Report to DECC on

Heat metering for the RHI

Prepared by:	GASTEC at CRE Ltd
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Heat metering for the RHI

Contents

1 Introduction

The proposed Renewable Heat Incentive (RHI) is designed to encourage the generation of renewable forms of heat. The sources of energy and technologies that could be supported by the RHI are listed in Section 100 of the Energy Act 2008.

Those included for the purposes of this report are:

- Heat pumps (ground source, water source and air-to-water)
- Biomass hot water boilers
- Biomass thermal fluid (oil) heaters
- Biomass steam boilers
- Biogas from anaerobic digestion which can be upgraded to bio-methane
- Solar thermal.

Technologies excluded for the purposes of this report are:

- Air-to-air heat pumps
- Bio-liquids and bio-liquid boilers
- Biomass air heaters.

This report concerns the measurement of renewable heat in the non-domestic sector to ensure it is measured robustly and cost-effectively and that the RHI therefore only rewards the correct quantity of heat or an equivalent energy vector e.g. biogas.

The RHI should only support renewable heat where the heat generated is usable and useful. So this report concentrates on how to meter the production of useful heat from renewable sources. Although the concept of "useful heat" is not a legal definition, it is a valid concept for metering RHI eligible heat so it is used in this report.

The use of heat will be deemed legitimate for the RHI if the heat need is being or would otherwise have been met through fossil fuel heating. Additionally, the RHI would not incentivise the deliberate wasting of heat or heat generated simply to meet a heat load which would not otherwise have existed had the incentive not been in place, i.e. it should not pay an incentive for heat which is vented into the atmosphere or where a heat requirement has been created artificially in order to claim the incentive or where the use of heat is unnecessary or wasteful.

Metering should measure heat where it is used for example for space heating, water heating, cooking, high temperature process, low temperature process, drying and separation.

Heat used in a process which will deliver electricity or the re-use of condensate in a process to make the system more efficient will need to be deducted from the meter reading or the system will need to be configured in such a way that it is not recorded by the heat meter, thus avoiding giving double incentives for the same unit of energy/heat.

This report therefore presents options for metering of renewable heat/gas/steam from the small commercial to larger industrial scales of operation.

Before discussing the requirements for individual RH technologies, we will discuss:

- how meters should be chosen and maintained
- how the data gathered could be reported
- the cost of metering.

2 Detailed choice and maintenance of metering

There are detailed performance specifications for heat, gas and electric meters contained in Directive 2004/22/EC of the European Parliament and of the Council of 31 March 2004 on measuring instruments, and further statements on the use to which they should be put. If DECC were to require operators to go beyond these functional requirements and/or existing UK fiscal quality products, there would be a strong risk of a legal challenge, as there is no evidence base to require other standards. It is therefore recommended that DECC require meters that are compliant with the Measuring Instrument Directive (MID). For heat metering residential use, MID allows any Class 3 meter. For commercial and/or light industrial use it requires any Class 2 meter. The European Standards for heat metering are BS EN 1434 – 1 to 6. These refer to the general requirements, data exchange, installation, commissioning, operational monitoring and maintenance of heat meters. The classes stated in these standards are the same as in the MID, MID encompasses more types of metering and only requires one test per heat meter for the whole of the EU.

Most energy meters operate using highly refined energy vectors (eg oil, gas, or electricity) controlled within tight parameters (ie gas calorific value or oil density do not vary greatly from day to day). Heat meters were originally designed for district heating schemes (DH) operated by professionals. They are designed to operate with a clean fluid, usually water plus corrosion inhibitor. In many countries, such DH installations have to be inspected annually by law.

Heat meters operate successfully when installed correctly, particularly if fitted with a de-aerator and filter. It is thus suggested that a guide to the regulations should recommend such devices, for costs see Section 5. De-aerators and strainers should be recommended on sites where there are likely to be problems with air or sludge build up in the heating system (for costs see Appendix C). Heat meters cannot work effectively when there is air in the system so all efforts should be made to empty the system of air. Sludge can also cause problems in the reliability of heat meters.

Important considerations for the specifier when deciding upon choice of metering include:

- type of meter – ultrasonic/ electromagnetic/non-invasive
- location – number of pipe diameters from bends etc
- pressure drop considerations (so as not to affect the flow)

These issues are not specifically covered in the MID, and we would suggest that these matters may not be suitable subjects for regulation given the level of technical detail but would suggest they are contained in accompanying guidance.

Heat meters are usually supplied complete with calibration certificates which are valid for a set time period as stated by the competent authority, i.e. the test laboratory. After this time, the heat meter would normally be replaced or recalibrated. DECC has requested information on the likely required frequency for recalibration. Several manufacturers offer devices with a stated requirement for recalibration after 10 years of use. It should be noted that meters generally need to be removed and returned to the manufacturer for recalibration. This would require care during heat meter installation (e.g. the addition of a by-pass and perhaps flanged meters) to make this as straightforward as possible. The timescales between recalibration for the meters currently available on the market would require a detailed market survey beyond the scope of the current report.

Nearly all meters available on the market are tamper-proof. It is suggested that tamper-proof meters would need to be specified in the regulations. Standard EN1434-6:2007 specifies that a heat meter should have protective devices which should be sealed at the completion of commissioning by representatives of the competent authority (in this case probably Ofgem) with no possibility of dismantling, removing or altering the heat meter or its adjustment devices without evident damage to the device or seal. It is suggested that the tamper proofing of the meter (and seals etc) should be checked after initial installation and during subsequent site visits by meter readers or verifiers

In a professionally installed and monitored system, the operator may develop his own maintenance regime. However, in metering systems installed to measure heat under the RHI, the quality of installation and operation is likely to be more variable due to the variability of installer training and competence. It is therefore recommended that the maintenance regime to be followed is that suggested by the manufacturer. In the Netherlands the maintenance regime is annual and in Germany it is understood to be similar. However in the Netherlands it is also understood that the heat meters within a district heating scheme are sometimes regarded as indicators of proportionate use rather than as providers of absolute values. The ‘sent out’ heat from the boiler house or heat substation is then divided between the readings in each flat. This avoids the issues of standing losses and absolute accuracy.

The mode of failure of heat meters is difficult to predict, sometimes they read high and sometimes low. It is recommended that examination of historical trends for the site is a good start to detect meter deterioration; this could be automated which would minimise costs. Appendix B discusses methods of using data to detect meter faults or fraud.

3 Automatic data collection and handling

By its nature, the production of renewable energy results in a wide geographical spread of energy production sites. The quantity of energy that will be produced at these sites will also vary between different sites. The challenge is to monitor and reward each of these sites in a practical and cost-effective way that is proportionate to their contribution of usable renewable heat.

3.1 Hot water energy monitoring, the practical options

It is recommended that all systems which require metering should have a MID compliant meter that records the heat produced (usually in kWh) at a particular site and the meter will as a minimum requirement produce a pulsed output which can be used for data logging purposes.

3.1.1 Methods of Reading Meters

1. Physical meter read
   1.1) Meter reading by an agent or Ofgem appointed representative who visits each site and gains access either physically or by attaching a meter reading device.
   1.2) Generator performs a personal meter read and forwards the reading (via letter, telephone, SMS, or website) to Ofgem

2. Remote Meter Read
   2.1) Short Distance Radio meter reading by an agent or Ofgem appointed representative who visits each site but does not require access to the site.
   2.2) Automatic Meter Reading (AMR) is performed over a GSM network, data is acquired on a periodic basis as required.
   2.3) Automatic Meter Reading (AMR) is performed over the internet, data is acquired on a periodic basis as required.

These options are analysed in more detail in the tables below

Table 1: Data Acquisition

Option	Pros	Cons
1.1 Meter Reader	Does not rely on any other infrastructure. Allows observation of the physical site and meter.	Very costly. Occasionally inaccurate due to human error. Mainly quarterly reads at best. Access not always possible. Missing data.
1.2 Client Reader	Low cost. Does not rely on any other infrastructure.	Inaccurate. Missing data. Open to fraud.
2.1 Short Distance Radio Reader	Less reliant on infrastructure.	Costly.
2.2 AMR- GSM	Low cost. Increased frequency of data capture. Interactive data for client.	Mobile phone system coverage required. Chain of data acquisition may be complex leading to potential for errors.
2.2 AMR- Internet	Very low cost. Increased frequency of data capture. Interactive data for client.	Broadband connectivity required. Chain of data acquisition may be complex leading to potential for errors.

3.1.2 Processing data

All options will require some form of data processing. Once the data has been captured electronically the costs for processing that data become very similar regardless of the quantity. Where data is collected more frequently (e.g. ½ hourly), it becomes more valuable to the generator as it can be used for monitoring and targeting of energy use and energy use reductions. In general, monthly data is more useful than quarterly or annual data, but daily or ½ hourly is significantly more useful for monitoring and targeting purposes of the generator. Monthly readings are more useful than quarterly because degree day data is generally provided either monthly or weekly. Quarterly data means that it will take much longer (2-4 years rather than 1 year) to have a real idea of what the heat requirement of the site is, and it will also take longer to see any meter reliability problems.

Table 2: Data transfer and processing

Option	Reading	Transfer	Processing	Data
1.1 Meter Reader	Data is usually recorded locally to a PDA or handheld device. This involves a visit to the site which could be combined with verification, decreasing fraud.	Data is uploaded to a main database from a remote location.	Transactions read and processed for payment.	As the data is generally quarterly or annual readings it could be hard to spot fraud or meter reliability problems.
1.2 Client Reader	Client takes a reading by hand from the meter.	Card by post or telephone which is entered into the processing database. Possibility of a web portal based data entry.	Transactions read and processed for payment.	Data is of value as it will be at a monthly level.
2.1 Short Distance Radio Reader	Data is logged at the meter and transmitted locally to a PDA or handheld device.	Data is uploaded to a main database from a remote location.	Transactions read and processed for payment.	As the data is generally quarterly or annual readings it could be hard to spot fraud or meter reliability problems..
2.2 AMR- GSM	Data is logged at the meter and transmitted at interval as frequently as every ½ hour.	Via GSM network.	Transactions read and processed for payment.	Data is of value as it will be at a monthly or greater level of granularity.
2.2 AMR- Internet	Data is logged at the meter and transmitted at interval as frequently as every ½ hour.	Via internet network.	Transactions read and processed for payment.	Data is of value as it will be at a monthly or greater level of granularity.

Table 3: Costs of transferring and processing raw data

Option	Reading	Transfer of Data	Processing data	Data
1.1 Meter Reader	Manpower requirement for meter reading.	Low to zero cost via internet.	Manpower requirement for processing, see below for costs.	Simple Web display.
1.2 Client Reader	£0	Low to zero cost via internet/post /telephone.	Manpower requirement for processing, see below for costs.	Simple web display.
2.1 Short Distance Radio Reader	Manpower requirement for meter reading. Increased number of readings compared with the time period of 1.1.	Low to zero cost via internet.	Manpower requirement for processing, see below for costs.	Simple Web display.
2.2 AMR-GSM	£0	£13-18 per month.	Manpower requirement for processing, see below for costs.	Website with ability to display analytical data.
2.2 AMR-Internet	£0	£35 per year (using client's existing connection).	Manpower requirement for processing, see below for costs.	Website with ability to display analytical data.

It is suggested that the metering costs would be paid by the recipient of the RHI, i.e. the equipment owner. Where the cost is initially paid by DECC/Ofgem it should be taken out of the RHI payments.

The following table shows the prices for three different options, all costs are approximate, and are included to give comparative numbers for the various data capture options. The methodology for calculation of these costs can be found in Appendix C.

Table 4: Table of costs for Data Acquisition and Processing

	Price per site per year
Manual Data Capture	£2.40
Meter Reading by a billing organisation using a local area radio	£150
Meter Reading by AMR via GSM	£155 -£180
Meter Reading by AMR via Internet	£35 - £140
Data Processing (either using bespoke software or use of an outsource Agency)	£1.50 to £4.00

3.1.3 Fraud Prevention

Collecting monthly heat production data will have an extremely positive impact on the accuracy and veracity of data and therefore the confidence with which Ofgem will be able to make payments for RHI. There are however other checks and balances that could be added to a metering solution. These would generally concern comparing monthly data sets for the same building with the patterns of consumption of a cohort of similar buildings. These types of checks on data collected could be used as a first pass to produce a "possible fraud" flag for further investigation, see Appendix A.

3.1.4 Recording of Site data

It would seem reasonable that as part of the registration process that each site be requested to provide certain core metering data to Ofgem. For tariff calculation, the site will need to supply information on renewable generation technology, equipment type, make, postcode, etc. In addition they will need to supply further information on metering. Site data relevant to heat metering could include:

Table 5: Example of metering data that could be required

Heat meter information	Manufacturer, model, serial number
Meter calibration information	Required recalibration date
Site operation characteristics	24 hours per day, 7 days per week, or 9-5, 5 days per week, etc

With the profile of the site and using cohorts of data it will be possible to:

1) Ensure actual meter readings fall within the expected production level ranges (higher or lower)
    a. fraud prevention
    b. advise / highlight data to site (perhaps encourage them to look at low efficiency)
2) Report trends of behaviour
    a. by area (urban / rural / region)
    b. by sector
3) Allow the sites (the community) to peer review the data anonymously, and to evaluate their own activity/efficiency

4 Recommended data reporting regime

Following the analysis of data acquisition and handling systems in Section 3 of this report, the following systems are recommended. It is suggested that monthly RHI data reporting should be web-based and consist of one of the following options:

1) Monthly manual logging onto a website and completion of online forms as used by some utilities for web-based tariffs

2) Monthly automatic reporting using a GSM/dial up system

3) Monthly automatic reporting using a 'piggy-back' system on the site's existing broadband connection. With near universal internet access, data handling costs have fallen dramatically.

This data offers considerable information to sites to improve the management of their equipment.

5 Cost of metering

The cost of metering comprises the actual meter and the data handling / reporting.

5.1 Meters

Typical heat meter costs for new build and retrofit installations are given below. The capital expenditure (capex) consists of the following costs:

- 2 heat meters
- 1 de-aerator
- 1 strainer
- Installation of the above equipment

Two heat meters would be required, one at the beginning of the development in year zero, and the second after 10 years when it would require replacement or recalibration.

It is important to give careful consideration to preventing excessive pressure drop through the heat meter. If a heat meter with too small an orifice is chosen, then the resistance to flow will be high, leading to a drop in the flow rate. Thus oversized heat meters may be required in situations where a flow restriction would limit the appliance's ability to deliver heat at the required rate. Some heat meters claim to have a rated capacity which will result in high pressure drops and thus cause a flow restriction. This is a subtle point, but one which is likely to be overlooked if meter prices are simply taken from catalogues. In this report we have sized meters relatively conservatively with a fluid velocity of about 2.5m/s and a temperature difference (between flow and return fluid) of 15°C.

Table 6: Heat meter costs for a new build

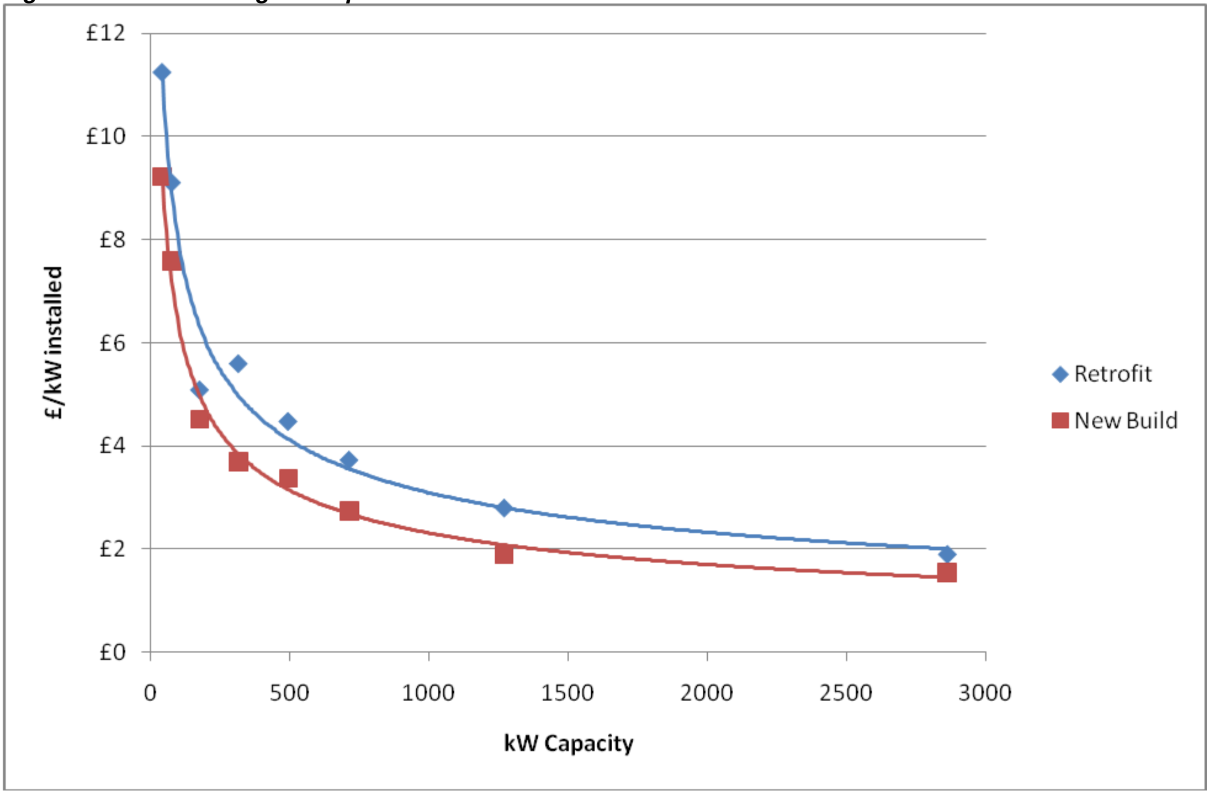
New Build						
Diameter	**List price**	**Installation**	**Total Price**	**ID mm**	**kW**	**£/kW**
3/4"	£352	£60	£412	19	45	£9.22
1"	£523	£80	£603	25	79	£7.59
1 1/2"	£707	£100	£807	38	179	£4.52
2" flanged	£976	£200	£1,176	51	318	£3.70
2 1/2" flanged	£1,421	£250	£1,671	64	496	£3.37
3" flanged	£1,656	£300	£1,956	76	715	£2.74
4" flanged	£2,051	£350	£2,401	102	1271	£1.89
6" flanged	£3,893	£550	£4,443	152	2859	£1.55

These estimates are based on actual costs for installations purchased by the project team.

Table 7: Heat metering costs for Retrofit sites

Retrofit						
Diameter	**List price**	**Installation**	**Total Price**	**ID mm**	**kW**	**£/kW**
3/4"	£352	£150	£502	19	45	£11.24
1"	£523	£200	£723	25	79	£9.10
1 1/2"	£707	£200	£907	38	179	£5.08
2" flanged	£976	£800	£1,776	51	318	£5.59
2 1/2" flanged	£1,421	£800	£2,221	64	496	£4.47
3" flanged	£1,656	£1,000	£2,656	76	715	£3.72
4" flanged	£2,051	£1,500	£3,551	102	1271	£2.79
6" flanged	£3,893	£1,500	£5,393	152	2859	£1.89

Figure 1: Heat metering costs per kW installed for a new build and retrofit



It is useful to compare the cost of metering with the capital cost of the installation. Typical capital costs for installations have been produced by AEA for DECC and are therefore used in this report.

It is useful to consider the extra cost that such metering would make to the total installation cost for a range of renewable heat technologies of different capital costs. This is illustrated below.

As expected for very small sites the metering is disproportionately expensive, but quickly falls at larger thermal ratings.

In practice, the above heat meter curves may contain discontinuities. These may be at the transition between flanged (for larger diameter pipes) and screwed fittings, and at the transition between ultrasonic and electromagnetic meters (electromagnetic meters are usually used at larger scale, and are more expensive).

The following figures give the percentage of the total cost of installed metering for a range of RH technologies for retrofit and new installations. These costs are based on the cost of metering based on the type and capacity of the installation, including the additional costs for data acquisition and processing.

Figure 2: Total cost of heat metering as % of capex vs. capacity of installation on large scale sites

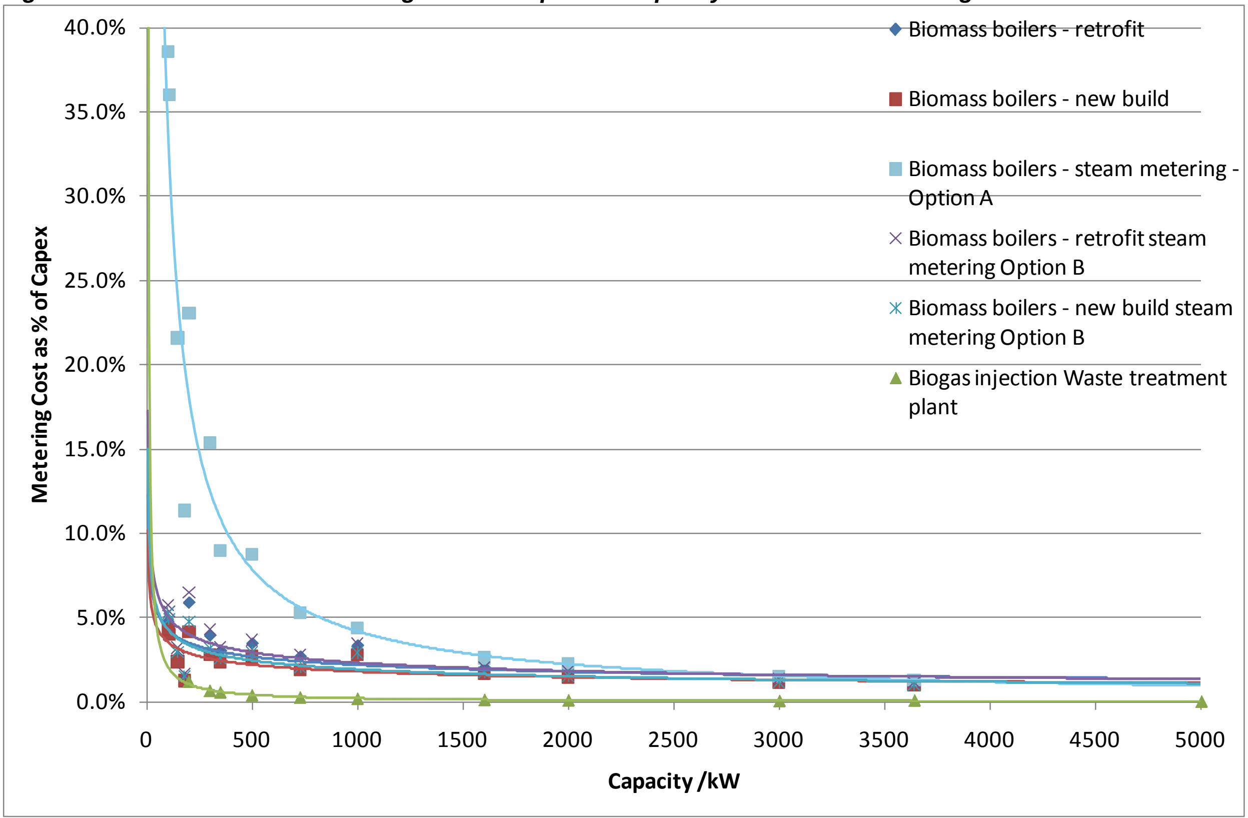


Figure 3: Total cost of heat metering as % of capex vs. capacity of installation on heat pump sites with and without extra electric metering

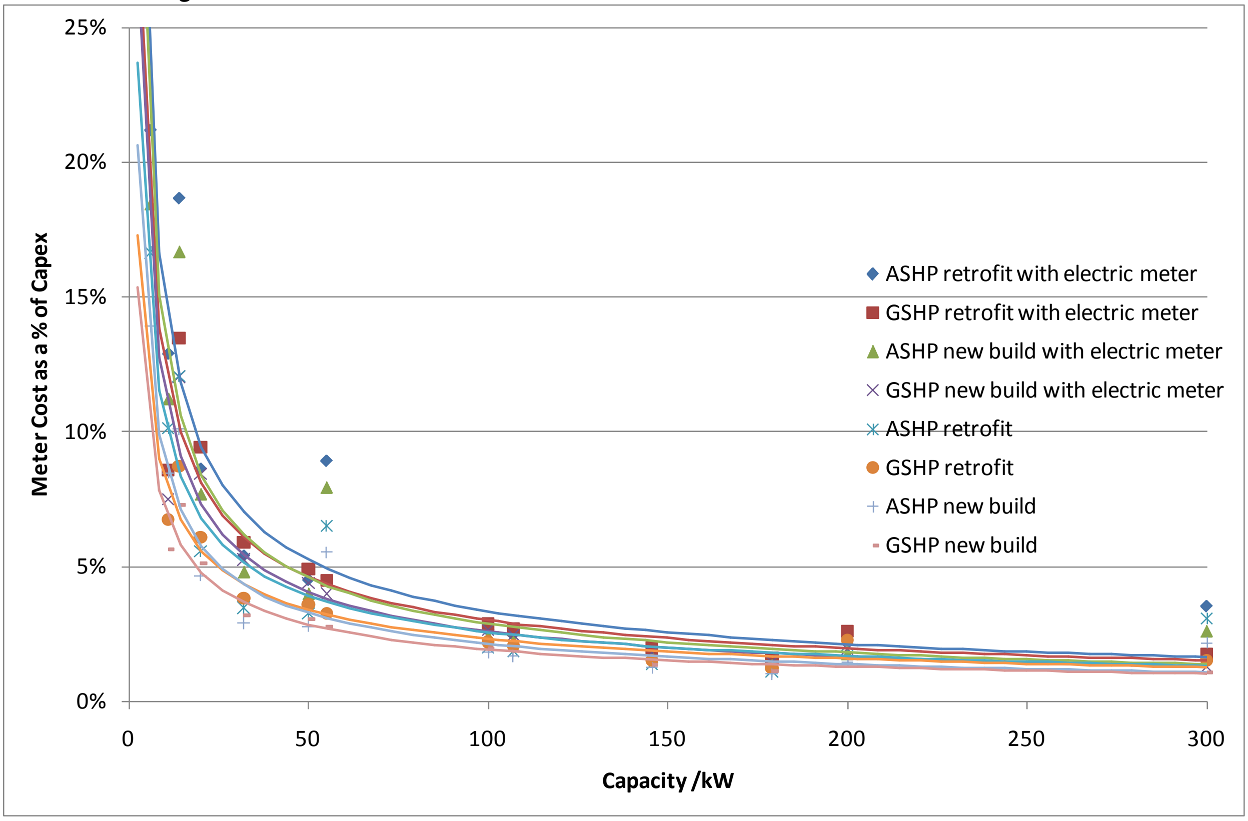
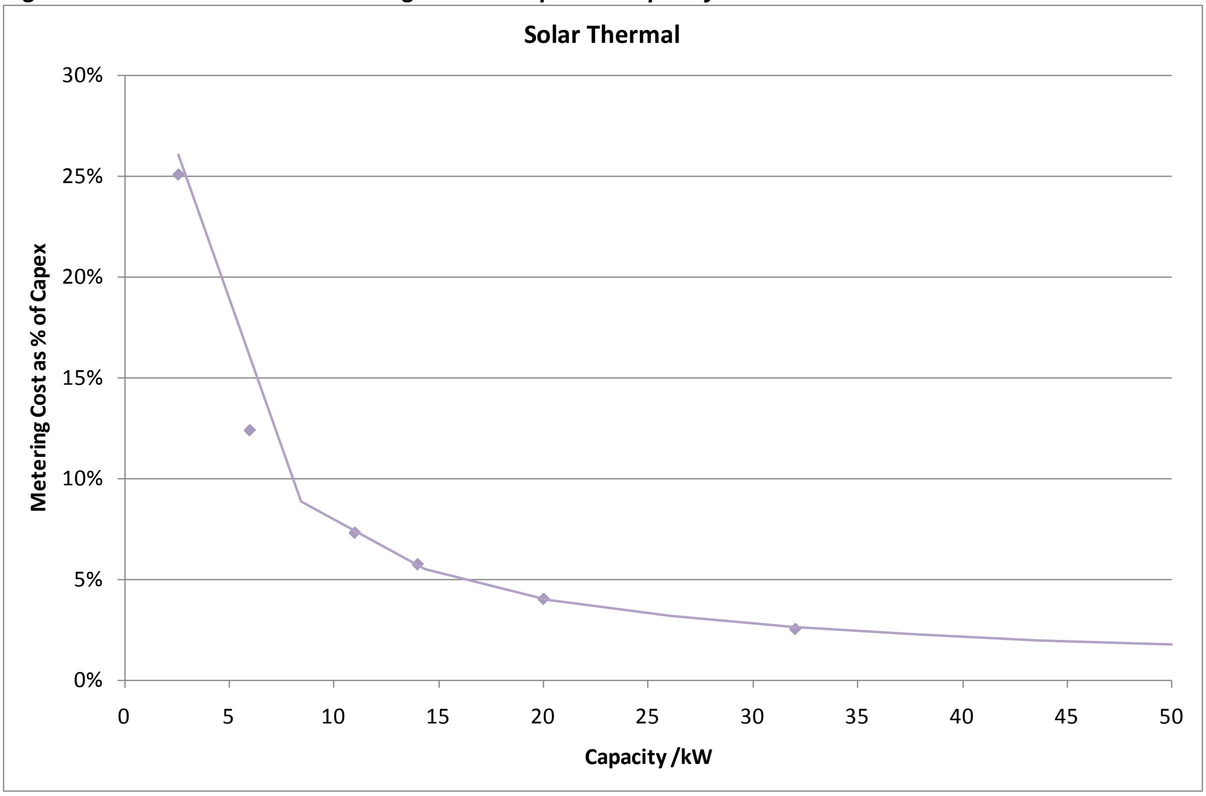


Figure 4: Total cost of heat metering as % of capex vs capacity of installation on solar sites



5.2 Annual cost of reporting energy consumption (as a percentage of operating costs)

Potential costs for the annual operating cost of supplying data to Ofgem were explored in Section 3. It is assumed that the chosen method of data acquisition is via a meter reader (£2.40 per site per year) and the data processing is the manual data capture (£2.40 per site per year). District heating schemes are assumed to provide their data to Ofgem at an assumed cost of £100. The operating costs of metering is compared to the operating costs (opex) supplied by AEA for DECC. Figure 5 and Figure 6 show the capacity of the large and small scale renewable technologies vs. the operating costs of metering as a percentage of the opex. For large scale technologies the metering costs are a maximum of 3% of the opex, while smaller scale technologies have much lower opex and thus the meter opex is a higher percentage of this i.e. up to 43%.

Figure 5: Capacity of large scale renewable technology vs. operating costs of metering as % of opex

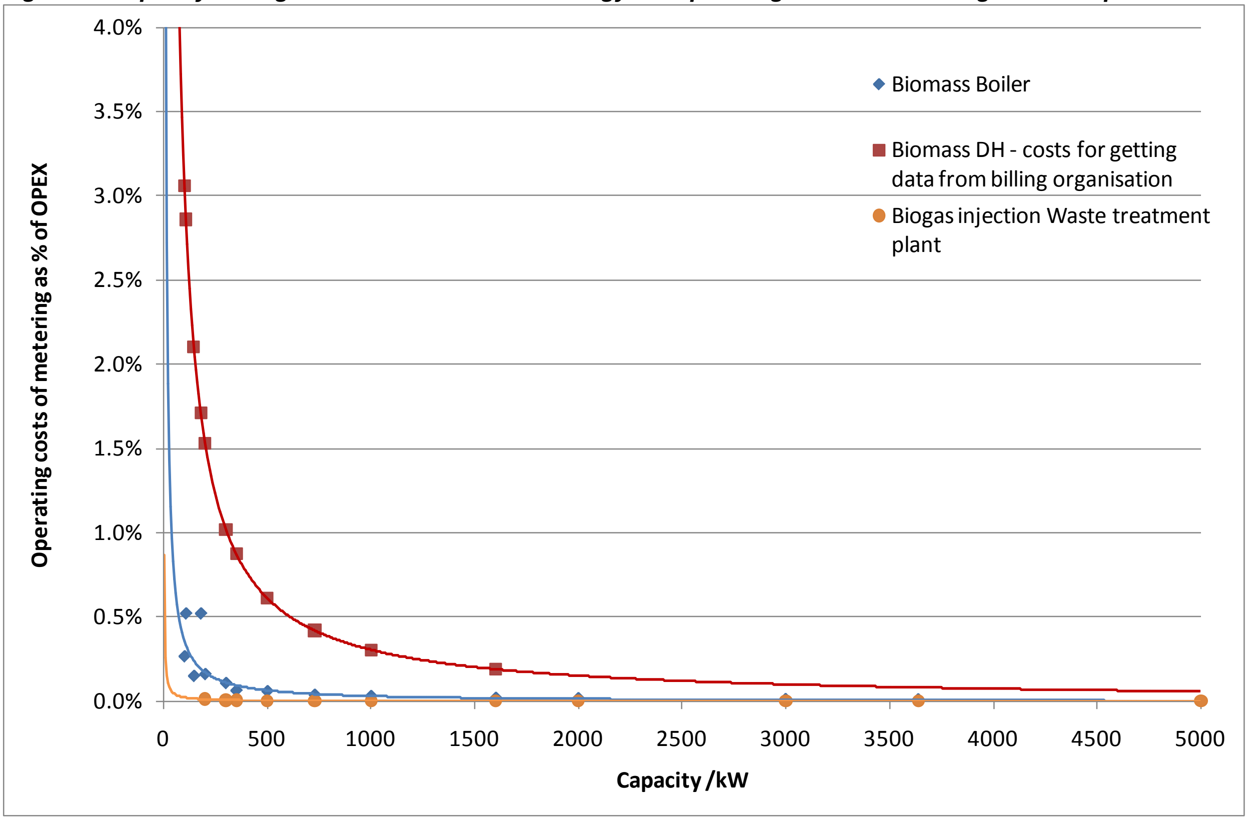
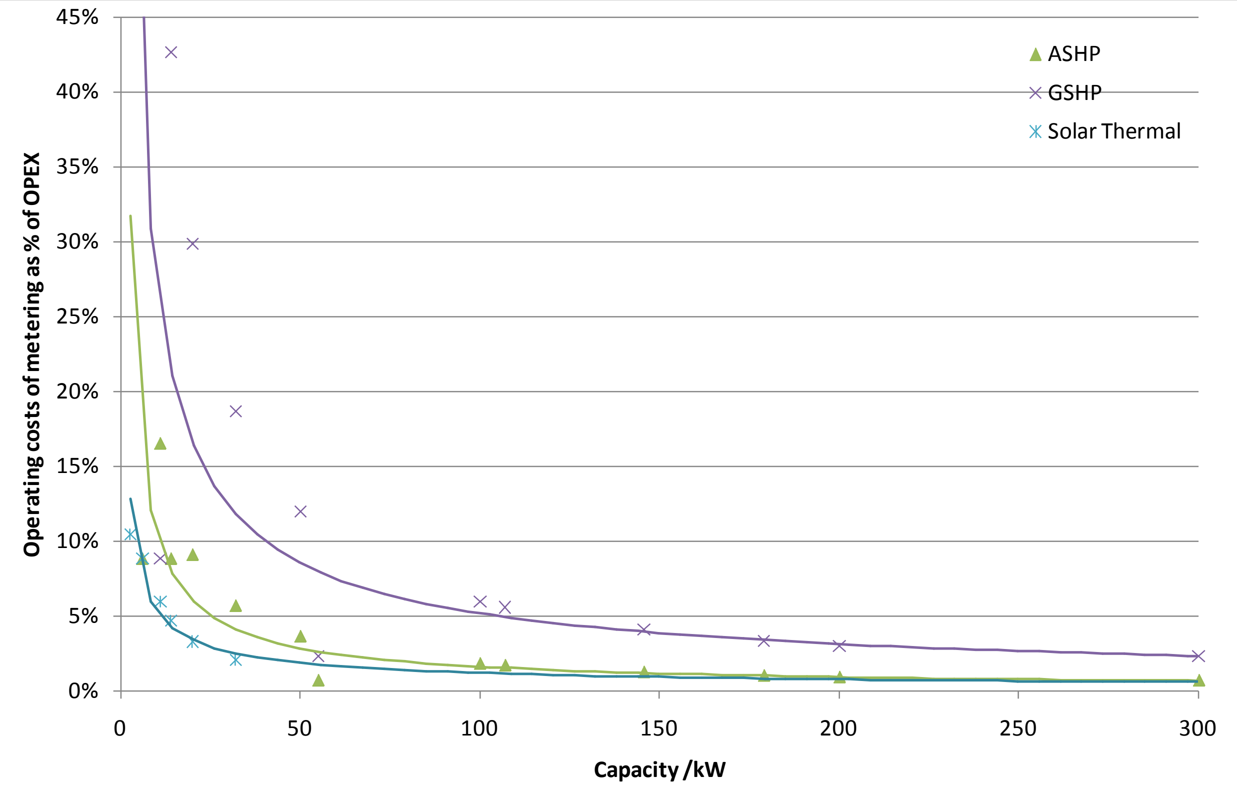


Figure 6: Capacity of small scale renewable technology vs. operating costs of metering as % of opex



6 Verification

The issue of requiring the metering of renewable energy has already been addressed by DCLG who from the 1st October 2010 required that *'meters should be provided to enable the performance of any renewable energy system provided as part of the works to be separately monitored'* (ref ADL2B (2010) Paragraph 4.35) in any non-domestic situation.

We suggest independent verification of the metering arrangements to be used to claim RHI payments by a person who understands the complexities of heat metering would offer a robust system to ensure that payments under the RHI are made correctly. There are a number of possible models:

Table 8: Options for Independent Verification

Option	Pros	Cons
Environmental or Energy Consultant (science or engineering graduate) Possibly ISO 14001 (emas) and ISO 16001 auditors with relevant energy metering experience.	There are a large number of potential verifiers.	Not a metering specialist so will need training. Variable quality of verification unless UKAS accredited.
Ofgem Auditor	Consistent approach by verifiers.	Costly (to Ofgem)– likely to be the most expensive option. Will need training Need to establish a UKAS type accreditation Only audit a percentage of installations.
EU-ETS Verifier	Low cost. Only a small extension to current scope under UKAS accreditation Large number of verifiers already trained and accredited to ISO 14065. Costs would be borne by the generator.	May need a small amount of training.
Generator provides Ofgem with verification	Generator determines the verification that needs to be made. Cost to generator, not scheme.	Ofgem would need to verify any information provided.

The cheapest and easiest option would be to require the generator to prove that the heat metering was installed correctly through documentation via the heat meter installer. However this could lead to fraud and would need further verification by Ofgem.

Thus it might be beneficial to use DECC-approved, UKAS-accredited EU-ETS verifiers as a simple method of verifying meter installations, calculations, and metered data. (The emissions verified under EU-ETS are usually derived by calculation from metered fuel use, so the verifier is often required to examine metering systems to ensure that the meter is providing correct information. Thus, this is only a small extension to the current scope of UKAS accreditation.)

Conversely Ofgem could hire and train additional staff as Ofgem auditors. This would lead to a consistent approach for all verifiers, but is likely to be a relatively expensive option.

Also there is the option to use Energy or Environmental consultants. There would be a large number of potential verifiers, however they would be required to undergo training to be able to perform the work. To ensure consistency of approach they would need to get UKAS accreditation, probably to ISO 14065..

7 Detailed Renewable Heat Technology Considerations

DECC may wish to consider a risk based approach to renewable heat metering. Thus greater accuracy would be required for large systems receiving a large RHI payment. For smaller systems, a cheaper but less accurate approach may be appropriate. This may also apply to the frequency and depth of the audit/verifications required. However, the MID states that all heat meters for use in commercial or industrial premises must be Class 2, and this is the approach recommended here.

The frequency of reporting could also be determined by the scale of the installation. Thus, a large renewable heat source may be required to report heat production monthly, whilst a smaller unit would only need to report annually.

There are several issues which are specific to the renewable technology employed, and these are discussed in this section.

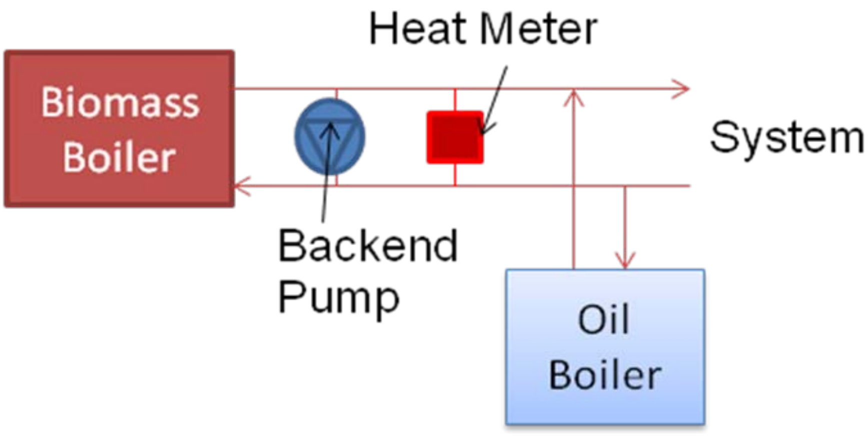
7.1 Biomass

There are several points to consider when metering heat from biomass boilers. A number of these revolve around the positioning of the heat meter to ensure that the correct parameters are measured. Figure 7 to Figure 11 below show typical installations for hot water boilers.

It is suggested that meters should be in compliance with the Measuring Instruments Directive (MID) 2004 Class 2 ANNEX MI-004 (as declared by the MID required for commercial Heat Metering). We suggest that DECC may want to consider paying the RHI upon the net heat output of the biomass boiler(s) subtracting any heat required for drying the fuel or winterisation of the fuel handling facilities.

Care should be taken to connect the heat meter downstream of the back-end corrosion prevention pump-around system which will be installed on virtually all biomass boilers.

Figure 7: Positioning of heat meter on a biomass boiler with backend pump



Biomass boilers are frequently installed in conjunction with fossil fuel boilers (typically oil fired). Because of this, the positioning of heat meters is crucial to ensure that RHI is only paid for renewable heat. Where the biomass boiler can also use fossil fuel, it may be necessary to consider the installation of a fossil fuel supply meter which could be used to correct the heat meter reading so that only renewable heat is rewarded.

In particular, some biomass units (usually greater than 300kW, and particularly above 700kW) have oil or gas fired start up burners which can supply a substantial proportion of the unit's rated output (as much as 40%). In this situation, DECC may consider it necessary to require the installation of an oil or gas supply meter.

Option A: meter fossil fuel input

Oil or gas input meters could be installed as shown in Figure 8. The meter readings could be submitted as discussed in Section 3 and the data handling software could calculate the renewable heat output using fossil fuel calorific value data from industry standard tables. Temperature and pressure data would be assumed to be at standard reference measurements (15°C, 1.013kPa).

Pros: reward only for renewable heat, decrease the likelihood of people running their boilers with oil/gas and claiming the RHI.

Cons: could cost up to £2,600 extra if installation is 5MW, involves more complicated processing and could increase the processing costs.

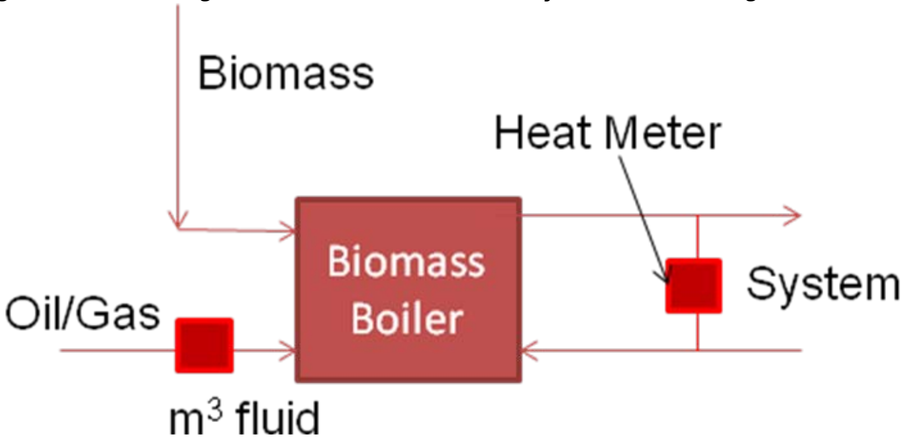
Option B: do not meter fossil fuel input

In situations where the amount of oil or gas used is small (for example less than 10%) this could be “deemed” by the verifier and additional oil/gas metering would not be required.

Pros: simple, cheap.

Cons: could be paying RHI for heat which could be up to 40% fossil fuel derived..

Figure 8: Positioning of heat and flow meters on systems where oil/gas can be used to serve the biomass boiler



The Carbon Trust Biomass Boiler field trial showed that there may be issues around the reliability of some biomass boilers. As a result most non-domestic sites are likely to fit either two biomass boilers or a biomass boiler with a fossil fuel boiler. Multiple biomass boilers can be connected to one heat meter as shown in Figure 9.

Figure 9: Position of one heat meter for more than one biomass boiler

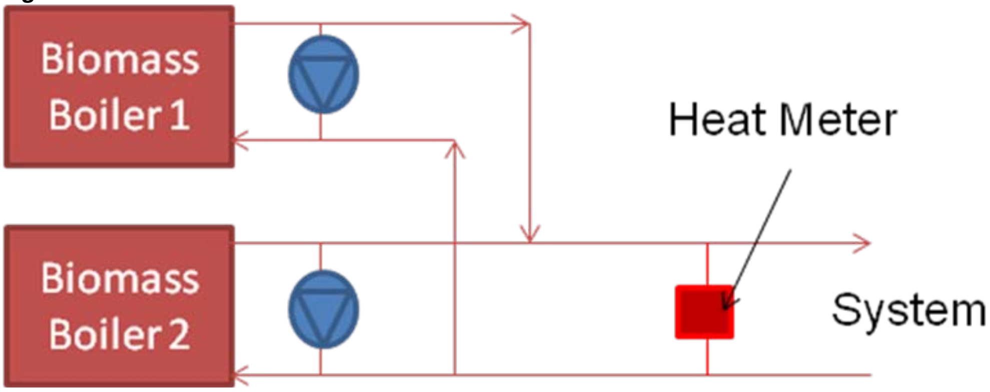
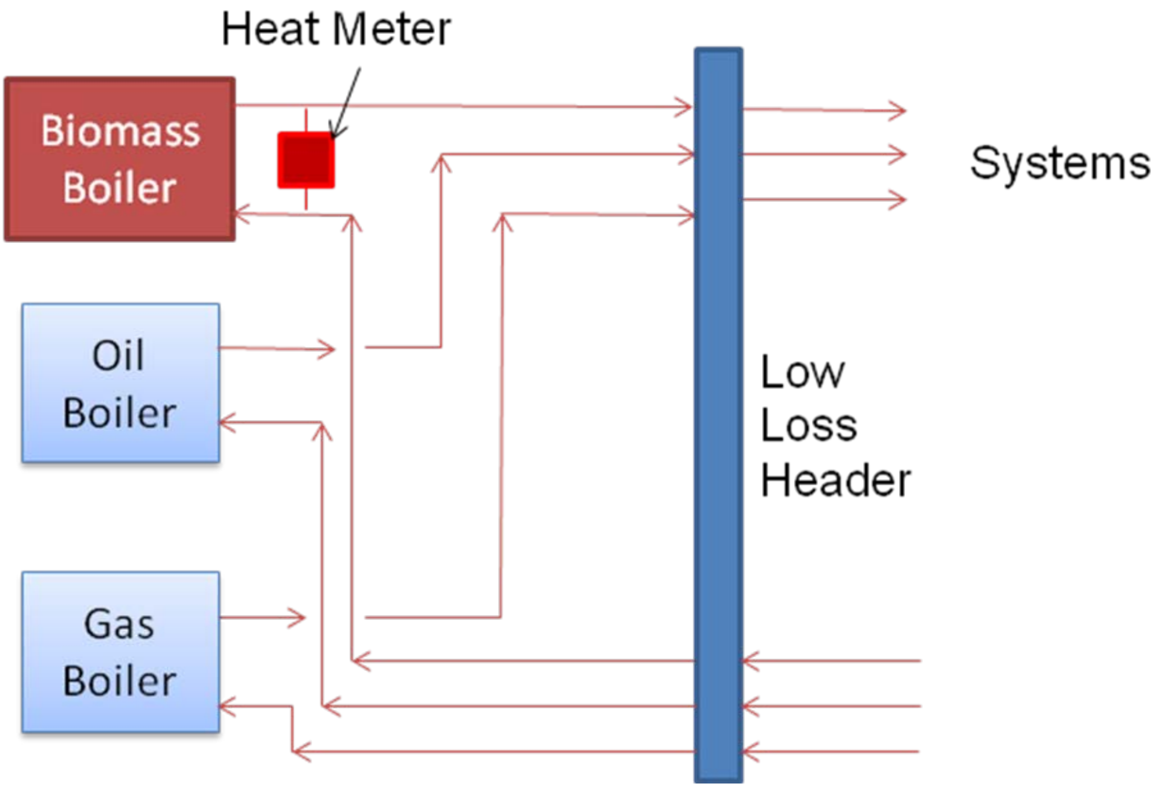


Figure 10 shows the positioning of heat metering in the common situation where biomass and fossil fuel boilers are connected to a low loss header. A low loss header is the most common method of heat distribution in the UK, and virtually all boiler/heat distribution systems employ this system.

Figure 10: Position of heat meter when biomass boiler feeds a low loss header



The storage and later release of heat from a biomass boiler may lead to potential problems with how to reward its production. DECC may consider losses from storage tanks/systems as inappropriate for fiscal support, so alternative heat meter positions are discussed.

Option A: meter before storage tank (heat meter A in Figure 11).

Should only be considered where a high proportion of this heat is to be consumed for either space heating, or the production of DHW, or commercial industrial use, within 24 hours of its production

Cons: could be rewarded for heat which is not used, but is lost from the storage tank.

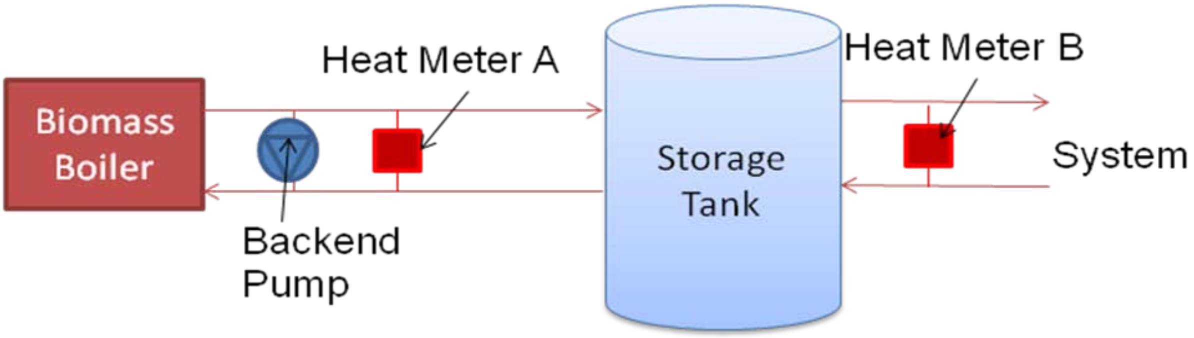
Option B: meter after storage tank (heat meter B in Figure 11)

Should be considered when heat is produced using technologies supported by the RHI and placed into large scale storage with the objective of storing for more than 24 hours. This heat would need to be metered after the storage tank to avoid double accounting. The proportion which would need to be used within 24 hours should be set to allow for reasonable buffering operations.

Pros: encourages proper design (sizing) and thermal lagging of storage tanks.

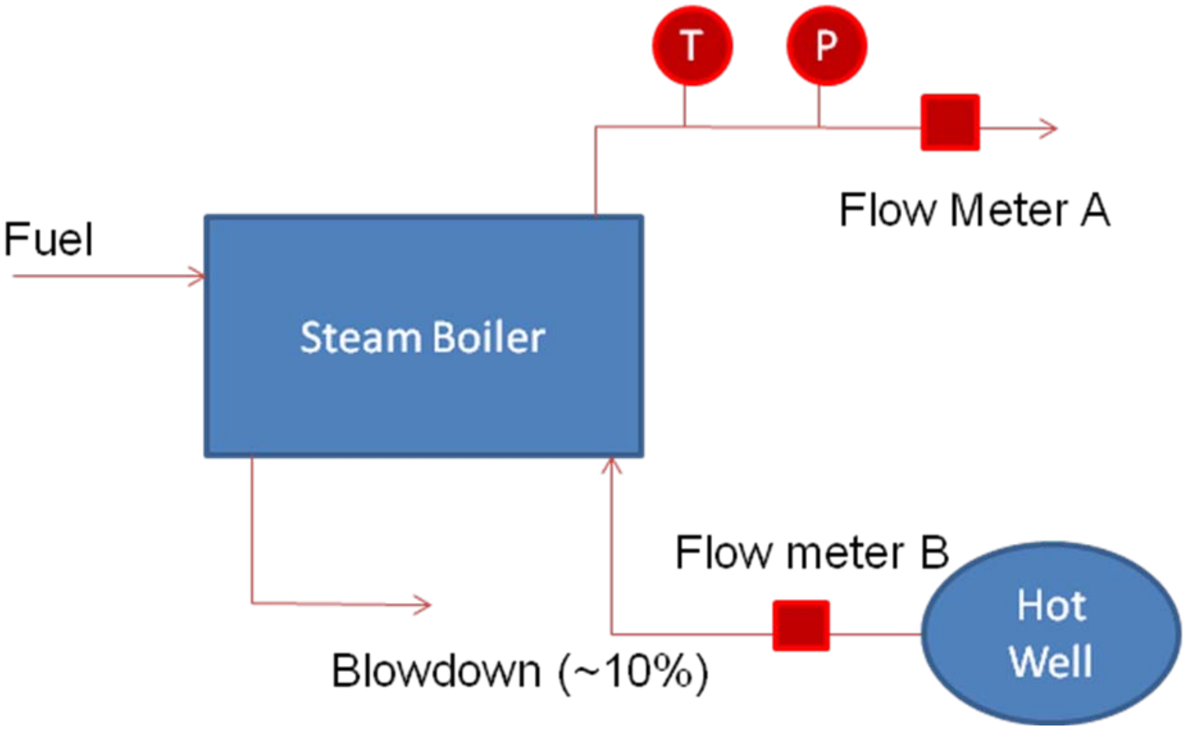
Cons: very careful design of the heat meter installation is necessary, in some systems the water flows can be bidirectional.

Figure 11: Position of heat meter when biomass boiler feeds a thermal store



For boilers which raise steam, the metering arrangements would need to be somewhat more complex. The biomass boiler would need to be fitted with steam metering as shown in Figure 12 below.

Figure 12: Measurements required on a Steam Boiler



Option A: Full steam metering package

The most accurate method would be to install a full steam metering package in accordance with the Carbon Trust Good Practice Guide (GPG018) for steam meters. This would comprise of a drier, a fixed or variable area orifice flow meter (Flow meter A in Figure 12), temperature and pressure measurement. Information from the sensors would be fed to an integrator which would calculate the steam energy flow rate. This would need to be corrected for the inherent energy in the hot well. The costs are significant as shown in Appendix A.

Pros: Most accurate way of metering steam

Cons: The equipment required is relatively expensive.

Option B: Meter the boiler feed water flow rate (Flow meter B in Figure 12)

At the small scale (less than 500 kW), it may be more appropriate to meter the boiler feed water flow rate and assume the steam is saturated at the working pressure of the boiler and blowdown (see glossary) accounts for 10% of this. These are typical industry standard figures for a steam boiler. Typical costs for this option are also shown in Appendix A.

Pros: cheaper option

Cons: less accurate, may require additional verification

It is suggested that steam supplied would be reported monthly and compared with a site-dependent unit of production (e.g. tonne of product). It is suggested that steam metering systems that are not designed using the good practice contained in GPG018 would need independent verification of the design, confirming that the lower cost option was considered to yield information with a known uncertainty. The level of uncertainty which DECC consider appropriate may vary depending on the scale of the installation.

7.2 Air, Water and Ground Source Heat Pumps

DECC may wish to consider two different options for the measurement of renewable heat from heat pumps based on the Energy Saving Trust heat pump field trial results which show that there are underperforming heat pumps in the UK which perform worse than alternative fuels providing no environmental benefit.

Option A: Meter Heat output only

Heat metering would be with meters in compliance with the MID 2004 Class 2 ANNEX MI-004.

Pros: simple approach, cheaper.

Cons: don't know if the heat is of good quality, could be rewarding sites which have poor performing heat pumps whose environmental impact is inferior to gas boilers.

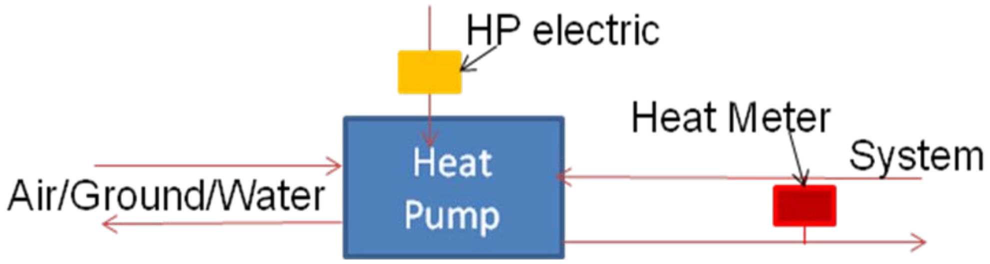
Option B: Meter electricity input + heat output

Electric metering should use a MID 2004 Class B ANNEX MI-003 electricity meter or an Ofgem approved fiscal meter.

Pros: can calculate the coefficient of performance, check on reliability of data, could reward for "quality" renewable heat. Encourages heat pump manufacturers/installers to improve heat pumps.

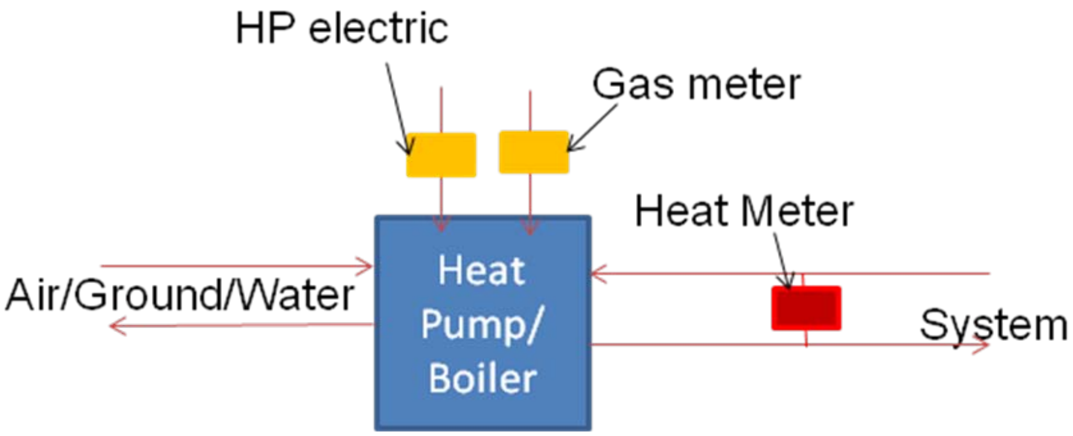
Cons: increased capex cost of metering by between £150 to £300 depending on the size of the installation, see Figure 3.

Figure 13: Positioning of meters on a Heat Pump system



The siting of heat meters is particularly important in duel-fuel systems (for example where the heat pump is designed to supply a nominal base load and peaks in demand are met with a gas boiler) should be used for guidance. In the majority of systems, it should be possible to choose a position for the heat meter where only the renewable heat would be measured. However, in complex systems it may be necessary to measure the fossil fuel input (gas and electric) as well.

Figure 14: Heat Pump/Gas Boiler system where additional metering would be required



Many heat pumps are installed with a substantial thermal store or buffer tank, which allows excess heat to be stored until it is required. This prevents the heat pump from cycling on and off frequently. Short cycling of the heat pump results in poorer performance. In this case similar considerations would apply as those explored in Section 7.1, particularly in Figure 11.

Air source heat pumps often have defrost cycles, to remove ice which can form on the external heat exchange surfaces under certain climatic conditions. During the defrost period, the heat pump takes hot water from either a thermal store or the DHW cylinder and uses this to heat the external heat exchanger. The following options are system dependent.

Option A: meter the defrost with bi-directional heat meter

Where the heat for defrost is taken from the DHW tank, a bi-directional heat meter should be installed just after the heat pump before any heat goes to the system or tank (see Figure 16) and only the net heat output should be rewarded.

Cons - this method of defrost is actually more efficient than either of the other two defrost methods in common use - electric resistive and hot gas by-pass. So there is a danger of encouraging systems with less efficient defrost if the RHI were to be based on net heat delivered.

Option B: meter after the storage tank

In systems with a thermal store it would be simplest to install the heat meter after the tank thus removing the need to subtract the defrost heat (see Figure 15).

Figure 15: Heat Pump with defrost from Buffer Tank

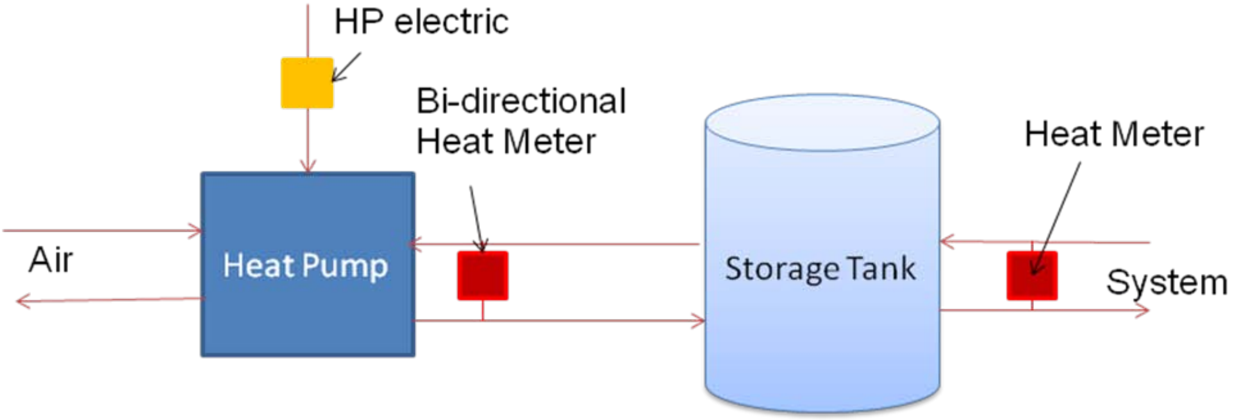
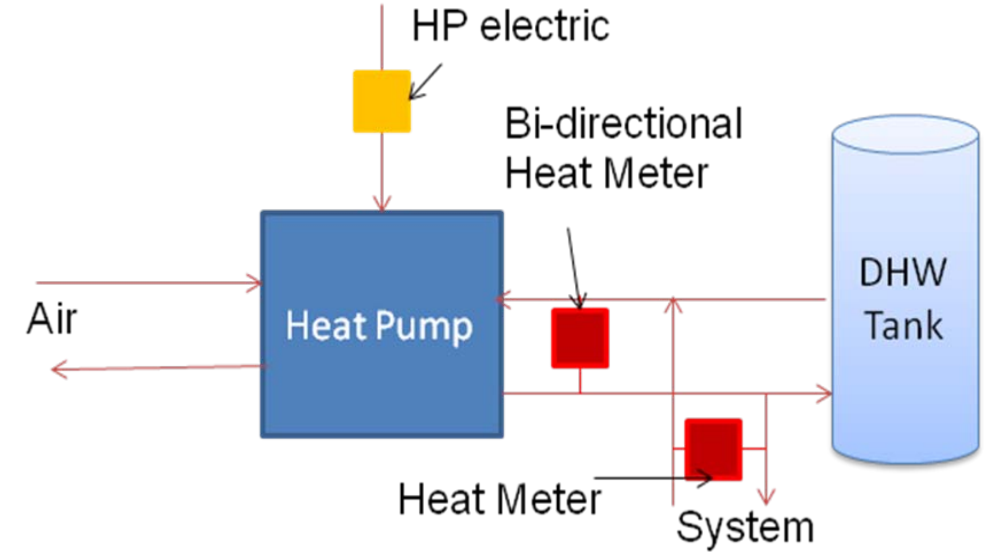


Figure 16: Position of heat meter when defrost comes from DHW Cylinder



7.3 Biogas

Where biogas is used, the RHI could be based on reported actual gas volumes (net of all aspects of the production of the biogas) at a set calorific value (CV). Thus, the calorific value would be deemed and the volume measured. Typical CVs of biogas range from 18 to 25 MJ/m^3. DECC may wish to consider the level at which to deem the CV, a typical value for the gross CV of the gas would be 24 MJ/m^3 at 15°C and 1.013 bar - i.e. 6.6 kWh/m^3.

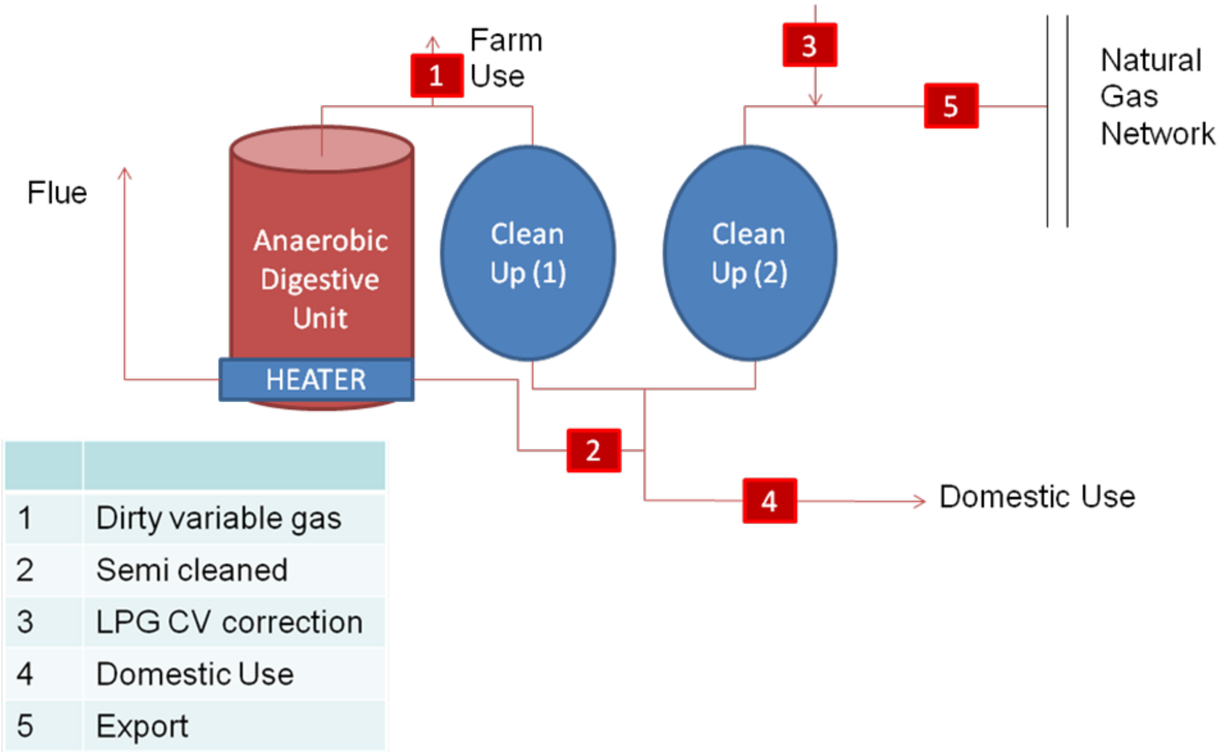
The positioning of the meters would need careful consideration to ensure that only the renewable fuel was measured, and that there was no possibility of adding fossil gas prior to the point of measurement.

Some biogas plants use fossil fuels (particularly during start up) which may need to be metered so that it can be subtracted from the renewable gas production.

It is recommended that volumes of gas be measured with MID 2004 Class 1.5 meters or Ofgem fiscal gas meters (installed cost ~ £200, depending upon site size). Temperature and pressure correction using appropriate IGEM (Institute of Gas Engineers and Managers) codes of practice may be used. IGEM codes state that such corrections are required if operating above 75mbar.

Alternative positions for meters are shown in Figure 17 below. The choice of metering position would be dependent on the use to which the gas was put and the level of gas clean-up required.

Figure 17: Alternative positioning for biogas metering



7.3.1 Biomethane – injection to the gas grid

It is envisaged that many large plants will opt to upgrade their biogas to bio-methane for injection into the National Transmission System and the Distribution Networks (meters 3 and 5 in Figure 17). The bio-methane must satisfy the requirements of the Gas Safety (Management) Regulations 1996 (GS(M)R) on gas quality (Schedule 3 of GS(M)R) at the entry point, or be granted an exemption under GS(M)R Regulation 11.

It is suggested that DECC may wish to prohibit the use of fossil fuel to operate bio-methane plants or the situation could occur where operators are buying in cheap fossil energy to ‘manufacture’ valuable bio-methane.

The following requirement for metering is extracted from “Biomethane into the Gas Network: A Guide for Producers”.

> *The volume of gas injected into the gas network should be measured. On sites designated as “directed” by Ofgem it is likely that Ofgem would require fiscal standard metering. This means that metering must be accurate to within ±1 % on volume measurement, and ±1.1 % on energy measurement; the latter must be determined using fiscal measurement of CV for billing purposes which must be carried out using Ofgem-approved apparatus*.

Currently the only apparatus approved for this purpose is the Daniels Model 500 Danalyzer gas chromatograph 18. This is highly specialised and costly equipment usually restricted to larger power stations and gas network operators. Because of this, DECC may wish to consider deeming the calorific value of the gas whilst requiring measurement of the flowrate using a standard gas meter.

7.4 Solar Thermal

In general, solar thermal systems installed in the UK are relatively small scale and the majority only supply a few thousand kWh of hot water per year. Because of this, it is likely that output from small scale solar thermal systems will be deemed using SAP Appendix H or a comparable methodology.

The report by NERA Economic Consultants on the design of the RHI suggests that a typical commercial/ industrial solar thermal installation would be rated at 32kW and would produce 18000kWh of useful heat per year. This would be a relatively large solar thermal array with an area of 36 m^2. At this scale of operation it may be worth considering metering of the heat supplied. It should be noted that at the rate proposed in the DECC RHI consultation documents for solar thermal (17p/kWh), this would result in an RHI payment of around £3,000/y.

Option A: Deem output of all solar thermal

Pros: simple method, little cost to generator,

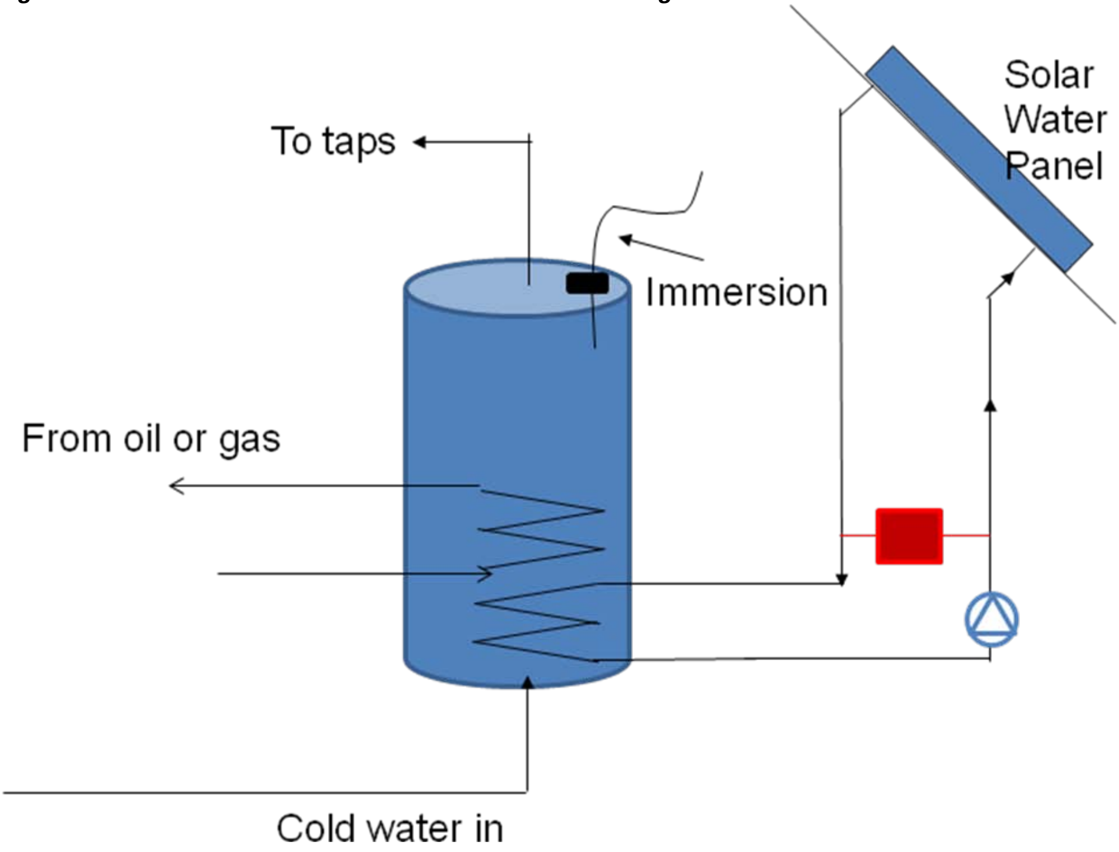
Cons: may over/under reward systems,

Option B: Meter heat output

Pros: ensures payments are made for the appropriate unit of heat generated.

Cons: an appropriate heat meter would need to be installed as shown in Figure 18. The working fluid of most solar thermal systems is a water/ethylene glycol mixture. Thus the heat meter must be able to operate with such a mixture and the calculations carried out by the meter should use the physical properties of the actual working fluid employed. These heat meters are widely available and for non-domestic it is recommended that the meters meet the MID 2004 Class 2 standard.

Figure 18: Position of heat meter in Solar Thermal metering



7.5 District heating

Payment of the RHI for district heating (DH) is a complex issue. A large number of DH schemes employ some fossil fuel for load peaking or summer use, thus there is immediately a complex apportionment between RH use, fossil fuel use, standing losses and 'useful heat'. Even greater complexities arise if the central plant employs CHP. Options are:

No CHP

1) Measure heat from biomass boiler(s) and reward with RHI, minus any fossil fuel used to start up burner etc. This is the simplest option but does not encourage reduction in standing loss.
2) Measure heat from biomass boiler(s) and reward with RHI, minus any fossil fuel to start up burner etc, but then reduce this figure by a conventional risk factor evaluated on a monthly basis from the ratio of:

Total heat metered and billed to users / Total heat sent out from central plant

This would apply pressure upon the site operator to minimise losses. Consideration could be given to require operators to publish basic financial information to demonstrate to users that the RHI is not being abused.

All figures in kWh. Metering of the biomass boiler would be as discussed in Section 7.1.

With CHP

The plants can rapidly become immensely complex with different winter and summer operating regimes. The ratio of electricity production may not be a simple ratio of energy input from RH and fossil fuels. It is suggested that a substantial number of these types of sites could be planning to register with CHPQA. If this is the case then CHPQA metering is likely to be of a high enough standard to be regarded as suitable for the payment of RHI. To avoid having to construct bespoke rules for non CHPQA sites it is suggested that the proportion of exported heat eligible for RHI should be in proportion to the kWh per month of the renewable and fossil fuel energy fed to the generating station. This is a simplification which may slightly over-reward the RH on some sites. Exported heat may or may not be reduced for distribution losses. (Losses in district heating schemes can be substantial, particularly in older schemes with geographically spread users. In newer schemes with high density users, distribution losses are much less of a problem.

Glossary

Blowdown	In boiler systems that partially evaporate water, (as is the case in many steam systems) there may be a build up for water borne solids, which can lead to operational problems, blowdown is the partial draining of this water, and replacement with fresh water to control the concentration of solids.
Buffer Tank/Thermal Store	A tank which increases the volume of water in a system, allowing excess heat to be stored until it is required and reducing the on/off cycling of the heating appliance.
Capex	Capital Expenditure
CV - Calorific Value	The amount of heat produced by the complete combustion of a material or fuel
CH	Central Heating
De-aerator	A unit fitted to a heating system to remove air from the water circuit.
DHW	Domestic Hot Water
District Heating	A scheme where (for example) a block of flats is heated by one appliance usually each flat will have its own heat meter and be billed from that.
Electromagnetic flow meter	A fluid flow meter which works by applying a magnetic field to the metering tube, which results in a potential difference proportional to the flow velocity perpendicular to the flux lines.
Fixed area orifice flow meter	A fluid flow meter where a sharp edged plate (or nozzle, or venturi) with a central hole is placed in the flow path. The pressure drop across the plate can be related to the flow rate, using the Bernoulli Equation.
Flange fitting	A protruding rim, edge, rib, or collar used to attach a heat meter into the pipework, more common in larger bore piping.
Low Loss Header	A system where multiple circuits are connected in parallel across a common header so that each one has the full heat source available to it.
Opex	Operating Expenditure
Screw fitting	A standardised threaded connection between the flow meter and the pipework, most common in smaller bore piping.
Ultrasonic flow meter	A type of flow meter that uses high frequency sound waves to measure flow by either time of flight or Doppler methods.

Variable area orifice flow meter	A flow meter (for example a rotameter) which consists of a tapered tube with a float inside that is pushed up by fluid flow and pulled down by gravity. As flow rate increases, greater viscous and pressure forces on the float cause it to rise until it becomes stationary at a location in the tube that is wide enough for the forces to balance. The flow rate is proportional to the height of the float.

Appendix A: Detailed capex and opex

The following tables show the number of meters, strainers and dearators are required for each type of technology over the given life expectancy. Where there are two options given in Section 7 both have been costed and are shown as Option A or B.

Table 9: Metering requirement for biomass boilers

Number of meters required	Biomass boilers - retrofit	Biomass boilers - new build	Biomass boilers - retrofit steam metering Option A	Biomass boilers - new build steam metering Option A	Biomass boilers - retrofit steam metering Option B	Biomass boilers - new build steam metering Option B
Retrofit heat meter	2				2	
New build heat meter		2				2
Temperature and pressure measurement					1	1
Steam			2	2		
Deaerator	1	1			1	1
Strainer	1	1			1	1
Life Expectancy of technology	15	15	15	15	15	15

Table 10: Metering requirement for heat pumps

Number of meters required	ASHP retrofit with electric meter	GSHP retrofit with electric meter	ASHP new build with electric meter	GSHP new build with electric meter	ASHP retrofit	GSHP retrofit	ASHP new build	GSHP new build
Retrofit heat meter	2	2			2	2		
New build heat meter			2	2			2	2
Electric meter	2	2	2	2				
Deaerator	1	1	1	1	1	1	1	1
Strainer	1	1	1	1	1	1	1	1
Life Expectancy of technology	20	20	20	20	20	20	20	20

Table 11: Metering requirement for other technologies

Number of meters required	Solar Thermal	Biogas injection Waste treatment plant
Retrofit heat meter	2	
Biogas		2
Deaerator	1	
Strainer	1	
Life Expectancy of technology	20	15

Estimated metering costs are given below; these costs are based upon supplier costs in actual installations.

Table 12: Estimated metering costs

Capacity kW	Retrofit heat meter including installation	New Build heat meter including installation	Steam metering Option A	Steam metering Option B = Heat meter + Temperature and Pressure measurements	Electric meter	Gas meter	De-aerator	Strainer
5000	5393	4443	8000	400	300	2618	2700	300
3640	5393	4443	8000	400	300	2618	2700	300
3000	5393	4443	8000	400	300	2618	2700	300
2000	5393	4443	8000	400	300	2618	1305	200
1602	5393	4443	8000	400	300	2618	1305	200
1000	5393	4443	8000	400	300	2473	1305	100
728	3551	2401	8000	400	300	2473	898	100
500	2656	1956	8000	400	300	2473	898	100
350	2221	1671	8000	400	300	2473	898	50
300	1776	1176	8000	400	300	2473	500	50
200	1776	1176	8000	400	300	2473	500	50
179	907	807	8000	400	300	2473	130	40
145.6	907	807	8000	400	300	518	130	40
107	907	807	8000	400	300	518	130	40
100	907	807	8000	400	300	518	130	40
55	723	603	8000	400	300	518	130	40
50	723	603	8000	400	300	518	130	40
32	502	412	8000	400	300	518	80	15
20	502	412	8000	400	300	518	80	15
14	502	412	8000	400	300	518	80	15
11	502	412	8000	400	150	518	80	15
6	502	412	8000	400	150	518	80	15
2.6	502	412	8000	400	150	518	80	15

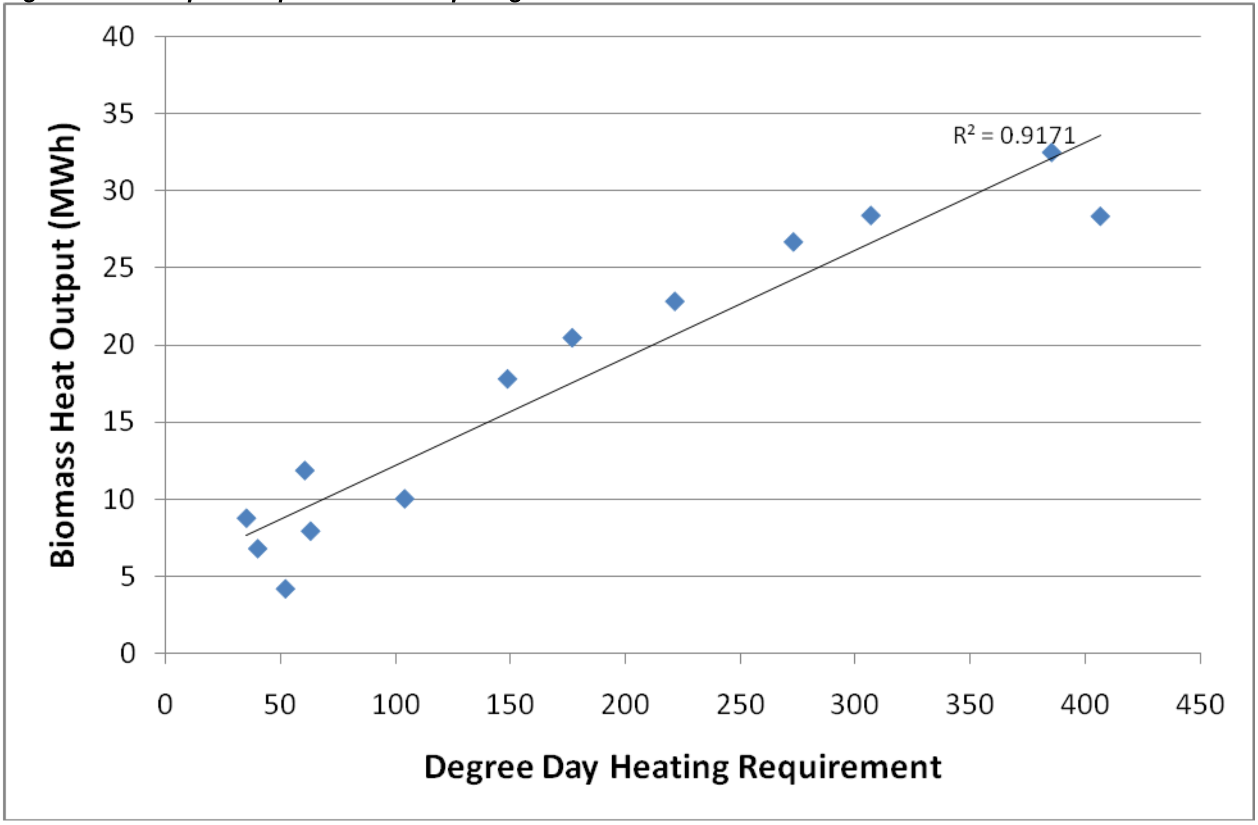
Appendix B: Degree Days

It is important to check whether the data provided by a site is real i.e. if the heat meter data is valid, or if the site is wasting heat or meeting a heat load that would not have been met if the incentive was not in place. This can be done by checking the consistency of the data with degree days if the site heat load varies with the external temperature. In process-led sites this type of analysis would be irrelevant and comparison to production figures may be required.

Heat output could be compared to the degree day heating (DDH) requirement for the site's location (these can be found weekly, monthly or daily from the MET office on websites such as: http://www.eci.ox.ac.uk/research/energy/degreedays.php).

If the external temperature is the driving factor for heating requirement this should form a plot with a straight line representing the expected consumption. If the energy consumption is much higher than this line for a month period the site could be over-generating to increase their RHI payments or the heat meter could be reading too high.

Figure 19: Example of a plot of heat output against DDH of a biomass boiler



It is important to compare similar sites to each other at the beginning until the degree day graphs have enough points for it to become significant.

Appendix C: Data Acquisition and Processing

The following appendix shows the build-up of costs and explanation of the data acquisition and processing procedures.

1) Manual Data capture

Number of Sites = 250,000
Readings = 12 per year (suggested minimum level)
Working day = 8 Hours = 480 minutes

Processing days available = 50 weeks (excludes statutory holidays etc.) * 5 = 250
Readings per day = (250,000 * 12) / 250 = 12,000 readings per day
Readings per minute = 12,000 / 480 = 25

Assume 75 % of people will use a web portal to enter the data.

Approximately 7 transactions per minute would need to be dealt with by a human being.

Assume 1 person can process a telephone call / letter / postcard per minute this would require a team of 7 people * 1.5 to cover holidays sickness etc. = 10 people.

Hourly rate = £30 (incl. overhead)

Cost = (People * hours * hourly rate * days) / Sites
Cost = (10 * 8 * 30 * 250) /250,000

This cost could be retrieved by taking admin fees out of the RHI payments.

Approx £2.40 per site per year.

2) Meter Reading by a billing organisation using a local area radio

9434 Electoral Wards in the UK, approximates to 10,000

If the 250,000 sites are split evenly between these wards = 25 per ward
Given 10 minutes per house (this would be in Urban areas) = 25 * 10 = 250 minutes

Assume 1 person could read 1 ward per 4 hours if they were using a short radio reader
Therefore 1 person is able to read 2 wards per day.

25 * 2 = 50 sites per day
50 sites * 250 (working days) = 12,500 per year
250,000 sites / 12,500 per year = 20 meter readers

20 * 1.5 (holidays cover etc) * 12 reads a year = 360 meter readers

Hourly rate = £35 (incl. overhead and transport)

Cost = (People * hours * hourly rate * Days) / Sites
Cost = (360 * 8 * 35 *250) / 250,000= £100

Add local radio Data logger cost £250 amortised over 5 years = £50

Approx £150 per site per year. (360 employees across the country ignoring setup costs)

3) Meter Reading by AMR via GSM / Internet

There are several organisations that already provide services for automated meter reading around the country and that have the staff and expertise to undertake such a process. The data that they would gather is the data available for Ofgem/DECC to process for payment.

The costs per site include
1) Data Logger
2) Installation
3) Site Survey
4) Reporting Software
5) Inclusive of all GSM airtime where necessary

Typical prices for ½ hourly metering:

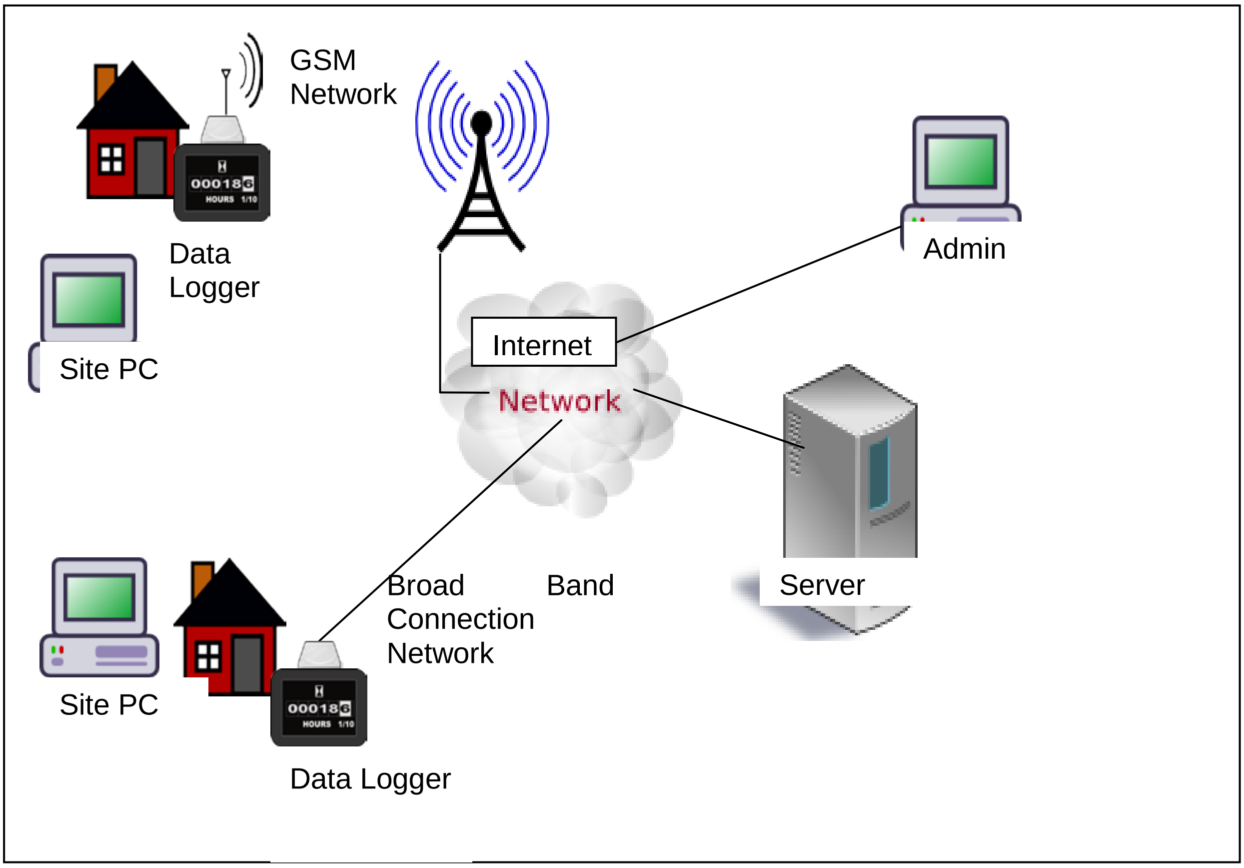
Via GSM using bespoke SIM card	: £155 - £180 per site per year
Internet using existing client ISP	: £35 - £140 per site per year

These prices may slightly reduce for monthly interactions but at £35/year, a 'minimum cost factor' comes into play.

The large range in price depends to a large extent on the business model of the company supplying the equipment. Businesses that are manufacturing the heat meters will provide hardware and software to read the data from those meters at a much reduced rate. Companies providing meter reading services will have a business model based on processing transactions, but to date numbers are low and the RHI could dramatically increase business activity in the sector and thus drive down prices.

The majority of data collection and billing systems in the UK have been based on GSM telemetry systems. This allows the billing organisations to retain control of the monitoring system, to prevent interference from the client. However with RHI the client will be motivated to keep the connection up thus the use of their own broadband system would be cheaper and is more likely to be acceptable to all parties. There are already a number of systems operating in the UK that provide small-scale electricity monitoring via an internet connection at a cost of £50 for equipment and £2.00 per month connection charge.

Figure 20: Automatic Meter Reading - How it works



An overview of automatic meter reading is shown in Figure 20.

Each site would have a data logger installed as illustrated in Figure 21.

Figure 21: Data logger

The data logger takes the output from the heat meters pulsed output. Each pulsed output represents a kWh.

The data logger would be connected to the internet either directly via a cable or through its own internal GSM modem (essentially a mobile phone without the human interface). The typical size of these units is 15-20 cm long by 10 cm high by 4 cm deep.

The data is fed back over the internet to a main server that takes in the readings. In most commercial cases this is each ½ hour.

The data is then available to be extracted to be processed by the Administrator to process payments or billing.

Examples of how the data can be displayed at the site via the users own internet connected PC.

Figure 22: Sites user interface available over the internet (example is GAS but is available for Water and Electricity)

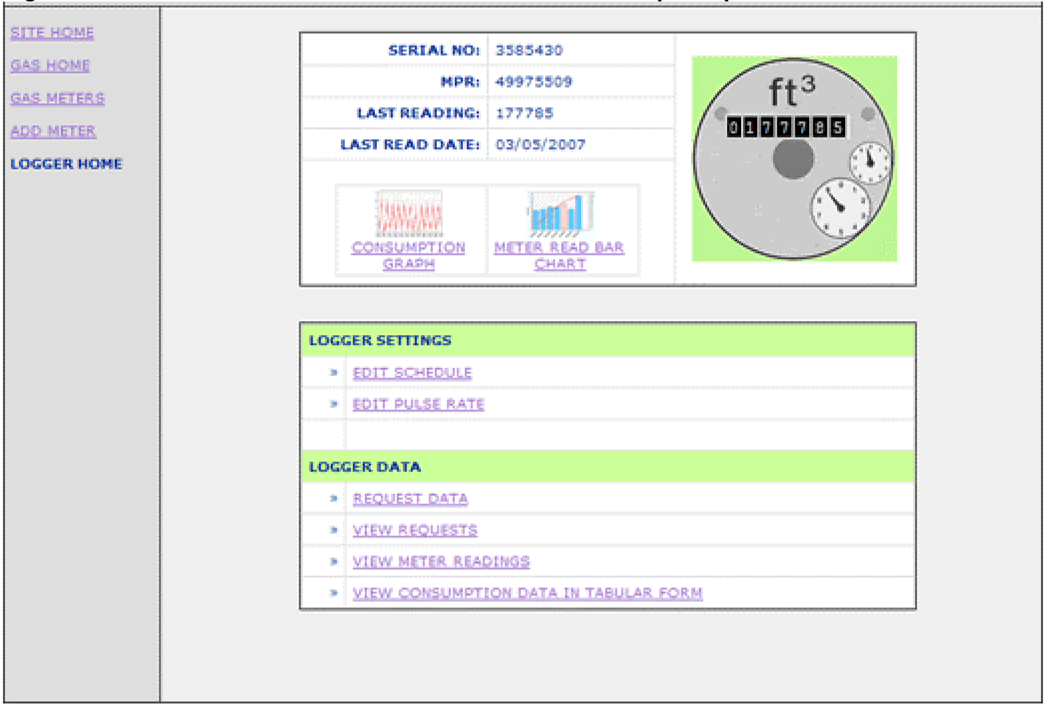


Figure 23: Monthly Consumption Figures across different sites

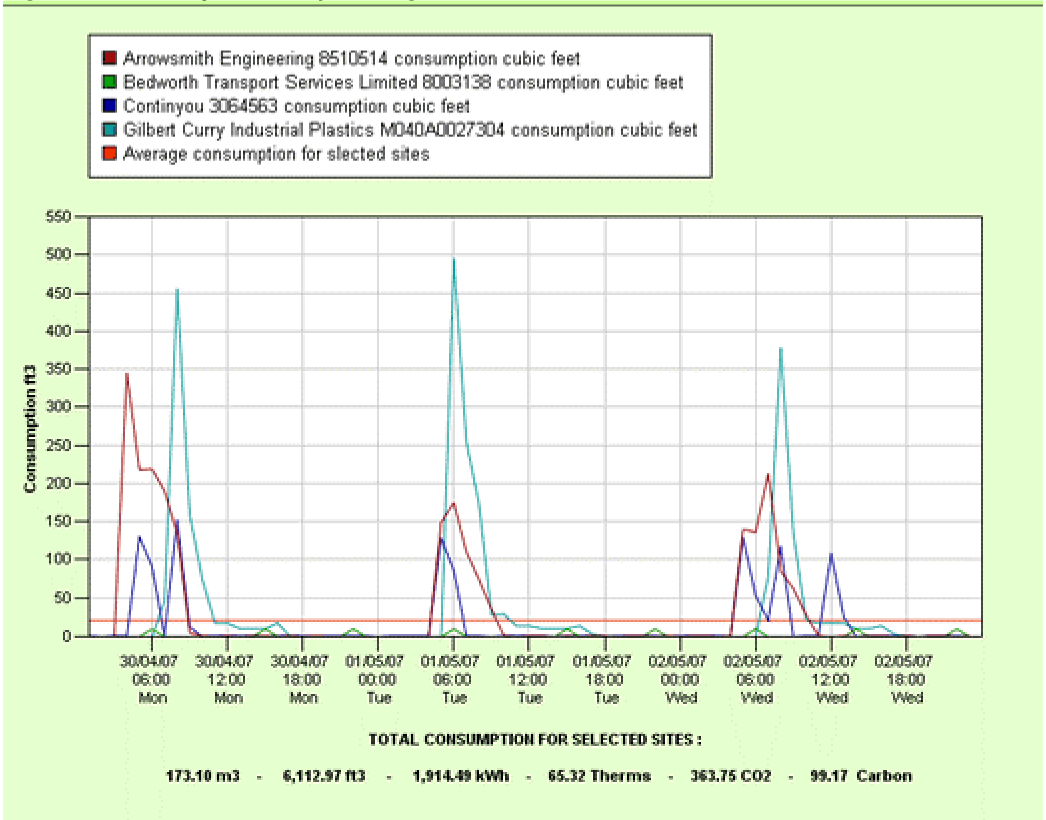
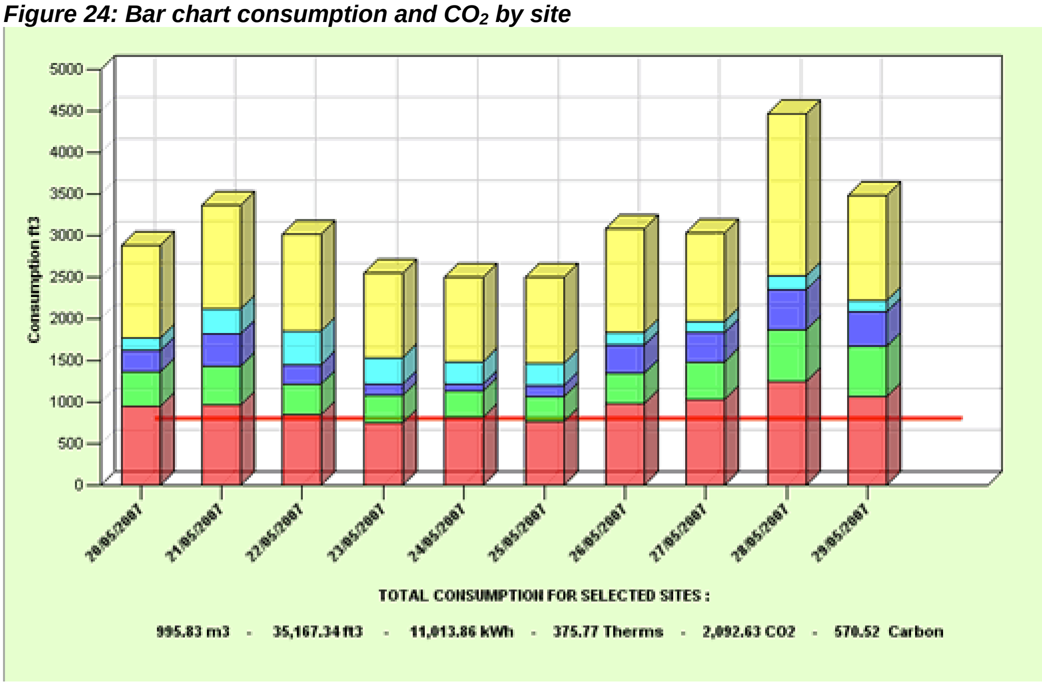


Figure 24: Bar chart consumption and CO_2 by site



4) Estimated Costs of Data Processing

Two options are considered:

1) Production of bespoke RHI software

Once the data is collected, it will have to be processed for payment.
Software Program to produce payment would probably be a £250,000 one-off cost

Processing staff assume 10 members of staff at hourly rate of £30 per hour
Hourly rate = £30 (incl. overhead)

Cost = (People * hours * hourly rate * Days) / Sites
Cost = (10 * 8 * 30 * 250) /250,000

Approx: £2.40 per site per year.

2) Use of outsource agency

It would also be possible to outsource the processing of the data, in the UK many organisations will take the data and process this on behalf of clients.

Range of costs from £1.50 to £4.00 per site per annum depending on frequency of payments.

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