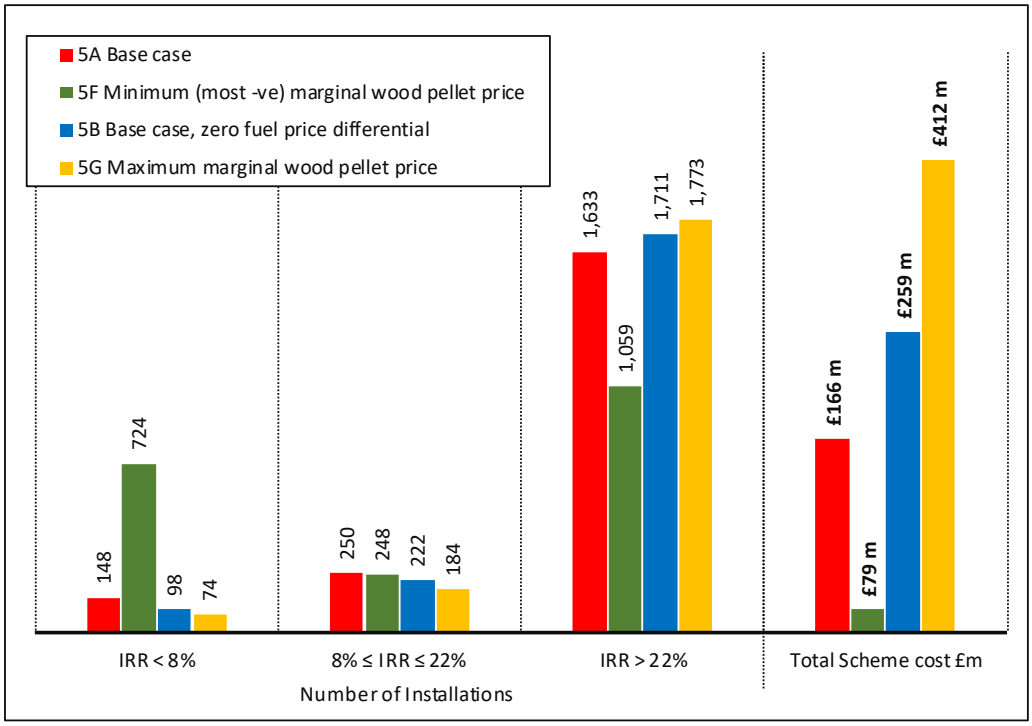
Table 2.28: Outcomes of Scenario 5 variants

Scenario		No. of installations			Scheme cost (2016 real terms)			
		IRR < 8%	8% ≤ IRR ≤ 22%	IRR > 22%	To Oct '17	Oct 17 to 31 Mar '19	From 1 Apr '19	Total
History from accreditation, then new tariffs from 1 April 2019: including fuel price differential, but no cap								
5A	Base-case	148	250	1,633	£79 m	£34 m	£53 m	£166 m
5C	Upper quartile biomass capex	122	250	1,659	£79 m	£34 m	£73 m	£187 m
5D	Lower quartile biomass capex	172	251	1,608	£79 m	£34 m	£35 m	£148 m
5E	Up front and fixed and ongoing barrier costs doubled	137	250	1,644	£79 m	£34 m	£59 m	£173 m
5F	Min (most -ve) marginal wood pellet price	716	245	1,070	£79 m	£34 m	-£94 m	£19 m
5G	Max marginal wood pellet price	74	184	1,773	£79 m	£34 m	£293 m	£407 m
5H	Marginal maintenance +30%	143	250	1,638	£79 m	£34 m	£56 m	£170 m
5I	Marginal maintenance -30%	149	255	1,627	£79 m	£34 m	£45 m	£159 m
5J	Variable ongoing barrier costs +20%	143	250	1,638	£79 m	£34 m	£56 m	£170 m
5K	Variable ongoing barrier costs -20%	149	255	1,627	£79 m	£34 m	£45 m	£159 m

Scenario		No. of installations			Scheme cost (2016 real terms)			
		IRR < 8%	8% ≤ IRR ≤ 22%	IRR > 22%	To Oct '17	Oct 17 to 31 Mar '19	From 1 Apr '19	Total
History from accreditation, then new tariffs from 1 April 2019: excluding fuel price differential, but with 400 MWh cap								
5B	Base-case	98	222	1,711	£79 m	£34 m	£145 m	£259 m
5BC	Upper quartile biomass capex	88	215	1,728	£79 m	£34 m	£162 m	£276 m
5BD	Lower quartile biomass capex	113	231	1,687	£79 m	£34 m	£128 m	£242 m
5BE	Up front and fixed ongoing barrier cost doubled	93	220	1,718	£79 m	£34 m	£153 m	£266 m
5BH	Marginal maintenance +30%	93	221	1,717	£79 m	£34 m	£154 m	£268 m
5BI	Marginal maintenance -30%	98	223	1,710	£79 m	£34 m	£145 m	£259 m
5BJ	Variable ongoing barrier costs +20%	93	221	1,717	£79 m	£34 m	£154 m	£268 m
5BK	Variable ongoing barrier costs -20%	101	225	1,705	£79 m	£34 m	£137 m	£250 m
History from accreditation, then new hybrid tariff from 1 April 2019, with 400 MWh cap								
5Hy	Hybrid tariff	114	241	1,676	£79 m	£34 m	£101 m	£214 m

The sensitivities on capital, barrier and marginal maintenance costs make only a modest impact on the spread of installations across the three IRR groups and the overall Scheme cost to government. Assumptions in deriving the tariffs on fuel price differentials have more impact, as illustrated in Figure 2.25. We believe that the general insensitivity of the results to most parameters is due to the incentive payments already made and projected to be made up to April 2019.

Figure 2.25: Impact of tariff fuel price differential assumptions



2.7.3.1 Reduction in the annual heat cap

We have also considered scenarios whereby the annual heat cap is reduced from its current level of 400,000 kWh (400 MWh). Specifically, we have examined Scenario 5B modified with caps of 300, 100 and 50 MWh pa (Scenarios 6B, 7B and 8B respectively). The results are shown in Table 2.29 below.

Table 2.29: Impact of reduction in the annual heat cap

Scenario		No. of installations			Scheme cost (2016 real terms)			
		IRR < 8%	8% ≤ IRR ≤ 22%	IRR > 22%	To Oct '17	Oct 17 to 31 Mar '19	From 1 Apr '19	Total
From 1 April 2019 – excluding fuel price differential								
5B	Base-case (cap at 400 MWh pa)	98	222	1,711	£79 m	£34 m	£145 m	£259 m
6B	Cap reduced to 300 MWh pa	98	222	1,711	£79 m	£34 m	£138 m	£251 m
7B	Cap reduced to 100 MWh pa	113	242	1,676	£79 m	£34 m	£91 m	£204 m
8B	Cap reduced to 50 MWh pa	139	276	1,616	£79 m	£34 m	£49 m	£162 m

Reducing the cap to 300 MWh pa has no impact on the distribution of installations in the three IRR categories. It does however reduce the cost to government by around £8 million. Further cap reduction increases the numbers of installations in the <8% and 8 to 22% ranges by 15 and 20 respectively with a 100 MWh cap, and by a further 26 and 34 respectively with a 50 MWh cap. The corresponding cost to government reduces by a further £47 million with the 100 MWh cap and a further £42 million with the 50 MWh cap. There appear therefore to be significant financial savings to government with a lower cap, but with comparable impact regarding the increase of installations failing to reach an 8% IRR.

2.7.3.2 Reduction in future heat generation

So far, we have assumed that the annual heat production of installations in the future will be the same as the historical average. There is evidence that the 1 April 2017 introduction of Tier 2 and the 400,000 kWh pa cap has stimulated a reduction in heat production from many installations that were accredited prior to 19 November 2015. Whilst weather (ambient temperature) has probably had some impact, it could well be that better energy efficiency practices and the reduction of inadvertent or deliberate waste have played a part.

We have consequently run a further scenario using Scenario 5B as the starting point. In this, Scenario 9B, we have reduced the assumed future annual heat generation by 20%. The outcome compared with Scenario 5B is shown in Table 2.30.

Table 2.30: Impact of reduction in the future heat production from all installations and increase in load factor threshold

Scenario		No. of installations			Scheme cost (2016 real terms)			
		IRR < 8%	8% ≤ IRR ≤ 22%	IRR > 22%	To Oct '17	Oct 17 to 31 Mar '19	From 1 Apr '19	Total
From 1 April 2019 – excluding fuel price differential								
5B	Base-case: future heat = average historic production pa	98	222	1,711	£79 m	£34 m	£145 m	£259 m
9B	20% reduction in future heat for 5B	117	230	1,684	£79 m	£32 m	£140 m	£251 m
10B	35% tier threshold for 5B	94	193	1,744	£79 m	£34 m	£247 m	£361 m

2.7.3.1 Increase in the load factor threshold between Tiers 1 and 2

Scenario 10B examines the impact of increasing the load factor threshold between Tier 1 and Tier 2 from 15% to 35%. Again, Scenario 5B is the starting point for this variant and the outcome is also presented in Table 2.30 (above). It is clear that such a change would simply increase the overall level of over-compensation and the add significant costs to government.

2.7.4 Application of GB tariffs to Northern Ireland

For comparative purposes, the Department requested that we run scenarios that assume:

- The current GB solid biomass boiler tariff is adopted in Northern Ireland from 1 April 2019 (2016 real prices):

  Tier 1 = 2.84 p/kWh

  Tier 2 = 2.00 p/kWh

  Tier threshold = 35%

  No annual cap

  The current GB tariff applies equally to all capacity bands. The difference between Tier 1 and Tier 2 at 2.91 p/kWh and 2.04 p/kWh (2016 real) is much lower than for previous tariffs. The tier threshold is now 35%, where previously it was 15%. We understand that the current GB biomass tariff is designed to encourage larger installations at greater load factors.

- The GB tariff that was current in November 2015 is adopted in Northern Ireland from 1 April 2019, which for the relevant NI capacity bands is (2016 real prices):

  Tier 1 = 4.17 p/kWh (2016 real)

  Tier 2 = 1.10 p/kWh (2016 real)

  Tier threshold 15%

  No annual cap

These are denoted Scenarios 11 and 12 respectively and include historical/projected payments up to April 2019. The outcomes are shown in Table 2.31, together with the corresponding Scenarios 11(4) and 12(4), which assume the NI RHI starts afresh at 1 April 2019 for 20 years.

Table 2.31: Impact of applying GB tariffs to Northern Ireland

Scenario		No. of installations			Scheme cost (2016 real terms)			
		IRR < 8%	8% ≤ IRR ≤ 22%	IRR > 22%	To Oct '17	Oct 17 to 31 Mar '19	From 1 Apr '19	Total
11	Current GB tariff from 1/4/2019	101	196	1,734	£79 m	£34 m	£280 m	£394 m
11(4)	Scenario 11, but starts afresh	149	295	1,587	£0 m	£0 m	£342 m	£342 m
12	Nov 2015 GB tariff from 1/4/2019	78	198	1,755	£79 m	£34 m	£241 m	£354 m
12(4)	Scenario 12, but starts afresh	93	296	1,642	£0 m	£0 m	£296 m	£296 m

Compared with Tariff B (Scenario 5B), employing the current GB tariff from 1 April 2019 (Scenario 11) provides no advantage to the Northern Ireland Scheme; it would make little difference to the installations below an 8% IRR and increase the number of installations being over-compensated. It would also increase the cost to government by around £135 million. Similarly, adoption of the GB Nov 2015 tariff would increase the number of installations with IRRs >22% and have a total cost of around £95 million greater than with Tariff B.

The full set of the scenarios, their tariffs and outcomes are provided at Appendix A.

3 Discussion of results

3.1 Calculated tariffs and scenarios

Our analysis shows that continuation of the pre-April 2017 tariffs for the full 20 years for each installation, would have resulted in a total cost to government of the RHI Scheme of around £847 million in 2016 real terms (Scenario 1). This assumes that all the existing installations continued in the Scheme for the full 20 years and that heat generation continued at the levels seen to date. On their own, we project that the introduction of the April 2017 tariffs will reduce that total cost to around £451 million should they continue unchanged (Scenario 2).

If the current situation was allowed to continue to April 2019 only and incentive payments then ceased altogether, we estimate that 1,734 installations out of 2,031 will have achieved an Internal Rate of Return (IRR) of at least 8%, with 1,519 having an IRR of greater than 22%. In other words, by April 2019 around 11% of installations will have achieved a return on investment within the original expectations of the Scheme and 75% will have exceeded those expectations. There is therefore an argument that at least those who have met or exceeded the 22% top of the anticipated range, or even the 12% central value, should receive no further public support. If such an option was adopted (and we appreciate that this is very unlikely to be the case), then additional measures would need to be put in place to ensure that the owners of the remaining installations were not disadvantaged. This might be achieved through some form of re-application or individual installation assessment process.

We have calculated a new set of 'base-case' tariffs for the three capacity bands selected. These are based on our best re-assessment of assumptions from data available to us. Compared with the original assumptions, the following are critical.

- **Capital costs**
  The original capital cost assumptions for boilers upwards of 20 kW capacity have been shown to be significant over-estimates when compared with the figures submitted by applicants and data validated in the course of recent site inspections. Since the original work the biomass equipment market and supply chain has significantly developed as a consequence of the RHI Schemes in both GB and NI.

  Whilst we have good confidence in the assumed capital costs we have employed to derive the tariffs, the figures provided by applicants exhibit a wide range with some of the costs being clearly unrealistic. This has an impact on the numbers of installations falling into each of the IRR categories under each scenario.

- **Load factors**
  Actual load factors have exceeded the original assumption. Whilst use of a single load factor for each reference boiler is unavoidable, this limitation needs to be managed by tariff tiering and capping.

- **Marginal fuel costs**
  The difference in fuel cost between the biomass and the counterfactual was assumed to be negative in the original tariff derivation work but was compensated for by ongoing barrier costs, which we consider to be too high. Since 2013 the actual marginal fuel cost has been both negative and positive. Our calculation of the base-case tariffs (Tariff A) is based on recent fuel prices, which has resulted in negative Tier 2 tariffs for the bands above 20 kW. The volatility of fuel prices means that the inclusion of the marginal fuel cost in the tariff derivation risks the tariff becoming inappropriate very quickly; the rates of return (at a particular tariff) are very sensitive to the marginal fuel cost. To avoid the need for almost constant review, we believe it better to remove marginal fuel cost from the tariff derivation altogether (Tariff B). Over time, there will be some balancing out, but overall we expect that bulk wood pellet prices will remain lower than for kerosene (this has been the case for the majority of the period from 2013 to date), and so RHI participants will not be disadvantaged. Whilst we have presented the results from all scenarios/sensitivities, we have concentrated on those omitting account of fuel price differences in the tariff derivation.

Scenario 4A applies the base-case tariffs (A) to each installation assuming accreditation on 31 March 2019. Whilst the number of installations within the 8-22% IRR range is greatly increased, the

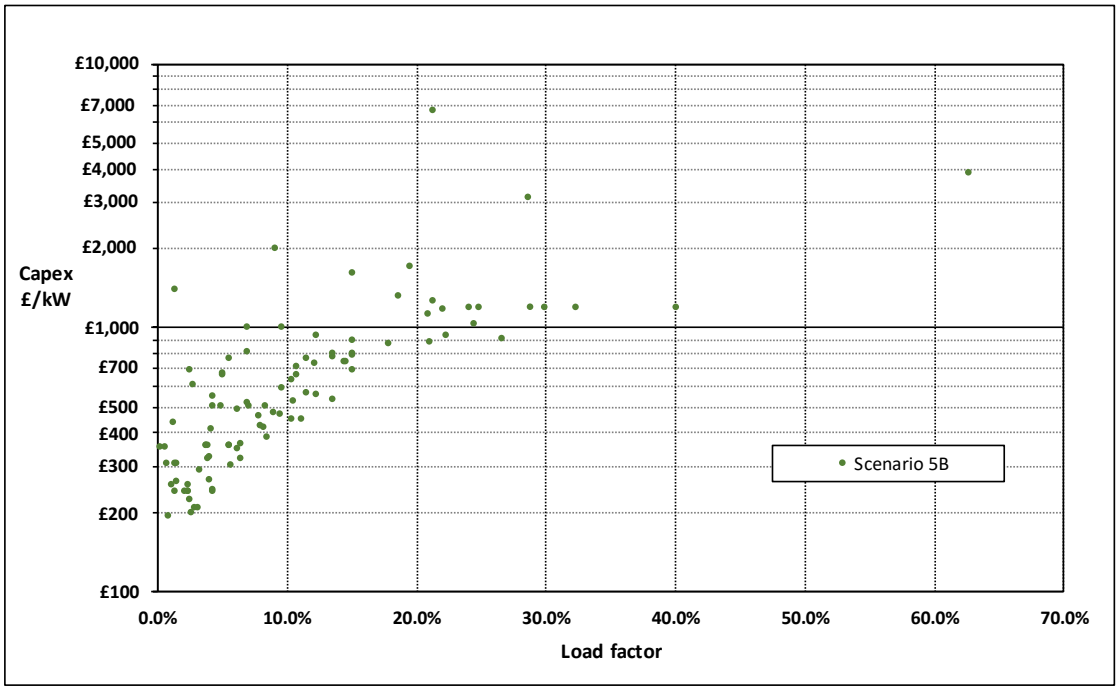
number achieving an IRR of less than 8% is also increased compared Scenario 2(4), starting afresh with the current tariffs.

Scenario 5A applies the base-case tariffs (A) from 1 April 2019 as a change of tariff from the current position. However, given the practical issues with implementing negative Tier 2 values and the associated need to regularly review relative pellet and kerosene prices, Tariff B and Tariff Hy are more practical options.

Assuming that heat generation remains unchanged in the future and there are no drop-outs from the Scheme then adopting Tariff B from 1 April 2019 as a long-term solution suggests a reduction in total Scheme costs to government of £192 million compared with continuation of the current tariffs, to around £259 million (2016 prices).

This would leave 98 installations with IRRs of less than 8%, compared with 51 under continuation of the current tariffs. Detailed examination of the characteristics of these installations is needed to ensure that they would not be unfairly disadvantaged, and if so, some alternative mechanism or mechanisms put in place. Given that under the original tariffs (Scenario 1), 47 installations are predicted to achieve IRRs less than 8%, it does not seem unreasonable to assume that there are either significant anomalies with the applicants' cost data or that these installations are technically inappropriate for the purpose for which they have been implemented. The RHI was never a guarantee that ill-conceived installations would make a return on investment. In section 2.7.2., Figure 2.18, we presented the capital costs and load factors of the 51 installations with IRRs less than 8% under continuation of the current tariffs. Figure 3.1 below shows the 98 installations (an additional 47) whose IRRs fall below 8% under the base-case tariff with no fuel differential under Scenario 5B.

Figure 3.1: Capital cost per kW plotted against load factor for Scenario 5B installations with IRRs <8%



Most of the additional 5B installations failing to reach an 8% IRR appear to have a relatively low load factor or high capital cost.

We noted when comparing Scenarios 4A, 4B and 4Hy (see Figure 2.24) that Tariff B risked being over-generous and that Tariff Hy gave a more balanced distribution of installations across the three IRR categories under the start afresh Scenario 4.

Scenarios 5A, 5B and 5Hy represent possible options for implementation as a long-term solution, and their outcomes are compared in Figure 3.2. Scenario 5Hy comes closer to the 'ideal' 5A (being based on the calculated base-case tariff), but avoids negative tariff values, has a cost that is £45 million less than Scenario 5B and has only sixteen more installations falling below an 8% IRR as also shown in Figure 3.3.

Figure 3.2: Comparison of base-case tariff outcomes under Scenario 5

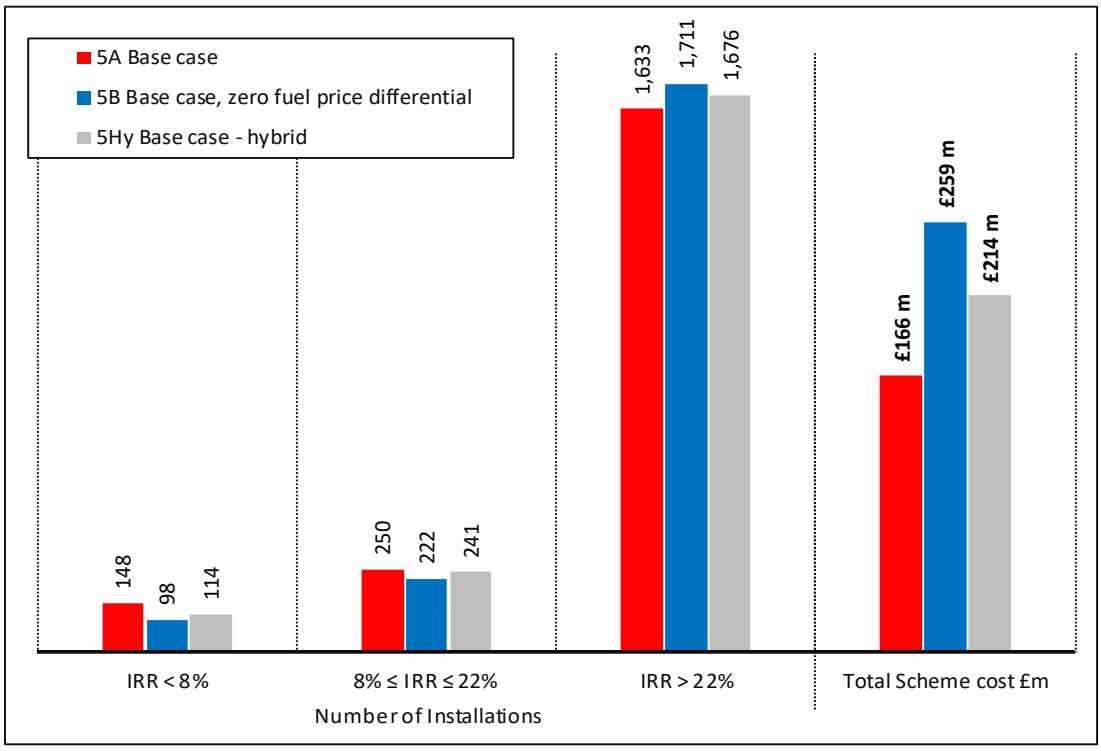
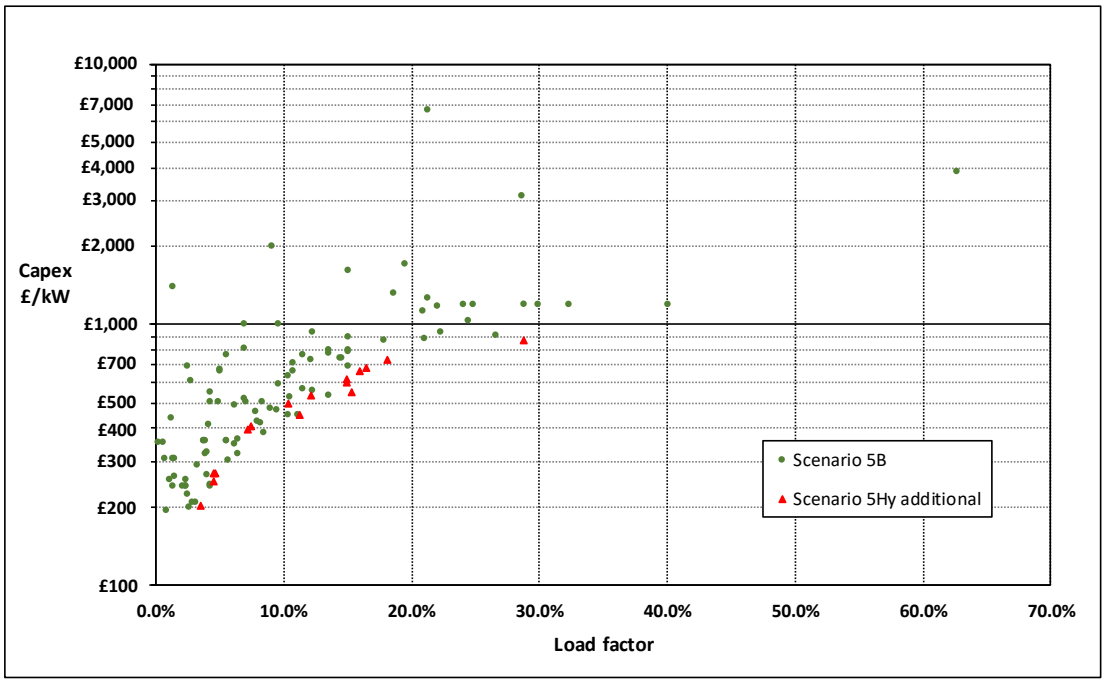


Figure 3.3: Capital cost per kW plotted against load factor for Scenarios 5B and 5Hy installations with IRRs <8%



3.2 Increase in tier threshold load factor

We consider the 15% load factor threshold between Tiers 1 and 2 to be appropriate. This approximates to the load factor of normal space heating and domestic hot water applications. Increasing the load factor at this stage would only serve to further improve the returns of installations that, due to their higher load factors, are already making good returns, without improving the position of installations with inherently lower load factors. Scenario 10B (35% threshold) decreases the number of installations with IRRs less than 8% by only four and increases those over 22% by 33.

The current GB tariff (applied as Scenario 11), which has a 35% load factor threshold, also favours those with already good returns, increasing the number with an IRR greater than 22% compared with Tariff B. The current GB tariff is designed to encourage new larger installations with higher load factors; it is not appropriate for the Northern Ireland RHI at this point.

3.3 Inflationary uplift of tariffs

As the 12% target IRR is on a real basis (and similarly the 8% to 22% range is on a real basis), implementation of any of the tariff options should continue to be subject to an annual inflationary increase. To date the Retail Prices Index (RPI) has been used to increase tariffs annually, but it would now be appropriate to employ a better measure of inflation such as the Consumer Prices Index (CPI).

3.4 Adjustment of calculated tariff to quarterly basis

The original tariffs derived by CEPA were calculated on an annual basis and then multiplied by a factor of 0.96 to take into account that payments would be made quarterly rather than annually. The tariffs derived in section 2.5 of this report have been similarly derived on an annual basis, which would suggest that they should also be adjusted by this factor.

3.5 Capital allowances

There has been some public commentary that participants in the NI RHI Scheme have received additional benefits from public funds through the corporation tax system of capital allowances. Businesses can claim capital allowances when they purchase assets known as 'plant and machinery' that are used in the business. Often the full cost of such items can be deducted from the business's profits before tax using the annual investment allowance (AIA) for that year. Once a business has used up its AIA in any year, the remaining value of such items can qualify for writing down allowances at a percentage depending on the type of asset. The remaining value can then be carried forward for writing down allowances in the following year.

The AIA has varied over the period of the NI RHI[26]:

Sole traders/partners	Limited companies	AIA
From 1 January 2016	From 1 January 2016	£200,000
6 April 2014 - 31 December 2015	1 April 2014 - 31 December 2015	£500,000
1 January 2013 - 5 April 2014	1 January 2013 - 31 March 2014	£250,000

The circumstances of each business will differ and what an individual business can claim under the AIA will depend on other eligible capital purchases. Assuming sufficient profits and AIA headroom, the maximum that could be gained in respect of reduced corporation tax in the year of purchase of an RHI installation would be 20% of the plant capital cost (assuming a 20% corporation tax rate).

If the tariff derivations in section 2.5 (Tables 2.19 to 2.21) are recalculated with a 20% lower capital cost to represent the maximum possible AIA benefit, then Tariffs A, B and Hy would be reduced as set out in Table 3.1. Only Tier 1*, and consequently Tier 1 are affected.

We have taken no further account in this work of these benefits for the following reasons:

- We are not aware that capital allowances (other than enhanced capital allowances) have been taken into account in any comparable government policy, including the GB RHI, Feed-in Tariffs and the Renewables Obligation.
- Capital allowances are a matter of general business taxation policy.

[26] https://www.gov.uk/capital-allowances/annual-investment-allowance

Table 3.1: Tariffs A, B and Hy, unadjusted and adjusted for full AIA capital allowance

Description	0 to 19 kW			20 to 99 kW			100 to 199 kW		
	Tier1	Tier1*	Tier2	Tier1	Tier1*	Tier2	Tier1	Tier1*	Tier2
Base-case (Tariff A)	7.0	5.3	1.7	2.2	2.7	-0.4	1.1	1.7	-0.7
Tariff A adjusted for full AIA capital allowance	6.1	4.4	1.7	1.7	2.2	-0.4	0.7	1.4	-0.7
Hybrid tariff (Tariff Hy)	7.0	5.3	1.7	2.7	2.7	0.0	1.7	1.7	0.0
Tariff Hy adjusted for full AIA capital allowance	6.1	4.4	1.7	2.2	2.2	0.0	1.4	1.4	0.0
Base-case, no fuel differential (Tariff B)	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3
Tariff B adjusted for full AIA capital allowance	6.1	4.4	1.8	2.7	2.2	0.5	1.7	1.4	0.3

3.6 Risks

There is anecdotal evidence that some participants have to some degree switched back to using fossil fuel from biomass. We currently do not consider this to be rational given the relative prices of biomass compared with kerosene, gas-oil and LPG; if this is true then we believe this is likely to be due to participants misunderstanding the relative costs. Tariffs B or Hy should still give the majority of participants a healthy return and, as we have shown in section 2.6.1, historically biomass prices tend to be lower than fossil fuel prices. Although a further reduced tariff carries the risk of some participants deciding to reduce their biomass use in favour of fossil fuels, we believe the risk to be acceptable.

As well as participants who might decide to reduce their use of biomass, some are likely to be removed from the Scheme or will exit of their own accord as a result of the comprehensive inspection programme. The number of inspections to date (Phase 1) has been insufficient to make any sort of estimate as to the numbers or heat capacity that might ultimately exit.

Given the scope within the regulations for the transfer of accredited installations to other applications under new ownership, there may be movements of boilers from inappropriate uses to sites where there are heat loads more suited to the technology. We are seeing evidence of biomass boiler suppliers and others facilitating such moves within GB. It would be appropriate for the Department and Ofgem to review the current rules for such transfers to ensure that the process is robust and that the integrity of the Scheme is not undermined.

3.7 Limitations of the analysis

As already mentioned in sections 2.3.1 and 3.1, there are significant uncertainties in respect of the quality of the information that participants provided on capital costs in their original applications. Whilst the capital cost assumptions used in calculating the base-case tariff are mainly supported by data from the inspections, the cash flow model used to determine the overall impact of the different scenarios is dependent on the direct capital costs as provided by the participants. This introduces uncertainties to the resulting numbers of installations in each of the IRR categories.

Another limitation of the cash flow analysis is that we have no actual data by installation for biomass maintenance costs and barrier costs. We have therefore had to assume that the actual values are as per the values selected in deriving the base-case tariffs (Tariff A). The maintenance and barrier cost tariff sensitivities, as tested via relevant scenarios, have limited impact on the distribution of installations by IRR category, which gives comfort that this uncertainty is not critical to the overall conclusions.

4 Review of the biomass CHP tariff

4.1 Background to the CHP tariff

In the original 2012 Regulations there was no specific CHP tariff; biomass CHP fell under the same tariffs as biomass boilers, which meant that the heat capacity of any installation was limited to less than 1 MW. In 2013 further modelling work was undertaken for DETI (now DfE) by CEPA, with technical support from Ricardo-AEA. The outcome of this work was presented in the report *Development of Phase II of the Northern Ireland Renewable Heat Incentive*, June 2013. In section 6.3 of that report, a specific biomass CHP tariff of 3.5 p/kWh was recommended. Subsequently, the Renewable Heat Incentive Scheme (Amendment) Regulations (Northern Ireland) 2015 introduced a specific tariff for biomass CHP at all sizes of 3.5 p/kWh for new systems accredited after 18th November 2015. However, we understand that the CHP tariff was never notified to the European Commission and consequently has not received state aid approval. One of the commitments made by the UK government in securing state aid approval for the Renewable Heat Incentive Scheme (Amendment) Regulations (Northern Ireland) 2017 was that a review of the CHP tariff would be undertaken in advance of a request for state aid approval of support for CHP plants.

Ofgem received applications for preliminary accreditation of two separate, but similar, biomass CHP plants just prior to the suspension of the Scheme on 29th February 2016. With the suspension of the Scheme, the lack of state aid approval for the CHP tariff, and the fact that neither plant yet exists (the applications indicated that commissioning of both plants was anticipated to be during 2018), they remain unaccredited.

4.2 Review methodology

As was described in section 1.3, in accordance with the Department's specification for the work, the objective of this part of the study has been to undertake a comprehensive review of each of the elements affecting the suitability of the tariff for CHP plants as the basis for a set of recommendations on the most appropriate structure for the remainder of the lifetime of the Scheme.

Since accreditation for just two biomass CHP plants was sought, the review has been undertaken based on the detailed and specific technical and cost information that has been available to us regarding these plants. It should also be understood that the June 2013 modelling was based on assumptions appropriate to a much wider range of CHP applications and plant types, which differ in various key respects to the two specific cases in question, and which were appropriate at the time.

For each plant we have undertaken a review of the plant's technical and financial parameters and have calculated the RHI tariff that would be needed for each plant to provide a 12% Internal Rate of Return (IRR) over 20 years. We refer to these as the base-case tariff for each plant and we have undertaken sensitivity analysis around the two base-cases.

We have also produced a full lifetime cash flow for each of the plants, assuming that they each come into operation on 1st April 2019 and that would be their effective accreditation date if accepted under the RHI. The analysis period is 20 years, which is the assumed period over which any RHI payments would be made; this is also comparable with the likely lifetime of the CHP plants.

Negative cash flow items (costs) are:

(i) capital costs;
(ii) upfront barrier costs;
(iii) biomass fuel costs;
(iv) operation and maintenance (O & M) costs, excluding fuel.

Positive cash flow items are:

(v) income from exported electricity;
(vi) avoided costs of the counterfactual:
   a. capital costs;
   b. fossil fuel;
   c. imported electricity, including associated Climate Change Levy (CCL).

By means of the cash flows, the return on investment for each plant has been determined as an IRR without any RHI payments. We have expressed all values in 2016 prices (real terms) and so the calculated IRRs are also in 2016 prices, which is consistent with the original CEPA work.

Due to the commercial sensitivity of the plant specific data that has been made available to us, a separate detailed confidential report has been prepared for the Department. The outcome of the review is summarised in the following section.

4.3 Review outcome

Based on current energy prices and the plant specific data available to us, we have concluded that both proposed CHP plants have good rates of return, with IRRs of around 30%. Even under the assumption of a significantly higher capital costs and reduced load factors the two plants would not require RHI support to achieve a return of 12%. Only under conditions quite different from those presented to us would either plant require financial assistance, and we therefore conclude that it would be inappropriate to support them under the NI RHI Scheme.

The main purpose of the heat from both plants is to provide drying for wood fuel in new processes. It is highly relevant that for the GB RHI the government has decided to remove wood-fuel drying as an eligible heat use other than where the renewable heat installation is replacing a fossil fuel source[27]. This sets a general principle regarding whether wood-fuel drying should receive public funding support. It would go against this principle for the two Northern Ireland CHP plants in question to now be supported, especially so given their likely rates of return without support.

4.4 Recommendations

We recommend that:

1. The Department does not offer any NI RHI support to either of the two plants reviewed in this study and excludes a CHP tariff in any forthcoming amendment legislation.
2. Should the Department wish to consider support for renewable heat from bio-fuel CHP in the future, then further analysis and design work would be needed to be undertaken to ensure that any incentive provides appropriate support for types of CHP installation that displace fossil-fuel use and maximise the efficient use of renewable resources. It would be appropriate to link specific CHP support, as under the GB RHI, to certification and performance under the government's CHP Quality Assurance programme (CHPQA).

[27] In January 2018, BEIS published its response to the Chapter 2 questions in the September 2017 consultation *The Non-Domestic Renewable Heat Incentive: further proposed amendments*. https://www.gov.uk/government/consultations/the-non-domestic-renewable-heat-incentive-further-proposed-amendments

Appendices

Appendix A: Summary of Scenarios, Sensitivities and Outcomes

Appendix A:
Summary of Scenarios, Sensitivities and Outcomes

Scenario No. + Tariff sensitivity code	Description	<20kW			20 to <100 kW			100 to <200 kW			Number of installations			Scheme cost (2016 real terms)			
		Tier 1 p/kWh	Tier1* p/kWh	Tier2 p/kWh	Tier 1 p/kWh	Tier1* p/kWh	Tier2 p/kWh	Tier 1 p/kWh	Tier1* p/kWh	Tier2 p/kWh	IRR <8%	IRR ≥8% and ≤22%	IRR >22%	To Oct 17	Oct 17 to 31 Mar 9	From 1 Apr 19	Total
Reference scenarios																	
1	Tariffs at accreditation continued	6.8	6.8 / 5.3	0 / 1.5	6.5	6.5 / 5.0	0 / 1.5	1.5	1.5 / 0	0 / 1.5	47	126	1,858	£88.6 m	£65.6 m	£692.4 m	£846.6 m
2	Actual tariff history, continue Apr '17 tariffs from 1 Apr 19	6.8	5.3	1.5	6.5	5.0	1.5	6.5	5.0	1.5	51	142	1,838	£79.4 m	£34.1 m	£337.4 m	£451.0 m
3	Actual tariff history, cease payments from 1 Apr 19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	297	215	1,519	£79.4 m	£34.1 m	£0.0 m	£113.5 m
1(4)	Scenario 1, but starts afresh	6.8	6.8	0.0	6.5	6.5	0.0	6.5	6.5	0.0	41	115	1,875	£0.0 m	£0.0 m	£852.7 m	£852.7 m
2(4)	Scenario 2, but starts afresh	6.8	5.3	1.5	6.5	5.0	1.5	6.5	5.0	1.5	46	144	1,841	£0.0 m	£0.0 m	£416.7 m	£416.7 m
3(4)	Scenario 3, but starts afresh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,213	665	153	£0.0 m	£0.0 m	£0.0 m	£0.0 m
4A	NI RHI starts afresh with Tariff A (no cap)	7.0	5.3	1.7	2.2	2.7	-0.4	1.1	1.7	-0.7	364	1,182	485	£0.0 m	£0.0 m	£66.8 m	£66.8 m
4B	NI RHI starts afresh with Tariff B (400 MWh cap)	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3	165	490	1,376	£0.0 m	£0.0 m	£180.0 m	£180.0 m
4Hy	NI RHI starts afresh with hybrid tariff (Tariff Hy)	7.0	5.3	1.7	2.7	2.7	0.0	1.7	1.7	0.0	227	780	1,024	£0.0 m	£0.0 m	£125.3 m	£125.3 m
New calculated tariff and sensitivities applied from 1 Apr 19 - including fuel differentials but no cap																	
5A	Base-case	7.0	5.3	1.7	2.2	2.7	-0.4	1.1	1.7	-0.7	148	250	1,633	£79.4 m	£34.1 m	£52.8 m	£166.3 m
5B	Zero marginal fuel cost	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3	98	222	1,711	£79.4 m	£34.1 m	£145.2 m	£258.7 m
5C	Upper quartile biomass capex	8.6	6.9	1.7	2.8	3.2	-0.4	1.2	1.8	-0.7	122	250	1,659	£79.4 m	£34.1 m	£73.2 m	£186.7 m
5D	Lower quartile biomass capex	3.6	1.9	1.7	1.7	2.2	-0.4	0.9	1.6	-0.7	172	251	1,608	£79.4 m	£34.1 m	£34.9 m	£148.4 m
5E	Up front and fixed and ongoing barrier costs doubled	7.6	5.9	1.7	2.4	2.8	-0.4	1.1	1.8	-0.7	137	250	1,644	£79.4 m	£34.1 m	£59.4 m	£172.9 m
5F	Min (most -ve) marginal wood pellet price	6.0	5.3	0.7	0.9	2.7	-1.8	-0.3	1.7	-2.1	716	245	1,070	£79.4 m	£34.1 m	-£94.1 m	£19.4 m
5G	Max marginal wood pellet price	9.6	5.3	4.3	4.5	2.7	1.8	3.4	1.7	1.7	74	184	1,773	£79.4 m	£34.1 m	£293.0 m	£406.6 m
5H	Marginal maintenance +30%	7.2	5.3	1.9	2.3	2.7	-0.4	1.1	1.7	-0.6	143	250	1,638	£79.4 m	£34.1 m	£56.2 m	£169.7 m
5I	Marginal maintenance -30%	6.8	5.3	1.5	2.2	2.7	-0.5	1.0	1.7	-0.7	149	255	1,627	£79.4 m	£34.1 m	£45.4 m	£158.9 m
5J	Variable ongoing barrier costs +20%	7.2	5.3	1.9	2.3	2.7	-0.4	1.1	1.7	-0.6	143	250	1,638	£79.4 m	£34.1 m	£56.2 m	£169.7 m
5K	Variable ongoing barrier costs -20%	6.8	5.3	1.5	2.2	2.7	-0.5	1.0	1.7	-0.7	149	255	1,627	£79.4 m	£34.1 m	£45.4 m	£158.9 m
New calculated tariff and sensitivities applied from 1 Apr 19 - excluding fuel differentials but with 400 MWh cap																	
5B	Base case - zero marginal fuel cost	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3	98	222	1,711	£79.4 m	£34.1 m	£145.2 m	£258.7 m
5BC	Upper quartile biomass capex	8.7	6.9	1.8	3.7	3.2	0.5	2.1	1.8	0.3	88	215	1,728	£79.4 m	£34.1 m	£162.3 m	£275.9 m
5BD	Lower quartile biomass capex	3.7	1.9	1.8	2.7	2.2	0.5	1.9	1.6	0.3	113	231	1,687	£79.4 m	£34.1 m	£128.0 m	£241.5 m
5BE	Up front and fixed ongoing barrier cost doubled	7.6	5.9	1.8	3.4	2.8	0.5	2.1	1.8	0.3	93	220	1,718	£79.4 m	£34.1 m	£152.5 m	£266.0 m
5BH	Marginal maintenance +30%	7.2	5.3	1.9	3.3	2.7	0.6	2.1	1.7	0.4	93	221	1,717	£79.4 m	£34.1 m	£154.4 m	£268.0 m
5BI	Marginal maintenance -30%	6.9	5.3	1.6	3.2	2.7	0.5	2.0	1.7	0.3	98	223	1,710	£79.4 m	£34.1 m	£145.2 m	£258.7 m
5BJ	Variable ongoing barrier costs +20%	7.3	5.3	2.0	3.3	2.7	0.6	2.1	1.7	0.4	93	221	1,717	£79.4 m	£34.1 m	£154.4 m	£268.0 m
5BK	Variable ongoing barrier costs -20%	6.8	5.3	1.5	3.1	2.7	0.4	2.0	1.7	0.3	101	225	1,705	£79.4 m	£34.1 m	£136.7 m	£250.3 m
Hybrid tariff (Tariff A Tier 2 negative values set to zero)																	
5Hy	Hybrid tariff applied from 1 Apr 19	7.0	5.3	1.7	2.7	2.7	0.0	1.7	1.7	0.0	114	241	1,676	£79.4 m	£34.1 m	£100.6 m	£214.1 m
Reduced annual cap - new calculated base case tariff excluding fuel differentials applied from 1 Apr 19																	
6B	Annual cap at 300 MWh with zero marginal fuel cost tariff	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3	98	222	1,711	£79.4 m	£34.1 m	£137.6 m	£251.2 m
7B	Annual cap at 100 MWh with zero marginal fuel cost tariff	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3	113	242	1,676	£79.4 m	£34.1 m	£90.8 m	£204.3 m
8B	Annual cap at 50 MWh with zero marginal fuel cost tariff	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3	139	276	1,616	£79.4 m	£34.1 m	£48.5 m	£162.1 m
Reduced future heat output - new calculated base case tariff excluding fuel differentials applied from 1 Apr 19																	
9B	Reduction in future heat output by 20% on Scenario 5B	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3	117	230	1,684	£79.4 m	£31.7 m	£140.1 m	£251.2 m
Increase tier threshold - new calculated base case tariff excluding fuel differentials applied from 1 Apr 19																	
10B	Increase of tier threshold to 35% for Scenario 5B	7.1	5.3	1.8	3.2	2.7	0.5	2.0	1.7	0.3	94	193	1,744	£79.4 m	£34.1 m	£246.9 m	£360.5 m
GB tariffs																	
11	Current GB tariff from 1 April 19 (35% tier threshold)	2.84	0.84	2.00	2.84	0.84	2.00	2.84	0.84	2.00	101	196	1,734	£79.4 m	£34.1 m	£280.3 m	£393.8 m
11(4)	Scenario 11, but starts afresh at 1/4/19	2.84	0.84	2.00	2.84	0.84	2.00	2.84	0.84	2.00	149	295	1,587	£0.0 m	£0.0 m	£342.3 m	£342.3 m
12	GB tariff at 1 October 2015, from November 2015	4.17	3.07	1.10	4.17	3.07	1.10	4.17	3.07	1.10	78	198	1,755	£79.4 m	£34.1 m	£240.5 m	£354.0 m
12(4)	Scenario 12, but starts afresh at 1/4/19	4.17	3.07	1.10	4.17	3.07	1.10	4.17	3.07	1.10	93	296	1,642	£0.0 m	£0.0 m	£296.2 m	£296.2 m

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