The Certification Mark for Onsite Sustainable Energy Technologies

MCS

MCS Domestic RHI Metering Guidance v1.0

Contents

1. Definitions

This Microgeneration Installation Metering Guidance makes use of a number of terms when prescribing certain requirements and procedures. In the context of this document:

- The term 'must' identifies a requirement by law at the time of publication.
- The term 'shall' prescribes a requirement or procedure that is intended to be complied with in full and without deviation.
- The term 'should' prescribes a requirement or procedure that is intended to be complied with unless reasonable justification can be given.
- The term 'Contractor' identifies an individual, body corporate or body incorporate applying for or holding certification for the services detailed in this document.
- The term 'Contract' prescribes a written undertaking for the design, supply, installation, set to work and commissioning of microgeneration or metering systems and technologies.
- The term 'installation' refers to the activities associated with placement and fixing of a microgeneration or metering system.
- The term 'Commissioning' prescribes the activities to ensure that the installed system operates within the boundaries and conditions of the design and the product manufacturers' claims.
- The term 'Handover' specifies the point in a Contract where Commissioning and certification of the system have been satisfactorily completed to the Contract specification so enabling the installation to be formally handed over the client.
- The term 'Subcontract' specifies a written Contract between a certificated Contractor and another firm for supply of products and services in connection with the fulfilment of a Contract.

2. Introduction

The government is introducing the Renewable Heat Incentive (RHI) to support renewable heat generation in the domestic sector. The scheme will offer tariff payments for supported technologies which include MCS (or equivalent) certified solar thermal systems, ground source heat pumps, air source heat pumps and biomass boilers or stoves with back boilers for use in the domestic sector.

All RHI installations should be made meter-ready. In addition, in some cases, applicants will require metering for payment in order for their systems to be RHI compliant, whilst in other cases applicants could be paid extra for metering and monitoring system performance. This document sets out the specification of the metering and meter readiness required, and responsibilities that MCS Installers shall meet for the installation to be RHI compliant.

Installation of metering in accordance with this document shall only be undertaken by an MCS installation company certified for the corresponding RHI technology being metered.

NOTE: For existing installations the MCS installation company shall take into account the requirements of the corresponding MCS Installation Standards.

3. Scope

This document is concerned with three types of metering:

<u>Section 5: Meter-ready</u>- All RHI installations should be meter-ready for DECC's own metering to be fitted to the site if selected.

<u>Section 6: Metering for payment</u>- Where a heat pump or biomass boiler is installed alongside certain other heating systems or where the installer is advised that the property is a second home, then the renewable heating system shall be metered in order to receive payment under the RHI. Procedure A in Annex B provides further guidance for when Metering for Payment is required. The specifications for the metering and other requirements are detailed in Section 6.

<u>Section 7: Metering and Monitoring Service Packages</u>- A customer may install an optional metering and monitoring service package for either a pellet biomass boiler or a heat pump for which they will receive a financial uplift. The specifications for installation of meters as part of these packages are detailed in this section along with the other requirements in order for the package to be installed in a form that is compliant with the RHI.

4. Contracts and customer requirements

The normal MCS requirements regarding contracts and customer requirements as in MCS 001 apply here, some of the most pertinent of which are reproduced below:

> “A contract for the sale and installation of a system shall be entered into only between an MCS certified Company and a Customer. An MCS certified Company may carry out work under subcontract to another MCS certified Company in which case the requirements specified in Section 4.1 must be satisfied.
>
> “If the MCS certified Company obtains sales leads from any third party, the Company must require that the third party complies with all the relevant requirements of the MCS standards and Consumer Code. The Company will be responsible for any non-compliance.
>
> “The Company shall have procedures to handle enquiries, produce quotes and accept orders/contracts. Where relevant these must comply with the consumer code scheme.
>
> “The Company shall review orders, contracts or tenders to ensure that:
>
> - The requirements are adequately defined for each installation;
> - The Company has the resource and capability to meet the order/contract requirements. Where the time scales cannot be met, the Company shall detail when the order/contract will be fulfilled;
> - Responsibility for planning and building control compliance is clearly identified.
>
> “Records of this activity shall be maintained for all orders/contracts and tenders.
>
> “A process shall also exist for managing amendments to contracts/ orders.”

For Metering and Monitoring Service Packages, it is a requirement that the Company has a contract with a Customer (though aspects of this work, for example with respect to maintaining the data platform, may be subcontracted by the MCS Installation Company as in Section 4.1) that specifies that:

- The Company shall transmit information recorded as part of the MMSP automatically to a data platform and shall continue to provide a data platform in line with the requirements in Section 7, including that data completeness and the data platform should be maintained at 75 %

or higher for all sensors on an annual basis for the duration of the Contract (except where this is as a result of customer error);

- The Company shall inform the Customer if any part of the MMSP is to be delivered by a subcontractor on behalf of the MCS Installation Company and of the identity of any subcontractor who is providing a service as part of an MMSP. The Company shall also notify the Customer if that subcontractor changes;
- The MMSP can be assigned by the MCS Installation CompanyMCS Installation Company to another MCS Installation CompanyMCS Installation Company if the Customer consents;
- The Customer who entered into the MMSP contract may assign the contract to another owner of the accredited domestic RHI installation on giving notice to the MMSP installer if the Customer ceases to be the owner of the accredited domestic installation;
- The MCS installer providing an MMSP must provide to the Customer, on request, all of the information collected under the MMSP agreement over the 12 month period ending on the date on which the information is requested as well as any other information relating to the Customer or the MMSP held by the MCS Installation Company providing the MMSP.

4.1 Sub-contracting

Where installers want to install an eligible Metering and Monitoring Service Package, it may be particularly likely that the installer partners with a third party to fulfil some of the requirements in this guidance document. In this case, the normal MCS requirements regarding sub-contracting as specified in the latest version of MCS 001 [1] are particularly relevant and shall be complied with. For ease of use, these are replicated here:

> "In installations for private customers, any work within the scope of the scheme [where "scheme" is here taken to refer to the context of this guidance document] not undertaken by employees of the Contractor shall be managed through a formal subcontract agreement between the two parties in accordance with the policies and procedures employed by the certificated Contractor. These procedures shall ensure that the subcontractor undertakes the work in accordance with the requirements of this standard.
>
> "In other situations (for example new build, or for commercial customers), it is permissible for the physical installation, setting to work and commissioning to be undertaken by others (i.e. not sub-contracted to the Contractor) provided that:
>
> - "A contract between the Contractor and the commercial client details obligations on the

client to include that evidence of skills and training of those employed by the client to do elements of work not undertaken by the Contractor are to be made available to the Contractor to ensure that the competence requirements of this standard are met and that access to the site for training and supervision in accordance with the following sections is agreed in advance.

- "The certificated Contractor provides additional product-specific training for those undertaking the work not undertaken by the certificated Contractor.

- "The certificated Contractor assesses a sample number of installations under the contract which is not less than the square root of the number of installations rounded up to the nearest whole number (e.g. a new build site of 50 installations then a minimum of 8 are assessed).

- "The certificated Contractor assumes responsibility at handover that the installation is in full compliance with the standard."

5. Meter-ready

Some installations incentivised through the RHI will have DECC's own metering fitted where the metering data may then be used to allow DECC to evaluate the effectiveness of the policy. The data may be shared with MCS.

DECC intends to install meters to monitor the heat output from a renewable heating system, the energy consumed by those same heat sources, and the heat output from any back-up fossil fuel systems. This could require engineers, appointed by DECC, to install a number of heat meters, electricity meters or other energy meters, depending on the specific heating system and manner of installation. In addition, DECC will install a number of temperature sensors to develop an understanding of the behaviour of a range of heating systems, for example temperature measurement of space heating flow and domestic hot water flow. The sensor outputs will be connected to a logger that will store all readings and regularly transmit them to a centralized secure data centre.

Where a manufacturer has integrated metering into their product that is compliant with the metering specified in Section 6 or Section 7, then points 1-3 below will be deemed to have been met.

All RHI-compliant renewable heating installations should be made meter-ready. MCS installers should:

1. Leave sufficient space for appropriate meters to be fitted in defined locations;

a) Heat pumps and biomass boilers

Annex A shows a flow chart to explain how installers can decide on the number of meters required for some of the commonest types of biomass and heat pump renewable systems.

The flow meter and return temperature sensor of the heat meter(s) take up the most space and need to be situated on the return pipework between the circulation pump and the distribution system. The required length of straight pipework between isolation valves is 20 times the pipe diameter to enable DECC's chosen metering to be installed on the return pipework. Table 1 below shows the length of straight pipe required for a number of standard pipe sizes.

Pipe diameter (mm)	Total length of straight pipework required in return pipe (mm)	Total length of straight pipework required in the flow pipe (mm)
15	300	175
22	440	175
28	560	175
35	700	175
42	840	175

Table 1: Meter ready space requirements for different pipe diameters

For each location where a heat meter is required, a section of pipe of 175 mm should be left for the heat meter temperature sensor in the flow pipework. This should be no more than 2 m from the flow meter.

b) Solar Thermal

For solar thermal systems, DECC intends to install its own metering on a sample of systems to measure the heat supplied from the solar thermal panel to the domestic hot water cylinder, heat drawn from the domestic hot water cylinder and any energy input from other sources to the domestic hot water cylinder. Therefore an MCS installer should leave space in the flow and return pipes for each required heat meter in accordance with Table 1, specifically leaving space for the flow meter component of each heat meter on:

- the return to the solar thermal panel from the domestic hot water cylinder;
- the output from any other source that supplies the cylinder; and
- the draw off from the domestic hot water cylinder.

(Electricity supplied to immersion heating will be metered separately and there are no space requirements for such metering.)

2. Install low pressure-drop isolation valves to avoid the need to drain systems when fitting heat meters;

These should be installed at each point where heat metering is required. The flowchart in Annex A shows how an MCS installer shall identify where to locate isolation valves for the most common examples of heat pumps and biomass boilers or stoves with back boilers. Heat metering installed between the isolation valves should be able to record the total heat output from the heating system (excluding individual room heaters and immersion heating, the latter of which will be monitored through electricity sensors). Therefore, if there are several return pipes connected to a renewable heating installation, then each one will need to be heat metered, and each one will need to be fitted with isolation valves with sufficient separation to allow heat meters to be installed.

For solar thermal installations, isolation valves do not need to be installed but space must be left for the meters as specified in point 1b above.

3. Leave sufficient pipework accessible, i.e. not boxed in or under floor boards, to enable meters to be fitted;

4. Feedback information about the installation

DECC will need to know a number of factors about a site so an application will not be considered to be "meter-ready" if such information has not been provided. The information shall include the following:

To be fed back to MCS through the Compliance Certificates:

a. Whether it has been possible to make a system meter-ready in accordance with the above requirements and, if not, the reason why;

To be reported to the Customer as part of the document pack (so that the Customer can respond to DECC questions at a later date):

b. Whether the thermal transfer fluid in any metering location is composed of water or a water/inhibiter/antifreeze mixture and what are the components of the mixture concerned;

c. Whether the site uses a defrost mechanism that draws heat from the home;

d. Whether the heat pump or biomass boiler provides hot water and whether this is also heated with an immersion heater, solar thermal or other system;

e. Whether the RHI installation is a stove with a back boiler;

f. Whether the heat pump or biomass boiler has a single-phase or three-phase connection.

Notes on making an installation 'meter ready'

Heat meters that have been used by DECC in their metering programmes in the past have required a mains electricity connection. Therefore, at the same time as installing isolation valves for the heat meters, installers should consider the placement of an easily-accessible electricity supply to power the heat meters.

6. Metering for Payment

Installers shall use Procedure A (in Annex B) to determine where metering for payment is required for biomass and heat pump systems. Note that this procedure shall be followed for all RHI installations. Where metering for payment is required, installers shall install a meter or meters as follows for the appropriate technologies. Where metering that is already compliant with this section has been integrated into a manufacturer's heating product then no additional metering need be installed.

Metering for payment shall not be required for solar thermal RHI installations. RHI tariff payments for solar thermal systems will always be based on a deemed quantity as detailed in RHI Regulations [2].

Table 2 shows the required sensor accuracies for both Metering for Payment and for Metering and Monitoring Service Packages in Section 7.

Sensor type	Accuracy class
Heat meter	Class 3 Measuring Instruments Directive (MID) [3]
Electricity meter	Class A MID
Gas meter	Class 1.5 MID
Oil meter	Class 1 MID

Table 2: Sensor accuracies required for different types of energy meter

6.1 Metering concept for heat pumps and biomass boilers or stoves with back boilers

6.1.1 For a heat pump, an MCS installation company shall:

Measure the heat output from a renewable heating system, including compressors, and any non-renewable energy inputs (for example, electricity or gas) to the components from which heat is being measured.

For such situations, the renewable heat from the heat pump will be calculated from the measurements. The number of meters required and complexity of metering vary from one heat meter and one electricity meter to a combination of heat meters and energy meters. Annex C provides a number of examples to illustrate the concept. Note that electricity that shall be metered in accordance with the above requirements shall still be metered even if the electricity has been generated by a renewable source.

Note on Section 6.1.1:

Where MCS-certified heat pumps are capable of cooling as well as heating and where the system needs to be metered for payment purposes, the consumer will only be paid their RHI tariff for the metered heating function of the heat pump.

6.1.2 For a biomass boiler or biomass stove with back-boiler, an MCS installation company shall:

Measure the heat output by the thermal transfer fluid from the renewable heating system's components as close to the biomass boiler output (flow and return pipes) as possible.

Note that measuring of electricity, gas or oil input is not required for biomass heating systems where that fuel is being used for ignition purposes. In addition, electricity input to an immersion heater for a hot water cylinder or integrated electric heaters (where the electric heater is controlled by the same control system that governs the biomass boiler) also does not need to be measured. However, some other energy inputs may need to be recorded if it is not possible to exclude those energy inputs from the heat measurement, for example if it is not possible to measure only heat output from the biomass boiler part of a combined biomass boiler/oil system.

6.2 Meter details

Heat meters

All heat meters used to meter for payment in the domestic RHI shall consist of a flow meter, matched pair of temperature sensors and a calculator, as well as meet the following requirements:

- Comply with the relevant requirements set out in Annex I to the 2004 Measuring Instruments Directive (MID);
- Comply with the specific requirements listed in Annex MI-004 of the MID;
- Fall within accuracy Class 3 or better as defined in Annex MI-004 of the MID;
- Be installed according to manufacturer's instructions.

Where heat metering is to be conducted on an air source heat pump which draws heat from the home to the evaporator to undertake a defrost process ("reverse flow"), then bi-directional heat meters are not required. Ofgem will instead make assumptions for heat used for defrost. In this circumstance, the MCS installation company shall inform Ofgem that the heat pump operates a reverse flow defrost mechanism.

Notes on Section 6.2 "Heat meters":

Installers are advised to pay careful attention to the following as they can have a significant impact upon meter readings:

- Correct installation of temperature sensors, including appropriate mounting to ensure good thermal contact with the thermal transfer fluid, appropriate insulation and sensor cables to be run independently of power cables to limit interference. Sensor cable lengths shall be compliant with manufacturer's guidance. Where sensor pockets are used then the manufacturer's thermal transfer compound shall be used if specified.
- Appropriate selection of heat meters (including consideration of the meter manufacturer's limit of operating temperature difference and sizing of the meter to suit heating system's flow rate and pressure drop);
- Caution when fitting meters on the suction side of pumps. This should only be carried out in a manner that is compliant with heat meter manufacturer's instructions;
- Wiring of the heat meter calculator unit;
- Placement of heat meters so that the meter display is visible to the Customer and easy to read.

It should be possible for meters to be re-calibrated or replaced if necessary without significant disruption to the heating system.

Annex D outlines the basics of heat metering, including heat meter components and other key issues to consider.

Electricity meters (for heat pumps only)

All electricity meters used to meter for payment in the domestic RHI shall comply with the following criteria:

- Comply with the relevant requirements set out in Annex I to the 2004 Measuring Instruments Directive (MID);
- Comply with the specific requirements listed in Annex MI-003 of the MID;
- Fall within accuracy Class A or better, as defined in Annex MI-003 of the MID;
- Be installed by a competent, suitably qualified and registered person in accordance with industry standards and manufacturers' instructions, including with respect to safety requirements.

Gas meters (if required)

There are three possible options to metering combined gas and renewable heating systems (including hybrid systems):

1. If it is possible to meter the heat output from a renewable heating system without including gas-powered components in that measurement, then the gas input does not need to be metered.
2. If it is not possible to separately meter the heat output from the renewable heating system without including gas-powered components in that measurement, then the heat output from the combined system shall be metered (measurement a), and the heat output from the gas-powered components shall be metered (measurement b). The renewable system's heat output can be determined by Ofgem by subtracting measurement b from measurement a.
3. If it is not possible to conduct the heat metering as in Option 1 or 2, then the gas input shall be metered in a similar manner to the metering of electricity in the worked examples in Annex C, and the heat output from the combined gas/renewable heating system shall be metered. These measurements will be used by Ofgem to calculate the renewable heat generated by the system.

The preferred approach should be to meter heat only as in Option 1, followed by the approach in Option 2, and finally Option 3.

If metering gas, the gas meter shall comply with the following criteria:

- Comply with the relevant requirements set out in Annex I to the 2004 Measuring Instruments Directive (MID);
- Comply with the specific requirements listed in Annex MI-002 of the MID;
- Fall within accuracy Class 1.5, or better, as defined in Annex MI-002 of the MID;

- Be installed by a competent, suitably qualified and registered person in accordance with the requirements of the Gas Safety (Installation and Use) Regulations 1998, industry standards and manufacturers' instructions, particularly with respect to safety requirements.

Oil meters (if required)

There are three possible options to metering combined oil and renewable heating systems (including hybrid systems):

1. If it is possible to meter the heat output from a renewable heating system without including oil-powered components in that measurement, then the oil input does not need to be metered.
2. If it is not possible to separately meter the heat output from the renewable heating system without including oil-powered components in that measurement, then the heat output from the combined system shall be metered (measurement a), and the heat output from the oil-powered components shall be metered (measurement b). The renewable system's heat output can be determined by Ofgem by subtracting measurement b from measurement a.
3. If it is not possible to conduct the heat metering as in Option 1 or 2, then the oil input shall be metered in a similar manner to the metering of electricity in the worked examples in Annex C, and the heat output from the combined oil/renewable heating system shall be metered. These measurements will be used by Ofgem to calculate the renewable heat generated by the system.

The preferred approach should be to meter heat only as in Option 1, followed by the approach in Option 2, and finally Option 3.

If metering oil, the oil meter in question shall comply with the following criteria:

- Comply with the relevant requirements set out in Annex I to the 2004 Measuring Instruments Directive (MID);
- Comply with the specific requirements listed in Annex MI-005 of the MID;
- Fall within accuracy Class 1, or better, as defined in Annex MI-005 of the MID;
- Be installed by a competent, suitably qualified and registered person in accordance with industry standards and manufacturers' instructions, including with respect to safety requirements.

<u>Note on Section 6.2:</u>

It is not practical to meter solid fuel energy inputs. For combined non-renewable, solid fuel and renewable heating systems, such as a renewable heating appliance combined with a stove burning coal, metering shall only be conducted via the following two options:

1. If it is possible to meter the heat output from a renewable heating system without including solid fuel-powered components in that measurement, then the solid fuel input does not need to be metered.
2. If it is not possible to separately meter the heat output from the renewable heating system without including solid fuel-powered components in that measurement, then the heat output from the combined system shall be metered (measurement a), and the heat output from the solid fuel-powered components shall be metered (measurement b). The renewable system's heat output can be determined by Ofgem by subtracting measurement b from measurement a.

Option 1 is the preferred approach.

6.3 Additional requirements

An MCS installation company shall submit required information to Ofgem, as requested. This is to enable Ofgem to satisfy themselves that the requirements of the RHI regulations are being met and administer the scheme effectively.

An MCS installation company shall:

1. label meters clearly for the Customer in a manner that is compliant with Ofgem requirements;
2. explain to the Customer how to read the meters, including showing the RHI applicant how the first meter reading is conducted;
3. submit the baseline reading at the time of commissioning to Ofgem and, in addition, installers should verify that the installed meter or meters are functioning properly;
4. select meters that should not need to be re-calibrated during the 7 years of the RHI payments;
5. select heat meters capable of displaying energy in kWh or MWh, gas meters capable of displaying units of m^3 or litres and oil meters capable of displaying units of m^3 or litres.

Installers shall select meters that have been appropriately calibrated for the system in which the meters are to be installed.

An installer shall provide the Customer with a document pack that will include the process for verifying that the meter is operating, any maintenance requirements, calibration requirements, meter instructions, information required for meter-readiness by DECC and a schematic diagram of the installation.

Note on Section 6.3:

Examples of what further information Ofgem is likely to request include the following:

1. Declaration of compliance with MCS Domestic RHI Metering guidance document;
2. Heat use of eligible technology (i.e. space, water heating, room heating (via air, e.g. for stove), indoor or outdoor swimming pool or combination.
3. Details of fossil fuel inputs to heating system;
4. Information about meters, e.g. number and type of meters and evidence that meters are MID compliant.

7. Metering and Monitoring Service Packages

Metering and Monitoring Service Packages (MMSPs) consist of energy and temperature meters, logged on a 2-minute basis, in combination with a data-viewing platform that pulls together the data and presents it clearly. The aim is to help customers and industry to understand how well their renewable heating installations are operating and to aid in optimising performance for customers and in ensuring that the installed renewable heating system operates within the boundaries and conditions of the design and the product manufacturers' claims. A number of example packages are shown in Annex E.

Where an MMSP has been installed which is compliant with the requirements of both Section 6 and Section 7, then this system can be used for metering for payment. In addition, where an MMSP contains meters that have been integrated into a renewable heating manufacturer's equipment then these meters can form part of an MMSP providing that the metering is compliant with the requirements of both Section 6 and Section 7.

The RHI will support MMSPs being installed with heat pumps and pellet biomass boilers, though not pellet stoves with back boilers. It is noted that no other type of biomass boiler or stove with back boiler is eligible for MMSPs. This is different to the other metering sections in this document which pertain to all biomass units incentivised through the RHI.

An RHI applicant will receive an ongoing payment from the start of the MMSP installation until the end of their RHI tariff payments (maximum period of 7 years) so long as the MMSP continues to operate and the data platform continues to display data in accordance with RHI regulations [2] over this period. Where an applicant would normally receive an RHI tariff payment based upon deemed heat demand then the applicant will continue to receive a tariff based upon deemed heat demand, but would also receive a top-up payment for installing and maintaining the MMSP.

The information in this section represents minimum requirements for installation of an RHI-compliant MMSP package. Note that the specifications for the meters in MMSPs are the same as those for meters in ‘Metering for Payment’ (Section 6) but with higher resolution to account for the 2-minute data logging interval. This high- frequency metering is important because heat pumps and biomass boilers have components that can operate at very short intervals and therefore, in order to capture system performance as completely as is feasible, relatively high frequency logging is required.

Specifications for measurements for heat pump and pellet biomass boiler MMSPs are shown in the following tables. With the exception of oil and gas metering which are discussed later in this document, all measurements shall be recorded but, in some cases (e.g temperature), no minimum resolution or accuracy has been specified; instead some recommendations are provided. At other points in the summary tables, recommendations have been provided as suggestions for best practice.

Heat Pump MMSPs Summary Table

	Sensor type	Minimum resolution	Minimum accuracy	Example number required
1	**Heat metering of heat output from heat pump and heat metering of all additional fossil fuel boilers that are connected to the same heat distribution system**	*[Resolution of heat meter] ≤ 3 % multiplied by [min. non-zero heat output in 2 minutes]* AND heat meter resolution need not be finer than 1 Wh **See Section 7.1 for details**	Class 3 of Measuring Instruments Directive	1 x sensor required for heat pump with 2-pipe output 2 x sensors required for heat pump with 4-pipe or 3-pipe output or bivalent system with 2-pipe heat pump 3 x sensors required for bivalent system with 4-pipe or 3-pipe heat pump (Fewer meters may be used if manufacturer has integrated metering to their unit.)
2	**Metering of all electrical supplies to heat pump included in heat measurement plus DHW cylinder where this is supplied by heat pump** **(In addition, we recommend that all integrated electric heaters are metered.)**	*[Resolution of electricity meter] ≤ 3 % multiplied by [min. non-zero electricity input in 2 minutes]* (We recommend using high resolution meters but electricity meter resolution need not be finer than 1 Wh)	Class A of Measuring Instruments Directive	1 x sensor where heat pump is incorporated into single unit 2 x sensors where heat pump is composed of two units. + 1 x sensor for immersion heating where DHW is supplied by heat pump
3	**Gas metering of inputs to heat pump where required (see 7.1)**	10 L or equivalent for other units	Class 1.5 of Measuring Instruments Directive	1 x meter to monitor gas input to heat pump only (if a hybrid system has an integrated gas boiler) if not possible to meter heat output from gas boiler as in Row 1.
4	**Oil metering of any oil supplied to heat pump where required (see 7.1)**	0.1 litres or equivalent for other units	Class 1 of Measuring Instruments Directive	1 x meter to monitor oil input to heat pump (if a hybrid system has integrated gas boiler) only if not possible to meter heat output from oil boiler as in Row 1.
5	**Measurement of internal temperature, space heating flow temperature and DHW flow temperature, where this is supplied by the heat pump.** **(Note that this may need sometimes to be separate to temperature measurements involved in heat metering)**	We recommend 0.1 degrees C	We recommend Class B for Resistance Temperature Detectors (RTDs) (equivalent accuracy for other types of temperature sensor at typical measurement temperature)	3 x temperatures sensors - includes space heating flow metering, DHW flow metering (where DHW supplied by heat pump), internal temperature
6	**For ground-source heat pumps, measurement of ground loop flow and return temperatures.**	We recommend 0.1 degrees C	We recommend Class B for RTDs (equivalent accuracy for other types of temperature sensor at typical measurement temperature)	2 x temperature sensors for ground loop flow and return
7	**For air-source heat pumps only, measurement of external air temperature.** **This sensor should be suitably sited out of direct sunlight and away from other heat sources**	We recommend 0.1 degrees C	We recommend Class B for RTDs (equivalent accuracy for other types of temperature sensor at typical measurement temperature)	1 (air source heat pumps only)

Pellet Biomass Boiler MMSPs Summary Table

	Sensor type	Minimum resolution	Minimum accuracy	Example number required
1	**Heat metering of heat output from biomass boiler and heat metering of any fossil fuel boilers that are connected to the same heat distribution system**	*[Resolution of heat meter] ≤ 3 % multiplied by [min. non-zero heat output in 2 minutes]* AND heat meter resolution need not be finer than 1 Wh **See Section 7.2 for details**	Class 3 of Measuring Instruments Directive	1 x sensor for single biomass system 2 x sensors where overall system contains a fossil fuel boiler in addition to the above.
2	**Metering of all electrical supplies to biomass boiler included in heat measurement plus DHW cylinder where this is supplied by biomass boiler** **(In addition, we recommend that all integrated electric heaters are metered.)**	*[Resolution of electricity meter] ≤ 7.5 % multiplied by [min. non-zero electricity input in 2 minutes]* (We recommend using high resolution meters but electricity meter resolution need not be finer than 1 Wh)	Class A of Measuring Instruments Directive	1 x sensor for biomass unit + 1 x sensor for immersion heating where appropriate
3	**Gas metering of any gas inputs to biomass boiler where required (see 7.2)**	10 L or equivalent for other units	Class 1.5 of Measuring Instruments Directive	1 x meter to monitor gas input to biomass boiler (for bivalent system) only if not possible to meter heat output from gas boiler as in Row 1.
4	**Oil metering of any oil inputs to biomass boiler where required (see 7.2)**	0.1 litres or equivalent for other units	Class 1 of Measuring Instruments Directive	1 x meter to monitor oil input to biomass boiler (for bivalent system) only if not possible to meter heat output from oil boiler as in Row 1.
5	**Measurement of indoor temperature + flow and return temperatures at approximate location of heat meter** **(Note that this could be conducted using the temperature sensor components of a heat meter.)**	We recommend 0.1 degrees C	We recommend Class B for Resistance Temperature Detectors (RTDs) (equivalent accuracy for other types of temperature sensor at typical measurement temperature)	3 x temperature sensors
6	**Measurement of external air temperature.** **This sensor should be suitably sited out of direct sunlight and away from other heat sources**	We recommend 0.1 degrees C	We recommend Class B for RTDs (equivalent accuracy for other types of temperature sensor at typical measurement temperature)	1 temperature sensor
7	**Efficiency** **An estimate of efficiency should be provided based on metered fuel input (through measurement of auger revolutions or similar) or flue gas analysis**.	-	This should be done as accurately as possible. We recommend better than 20 %.	-

7.1 Heat pump MMSPs

Metering shall be installed as detailed in this section. All measurements shall be logged at 2-minute intervals with the specified resolution required.

Heat metering

Heat shall be metered from the heat output from the heat pump as well as from any fossil fuel boilers that are connected to the same heat distribution system.

The requirements specified in Section 6.2 shall also pertain to heat meters installed for MMSPs.

Resolution in Wh:

The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring. Heat meter resolution shall be calculated using the following formula for each meter:

[Resolution of heat meter] ≤ 3 % multiplied by [min. non-zero heat output to be measured in 2 minutes]

This formula calculates the smallest change the heat meter shall be able to measure in Wh. The minimum resolution required in all cases shall be 1 Wh.

For heat meters measuring draw-off from a domestic hot water cylinder, the maximum resolution shall be 10Wh in all cases in order to measure the energy content of short hot water draw-offs.

In practice, because heat meter resolution is normally a power of 10Wh, this formula can be translated into table 3:

Min non-zero heat output (Min. H) (kW)	Smallest change that must be measurable	Example heat meter display
Min. H < 10 kW	1 Wh	00000.**000** kWh
10kW ≤ Min. H < 100 kW	10 Wh	000000.**00** kWh
100 kW ≤ Min H.	100 Wh	0000000.**0** kWh
[All meters measuring draw-off from a DHW cylinder]	10 Wh	000000.**00** kWh

Table 3: *Heat meter resolution requirements in practice*

Note on heat meter resolution:

The smallest change that meters can measure (the meter resolution) has been prescribed in this guidance to ensure that the 2-minute readings logged by the MMSP are useful and accurate. These resolutions should ensure that individual system cycles can be detected and the Coefficient Of Performance (COP) or efficiency of short periods of operation can be estimated.

Note that where high resolution meters are required, it would be advisable to check with the meter manufacturer that the communication protocol employed is appropriate for the metering application.

High resolution heat meters require high-resolution flow meters. MCS installers are encouraged to check with heat meter manufacturers that the flow meter within the heat meter has sufficient resolution to be useful in their specific situation.

A suggestion for a satisfactory flow meter resolution installed in a primary circuit can be estimated according to the following formula for flow meters with 'nominal meter factors' expressed in pulses per litre:

[Nominal flow meter factor in pulse/litre at qp] ≥ 10 / [nominal thermal power output in kW]

For example, for a heat pump with a nominal thermal power output of 10kW, the smallest change that the flow meter can measure should be at least 1 litre.

When a heat meter is being used to measure draw-offs from a domestic hot water cylinder (i.e. to the taps), the flow meter needs to be especially high resolution in order to accurately capture short hot water draw-offs. A minimum resolution of 0.1 litres is recommended.

The 'nominal meter factor' will be written on the label of MID class 3 flow meters for heat meters that are composed of sub-assembled components. If the nominal meter factor is in pulses per litre, it will be given in units of imp/l, i/l, p/l or similar.

Electricity metering

All electricity supplies to the heat pump that are included in the heat measurements shall be metered. (This requirement is the same as that specified in Section 6.) In addition, electricity supplied to the domestic hot water cylinder shall be metered.

Requirements specified in Section 6.2 shall also pertain to electricity meters installed for MMSPs.

Resolution in Wh:

The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring. Electricity meter resolution shall be calculated using the following formula for each meter:

[Resolution of electricity meter] ≤ 3 % multiplied by [min. non-zero electricity input in 2 minutes]

This formula calculates the smallest change the heat meter shall be able to measure in Wh. The minimum resolution required in all cases shall be 1 Wh.

Note on Section 7.1:

We recommend that all integrated electric heaters are measured where possible so that their operation can easily be monitored.

Gas metering

There are three possible options to metering combined gas and renewable heating systems (including hybrid systems):

1. If it is possible to meter the heat output from a renewable heating system without including gas-powered components in that measurement, then the gas input does not need to be metered.

2. If it is not possible to separately meter the heat output from the renewable heating system without including gas-powered components in that measurement, then the heat output from the combined system shall be metered (measurement a), and the heat output from the gas-powered components shall be metered (measurement b). The renewable system's heat output can be determined by subtracting measurement b from measurement a.
3. If it is not possible to conduct the heat metering as in Option 1 or 2, then the gas input shall be metered in a similar manner to the metering of electricity in the worked examples in Annex E, and the heat output from the combined gas/renewable heating system shall be metered.

The preferred approach should be to meter heat only as in Option 1, followed by the approach in Option 2, and finally Option 3.

Where used, the gas meter shall comply with the criteria described in Section 6.2.

The smallest change a gas meter is able to measure shall be 10 L or better.

Oil metering

There are three possible options to metering combined oil and renewable heating systems (including hybrid systems):

1. If it is possible to meter the heat output from a renewable heating system without including oil-powered components in that measurement, then the oil input does not need to be metered.
2. If it is not possible to separately meter the heat output from the renewable heating system without including oil-powered components in that measurement, then the heat output from the combined system shall be metered (measurement a), and the heat output from the oil-powered components shall be metered (measurement b). The renewable system's heat output can be determined by subtracting measurement b from measurement a.
3. If it is not possible to conduct the heat metering as in Option 1 or 2, then the oil input shall be metered in a similar manner to the metering of electricity in the worked examples in Annex E, and the heat output from the combined oil/renewable heating system shall be metered.

The preferred approach should be to meter heat only as in Option 1, followed by the approach in Option 2, and finally Option 3.

Where used, the oil meter shall comply with the criteria described in Section 6.2.

The smallest change an oil meter is able to measure shall be 0.1 litres.

Temperature measurements

Internal temperature at a minimum of one location, space heating flow temperature and domestic hot water flow temperature shall be measured. In addition, for ground source heat pumps, temperature of the ground loop flow and return shall be measured. For air source heat pumps, as well as the temperature measurements specified above, external air temperature shall also be measured.

Note on Section 7.1:

It is recommended that temperature measurements are conducted with a minimum resolution of 0.1 degrees C and that an accuracy equivalent to Class B [4] for resistance temperature detectors is used.

For measurement of the flow to the space heating circuit and to the domestic hot water cylinder, temperatures may be logged using sensors that are part of the appliance's control system or through a combination of the temperature sensors that are part of the heat meter and the control system if the control system does not provide hot water and space heating simultaneously.

For external temperature measurements, it is recommended that sensors are sited out of direct sunlight and away from other heat sources.

7.2 Pellet biomass boiler MMSPs

Metering shall be installed as detailed in this section. All measurements shall be logged at 2-minute intervals with the resolution required.

Heat metering

Heat shall be metered from the heat output from the biomass boiler as well as from any fossil fuel boilers that are connected to the same heat distribution system.

The requirements specified in Section 6.2 shall also pertain to heat meters installed for MMSPs.

Resolution in Wh:

The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring. Heat meter resolution shall be calculated using the following formula for each meter:

[Resolution of heat meter] ≤ 3 % multiplied by [min. non-zero heat output to be measured in 2 minutes]

This formula calculates the smallest change the heat meter shall be able to measure in Wh. The minimum resolution required in all cases shall be 1 Wh.

For heat meters measuring draw-off from a domestic hot water cylinder, the maximum resolution shall be 10Wh in all cases in order to measure the energy content of short hot water draw-offs.

In practice, because heat meter resolution is normally a power of 10Wh, this formula can be translated into table 3:

Min non-zero heat output (Min. H) (kW)	Smallest change that must be measurable	Example heat meter display
Min. H < 10 kW	1 Wh	00000**.000** kWh
10kW ≤ Min. H < 100 kW	10 Wh	000000**.00** kWh
100 kW ≤ Min H.	100 Wh	0000000**.0** kWh
[All meters measuring draw-off from a DHW cylinder]	10 Wh	000000**.00** kWh

Table 3: *Heat meter resolution requirements in practice*

Note on heat meter resolution:

The smallest change that meters can measure (the meter resolution) has been prescribed in this guidance to ensure that the 2-minute readings logged by the MMSP are useful and accurate. These resolutions should ensure that individual system cycles can be detected and the Coefficient Of Performance (COP) or efficiency of short periods of operation can be estimated.

Note that where high resolution meters are required, it would be advisable to check with the meter manufacturer that the communication protocol employed is appropriate for the metering application.

High resolution heat meters require high-resolution flow meters. MCS installers are encouraged to check with heat meter manufacturers that the flow meter within the heat meter has sufficient resolution to be useful in their specific situation.

A suggestion for a satisfactory flow meter resolution installed in a primary circuit can be estimated according to the following formula for flow meters with 'nominal meter factors' expressed in pulses per litre:

[Nominal flow meter factor in pulse/litre at qp] ≥ 10 / [nominal thermal power output in kW]

For example, for a heat pump with a nominal thermal power output of 10kW, the smallest change that the flow meter can measure should be at least 1 litre.

When a heat meter is being used to measure draw-offs from a domestic hot water cylinder (i.e. to the taps), the flow meter needs to be especially high resolution in order to accurately capture short hot water draw-offs. A minimum resolution of 0.1 litres is recommended.

The 'nominal meter factor' will be written on the label of MID class 3 flow meters for heat meters that are composed of sub-assembled components. If the nominal meter factor is in pulses per litre, it will be given units of imp/l, i/l, p/l or similar.

Electricity metering

All electricity supplies to the biomass boiler that are included in the heat measurements shall be metered. In addition, electricity supplied to the domestic hot water cylinder shall be metered.

Requirements specified in Section 6.2 shall also pertain to electricity meters installed for MMSPs.

Resolution in Wh:

The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring. Electricity meter resolution for pellet biomass boilers shall be calculated using the following formula for each meter:

[Resolution of electricity meter] ≤ 7.5 % multiplied by [min. non-zero electricity input in 2 minutes]

This formula calculates the smallest change the heat meter shall be able to measure in Wh. The minimum resolution required in all cases shall be 1 Wh.

Notes on Section 7.1:

Electricity used by the biomass boiler during start-up and to move fuel and ash shall be included in the electricity metering of pellet biomass boilers.

We recommend that all integrated electric heaters are measured where possible so that their operation can easily be monitored.

Gas metering

There are three possible options to metering combined gas and renewable heating systems:

1. If it is possible to meter the heat output from a renewable heating system without including gas-powered components in that measurement, then the gas input does not need to be metered.
2. If it is not possible to separately meter the heat output from the renewable heating system without including gas-powered components in that measurement, then the heat output from the combined system shall be metered (measurement a), and the heat output from the gas-powered components shall be metered (measurement b). The renewable system's heat output can be determined by subtracting measurement b from measurement a.
3. If it is not possible to conduct the heat metering as in Option 1 or 2, then the gas input shall be metered in a similar manner to the metering of electricity in the

worked examples in Annex E, and the heat output from the combined gas/renewable heating system shall be metered.

The preferred approach should be to meter heat only as in Option 1, followed by the approach in Option 2, and finally Option 3.

Where used, the gas meter shall comply with the criteria described in Section 6.2.

The smallest change a gas meter is able to measure shall be 10 L or better.

Oil metering

There are three possible options to metering combined oil and renewable heating systems:

1. If it is possible to meter the heat output from a renewable heating system without including oil-powered components in that measurement, then the oil input does not need to be metered.
2. If it is not possible to separately meter the heat output from the renewable heating system without including oil-powered components in that measurement, then the heat output from the combined system shall be metered (measurement a), and the heat output from the oil-powered components shall be metered (measurement b). The renewable system's heat output can be determined by subtracting measurement b from measurement a.
3. If it is not possible to conduct the heat metering as in Option 1 or 2, then the oil input shall be metered in a similar manner to the metering of electricity in the worked examples in Annex E, and the heat output from the combined oil/renewable heating system shall be metered.

The preferred approach should be to meter heat only as in Option 1, followed by the approach in Option 2, and finally Option 3.

Where used, the oil meter shall comply with the criteria described in Section 6.2.

The smallest change an oil meter is able to measure shall be 0.1 litres.

Temperature measurements

Internal temperature at a minimum of one location and flow and return temperatures from the biomass boiler at approximately the same location as a heat meter shall be measured. In addition, external air temperature shall be measured.

Note on Section 7.1: It is recommended that temperature measurements are conducted with a minimum resolution of 0.1 degrees C and that an accuracy equivalent to Class B [4] for resistance temperature detectors is used. For measurement of the flow and return, temperatures may be logged using sensors that are part of the appliance's control system or the temperature sensors that are part of the heat meter. For external temperature measurements, it is recommended that sensors are sited out of direct sunlight and away from other heat sources.

7.3 Viewing platform

The MCS Installation Company or their subcontractor shall ensure that data being monitored for either heat pump or pellet biomass boiler MMSPs shall be presented to both the Customer and the MCS Installation Company.

As detailed in Section 4, MCS companies may choose to subcontract aspects of MMSPs. For the remainder of this document, only the MCS Installation Company has been referred to but it remains the case that the provision of this part of the guidance could be through a subcontractor.

7.3.1 Requirements for MCS Installation Company's view

The requirements for the MCS Installation Company's view of the data and the Customer's view of the data are different. The Company view of the data shall:

1. Present all of the data captured over a minimum of 1 year (or if the system has been operating for less than 12 months, then the period from the start of the

MMSP to at least the previous week) in a manner which would allow them to conduct a remote diagnosis of the system and its performance.

2. Allow the Company to view all recorded data points down to a 2-minute time period.

3. Make data visible to the Company automatically after a maximum delay of 1 week.

4. Provide an indication of data completeness over the most recent 12-month period (or, if the system has been operating for less than 12 months, then the period from the start of the MMSP to at least the previous week) as a percentage where this is defined in Section 7.3 “Data submission to DECC and to Ofgem” .

7.3.2 Customer view of the data

The MCS Installation Company providing the MMSP shall be able to provide an MMSP Customer, on request, at least every three months, an explanation of the meaning of data collected under the MMSP agreement.

The Customer view of the data shall (as a minimum):

1. Present the following data according to these requirements:

a) energy output

b) energy input

c) internal temperature

d) external temperature:

• For air-source heat pumps and biomass boilers, the external temperature presented shall be that measured at the site.

• For ground-source heat pumps, it is not mandatory for external temperature to be recorded by meters. The data platform shall still display external temperature by showing either:

1) the external temperature measured at a meteorological station that the MCS Installation Company regards as the most likely to measure temperature that represents the external temperature at the installation; or

2) on-site measurements of external air temperature if the MCS Installation Company has chosen to install meters.

e) For ground source heat pumps, ground loop flow and return temperatures

f) Efficiency of biomass boiler or heat pump system over the last 12 months (or for however long the data has been recorded if less than 12 months of data is available); the system boundary (i.e. the components included in the efficiency measurement); and an estimate of the uncertainty of the efficiency measurement.

All data shall be presented in a way that is as user-friendly as possible to ensure that the Customer can make maximum use of this service.

2. Present automatically a minimum of 12 months (or for however long the data has been recorded if less than 12 months) of data with at least monthly resolution, with the exception of the most recent week on the data platform, for which the data shall be automatically presented with at least an hourly resolution.

3. Provide data completeness as a percentage over the most recent 12-month period (or, if the system has been operating for less than 12 months, then the period from the start of the MMSP to at least the previous week) to indicate how well the metering package is working. This shall be calculated as in Section 7.3 "Data submission to DECC and to Ofgem".

4. Present new data on the platform automatically within 1 week of it being measured.

Data submission to DECC and to Ofgem

An MMSP shall be able to submit the following data to Ofgem, DECC or a third party nominated by DECC on a regular basis, if requested. This data may be required as part of a desk or site audit. The provision of this data may be automated where appropriate:

1. Data completeness- this will be calculated as follows:

a / b *100

a= number of non-null 2-minute meter readings received by the data platform from all sensors over a 12-month period or, where the system has been operating for less than 12 months, then the period from the start of the MMSP to at least the previous week.

b= maximum number of 2-minute meter readings that could have been received by data platform from all sensors during the 12-month period or, where the system has been operating for less than 12 months, then the period from the start of the MMSP to at least the previous week.

2. Seasonal Performance Factor (SPF) or efficiency. The system boundary and the estimate of the uncertainty in the efficiency measurement shall also be clearly stated.

3. Any internal and external temperature meter recordings

Furthermore, DECC may request, at any point for which the MMSP Contract is valid, that all information collected as part of the MMSP that is currently available is submitted to DECC or a third party nominated by DECC in a standard format such as a .csv file. Whilst DECC may request all available data, the MCS Installation Company shall ensure that it is able to provide at least all 2-minute data recorded by an MMSP over a 12-consecutive month period.

Note on Data Platforms:

The estimate of uncertainty in the efficiency can be determined as follows:

1. For heat pumps, this can be approximated as the average error in the heat meters;
2. For biomass boilers, this can be the uncertainty based on laboratory tests of the measuring equipment being used to conduct the efficiency calculation and the approximate uncertainty in applied assumptions.

Referenced publications

[1]: Microgeneration Installation Standard: MCS 001. Installer certification scheme requirements Issue 2.2

[2]: Domestic RHI Regulations

[3]:http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:135:0001:0080:EN:PDF
Directive 2004/22/EC of the European Parliament and of the Council of
31 March 2004 on measuring instruments

[4]: IEC 60751 Industrial platinum resistance thermometers and platinum temperature sensors

Annex A: Location of isolation valves for common types of heat pumps and biomass boilers

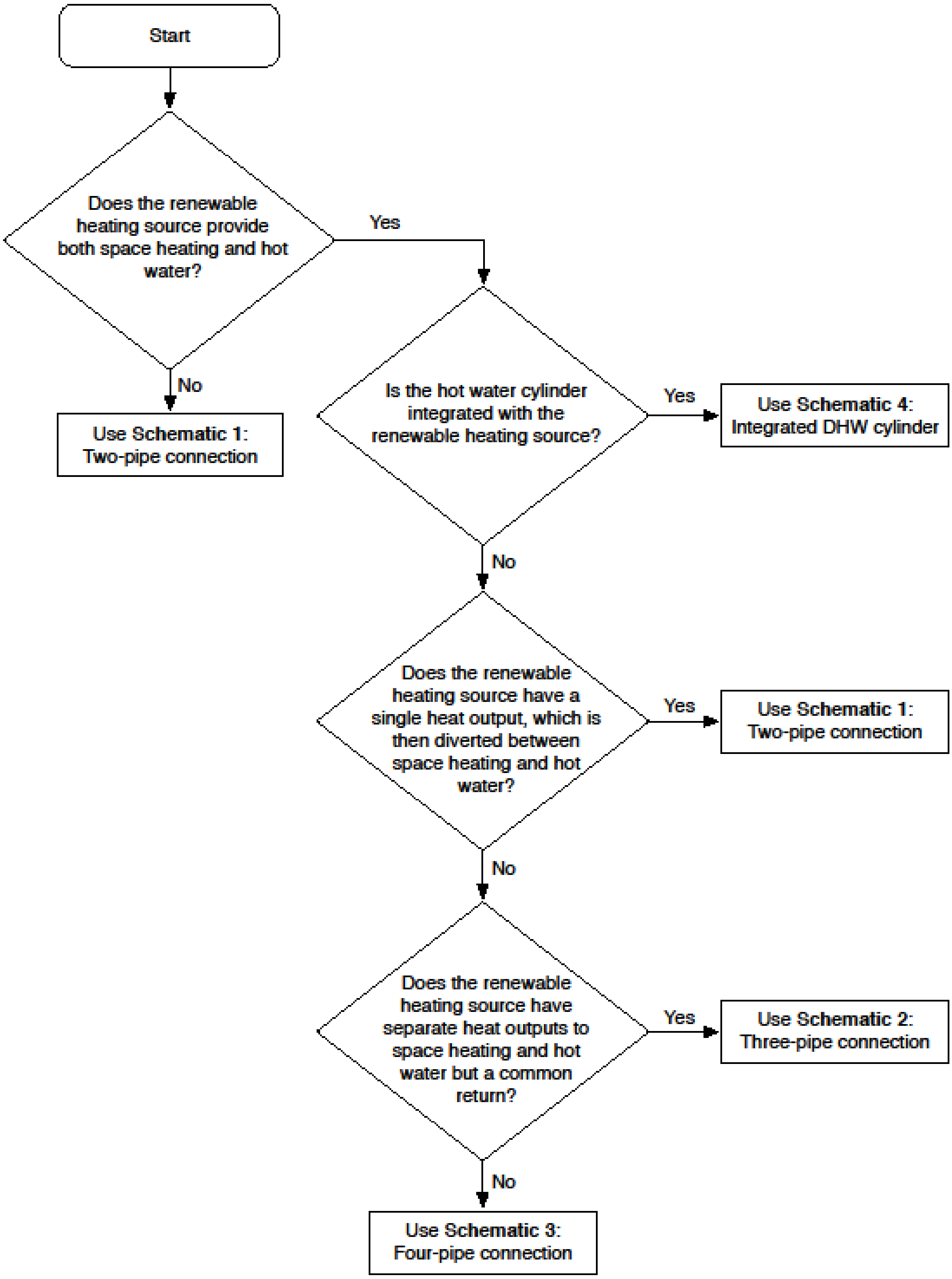


Figure 1: Flowchart to locate isolation valves for common biomass and heat pump renewable heating systems

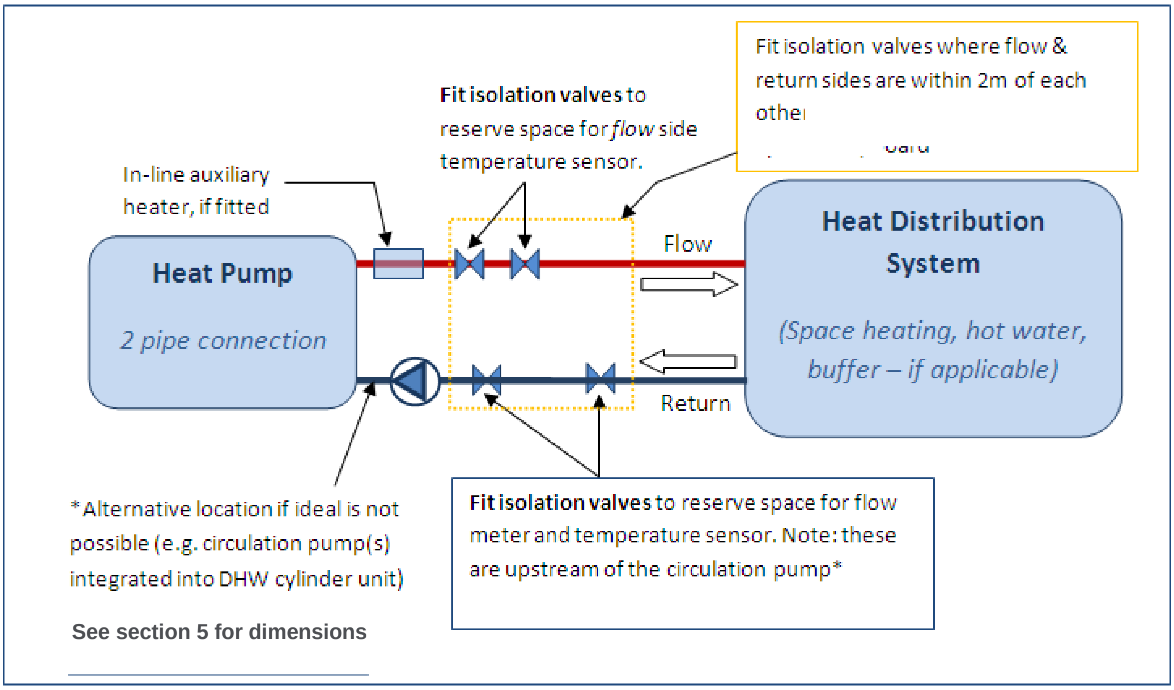


Figure 2: Schematic 1: Two-pipe connection, shown here for heat pumps but could apply to biomass boilers.

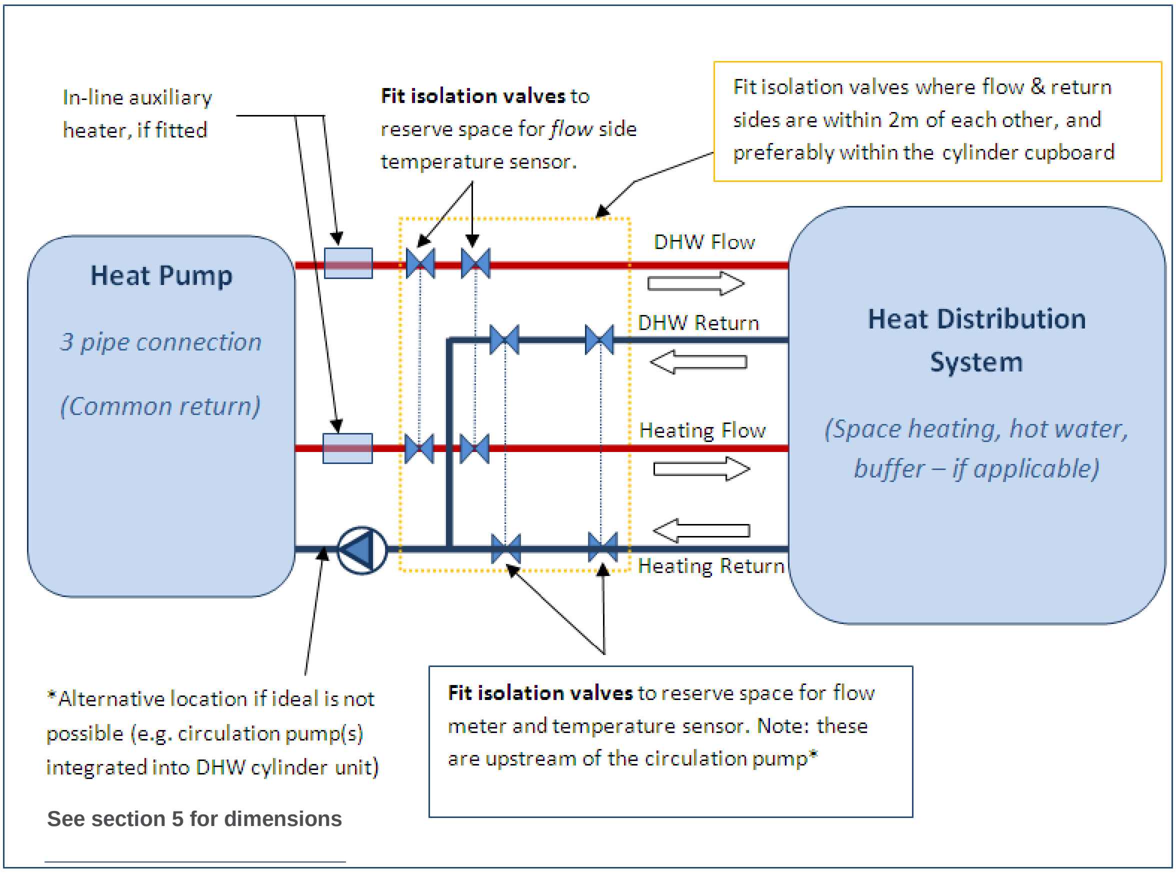


Figure 3: Schematic 2: Three-pipe connection, shown here for heat pumps but could apply to biomass boilers.

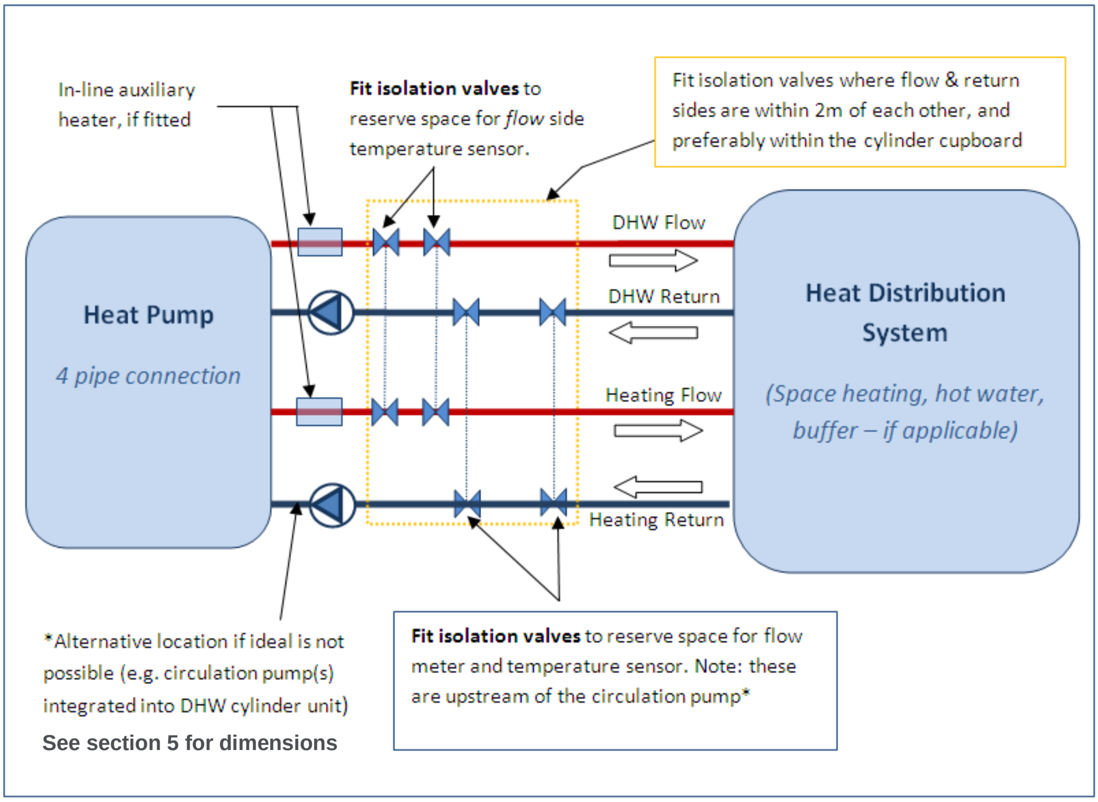


Figure 4: Schematic 3: Four-pipe connection, shown here for heat pumps but could apply to biomass boilers.

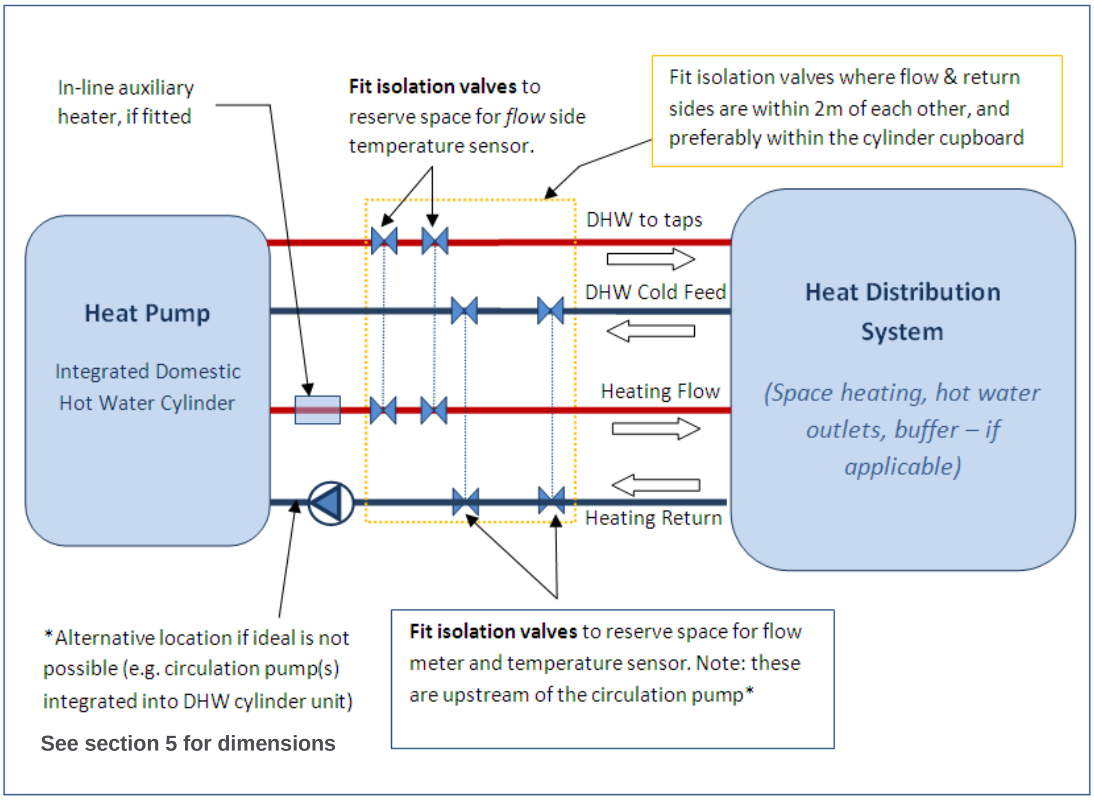
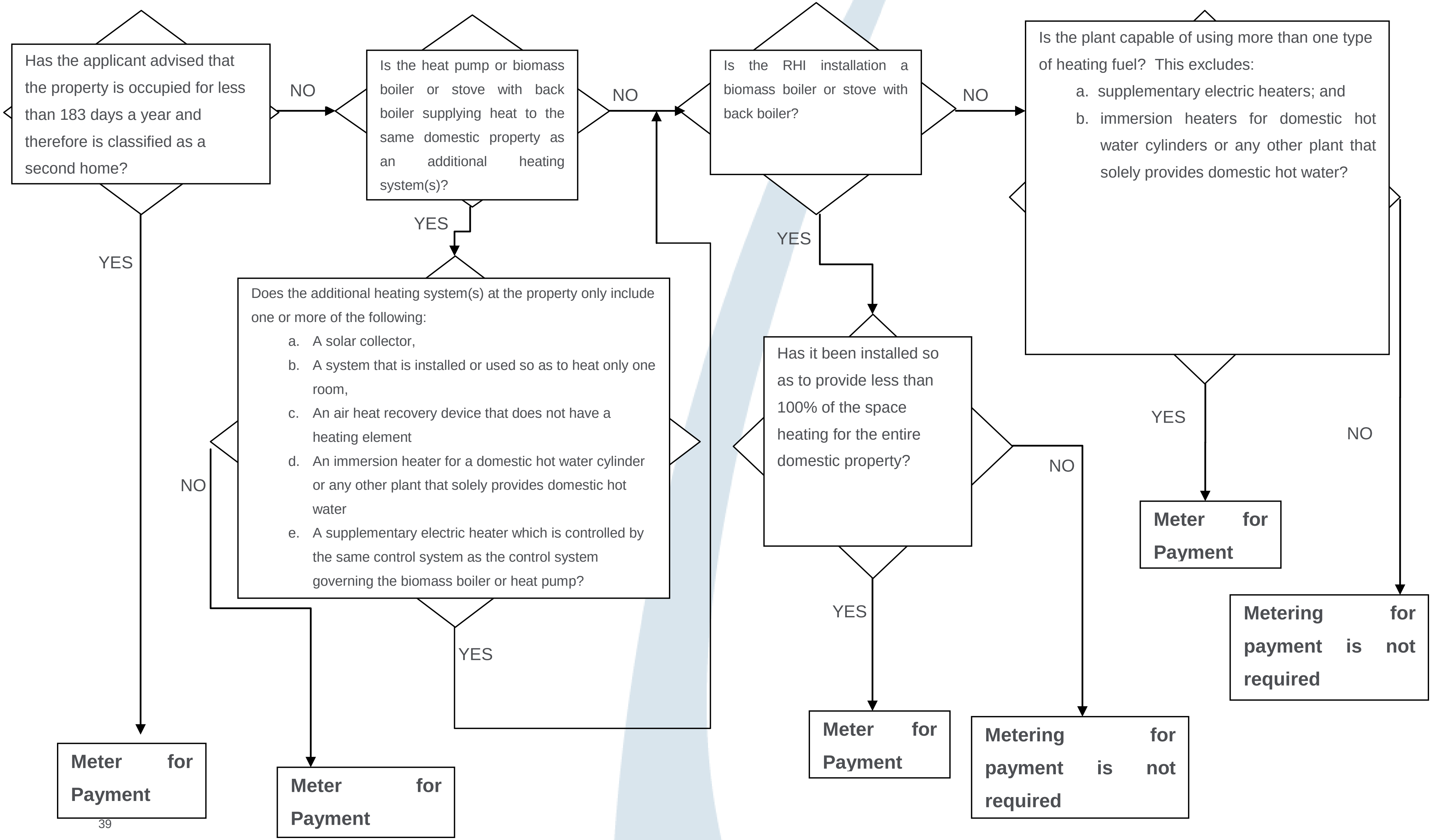


Figure 5: Schematic 4: Integrated DHW cylinder, shown here for heat pumps but could apply to biomass boilers.

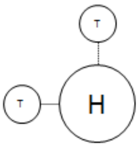
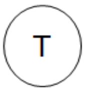
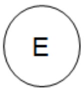
Annex B: Procedure A- When should a heat pump or biomass boiler or stove with back boiler be metered for payment?



Annex C: Examples for Section 6, Metering for Payment

This annex presents some case studies to illustrate the meter location requirements for Metering for Payment.

In the following, there are a number of simplified examples which illustrate placement of meters/sensors. A key for the types of meters/sensors is shown below:

	Heat meter, including flow meter (H part) and two temperature sensors
	Temperature sensor
	Electricity meter

Worked Example 1: A pellet biomass boiler providing space heating and domestic hot water in a second home

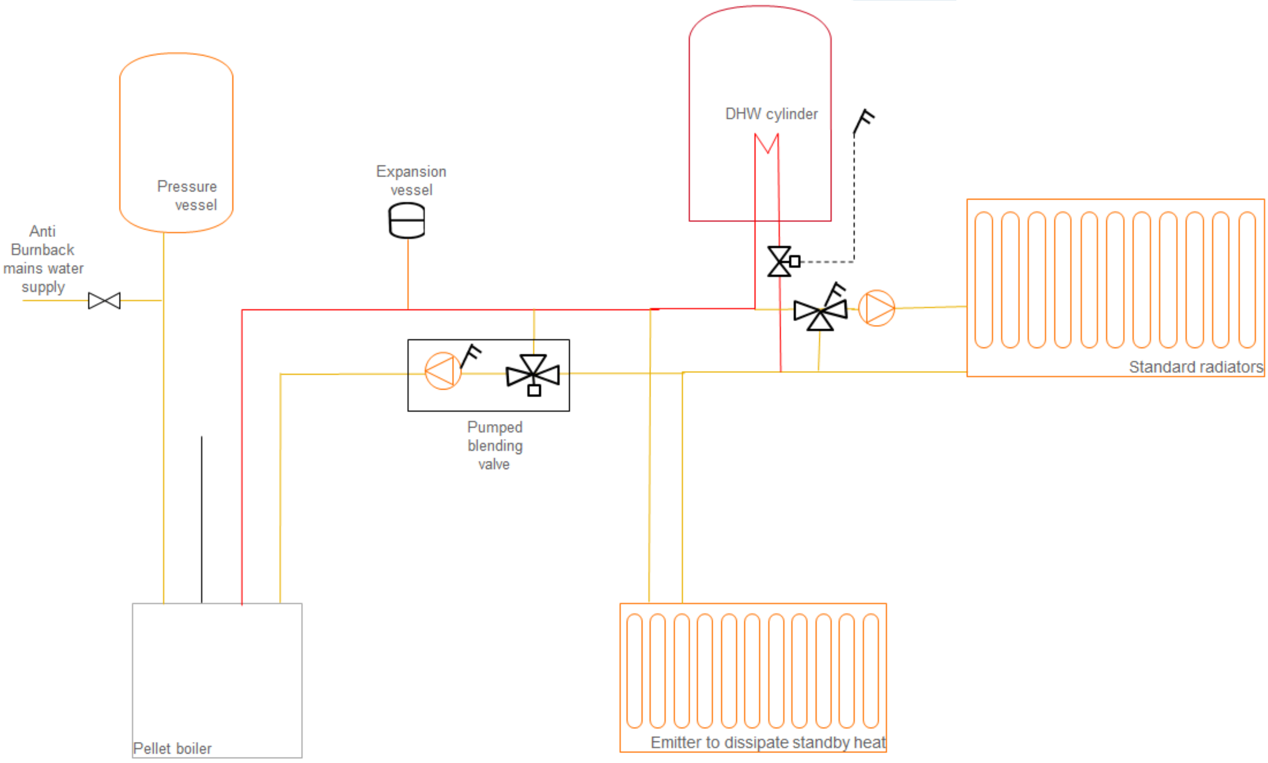


Figure 6: Pellet biomass boiler

For the simplified example shown in Figure 6, since the Renewable Energy Directive (RED) [1] classifies all heat output from the biomass boiler as renewable, and since the boiler is not a hybrid, inputs to the system do not need to be measured in most circumstances, and therefore the following metering (Figure 7) is one of the simplest approaches that can be taken and requires only a single heat meter:

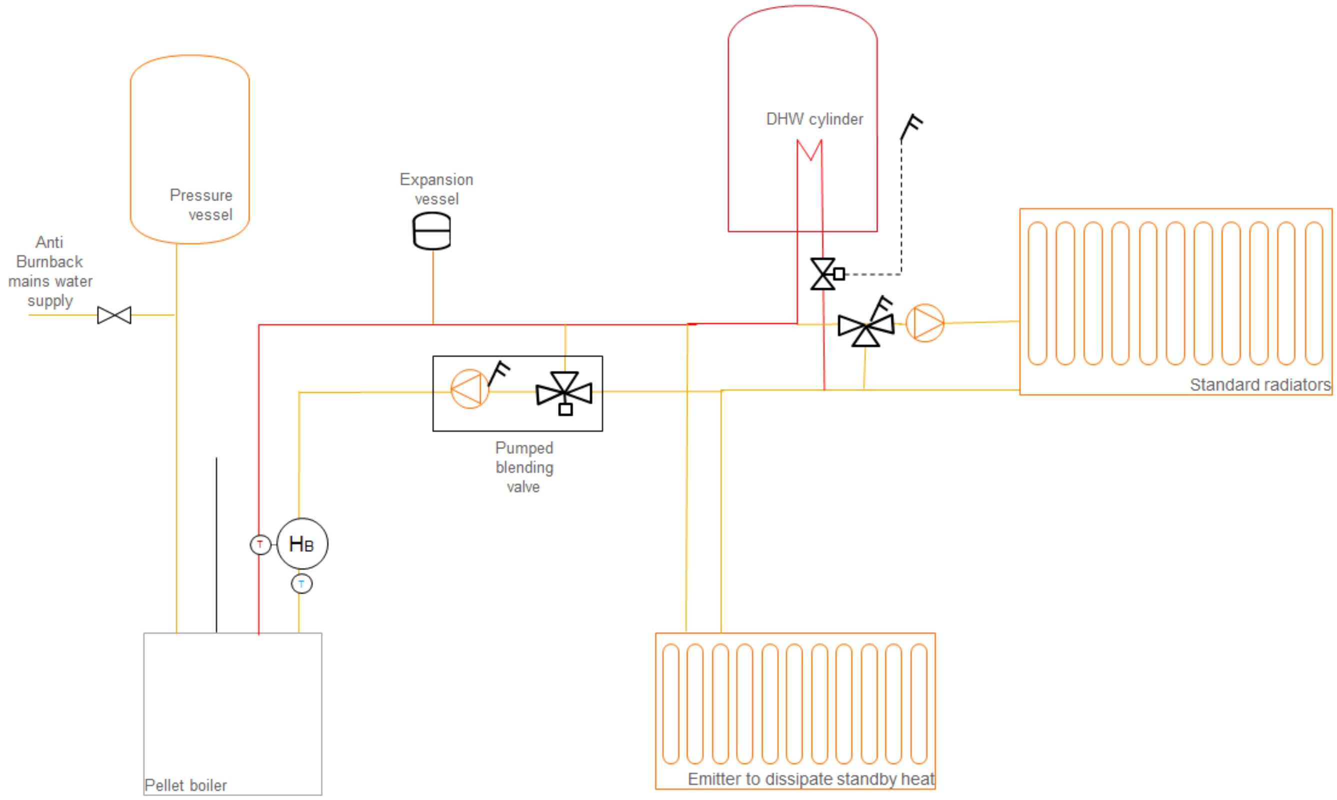


Figure 7: Pellet biomass boiler with metering option 1: 1 heat meter

Pellet stoves with back boilers are also eligible for the domestic RHI. For these systems, the thermal-transfer fluid can be metered as in the above example and Ofgem will make an assumption for heat conveyed directly to the room as detailed in RHI regulations.

1 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:en:PDF

Worked Example 2: An air-source heat pump with a back-up fossil fuel boiler providing both space heating and domestic hot water

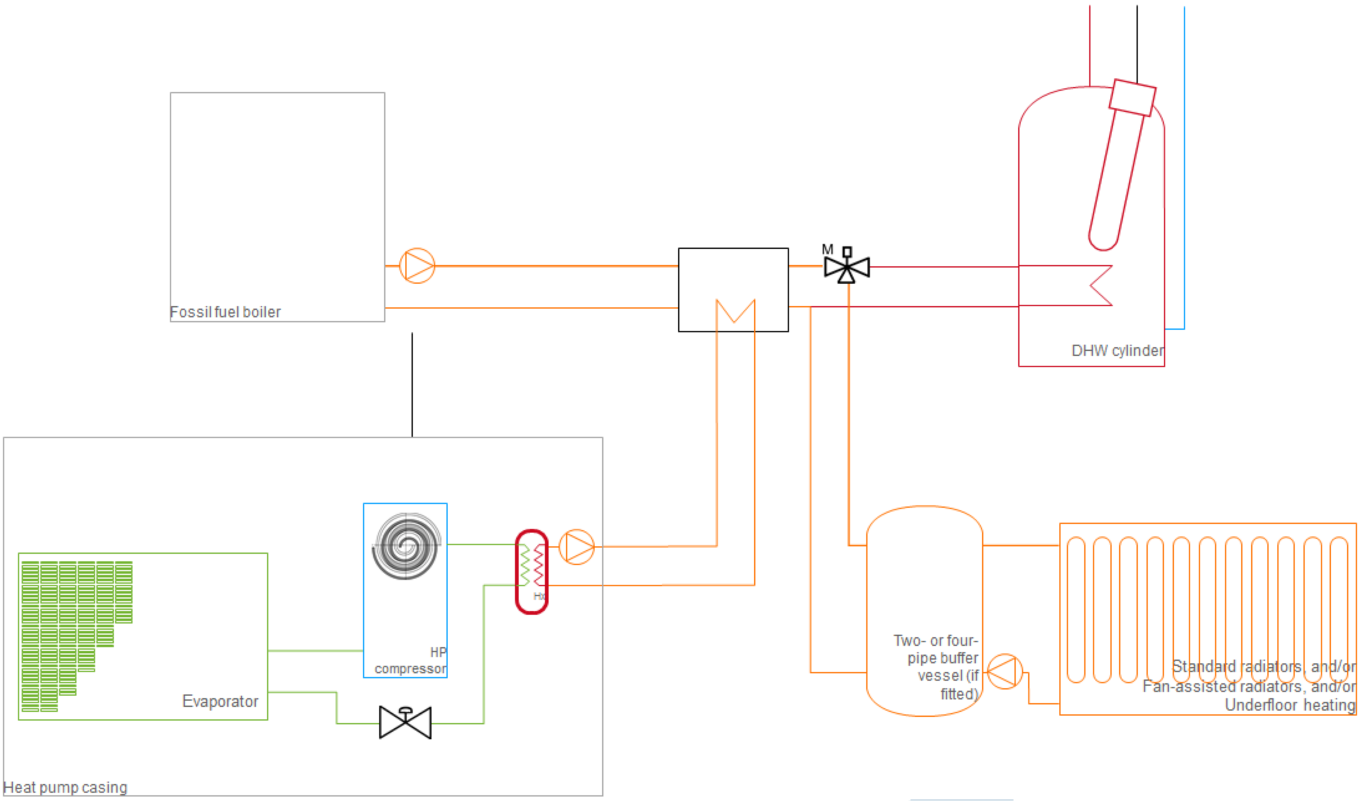


Figure 8: Air-source heat pump with back-up fossil fuel boiler

For heat pumps, the metering concept is that an MCS installation company shall:

Measure the heat output for a renewable heating system and any non-renewable energy inputs (for example, electricity or gas) to the components from which heat is being measured.

This potentially allows metering at a number of locations. One example of compliant metering would be metering of the electrical supply to the heat pump and metering heat on the heat pump distribution pipes as shown in Figure 9. This is compliant because where heat has been measured from components (i.e. the compressor, fan and circulation pump), the electrical supply to the same components has also been measured. The renewable heat here is then H_{hp} minus E_{hp}, i.e. the heat measured from the heat pump minus the electric power consumed by all of the components inside the heat pump.

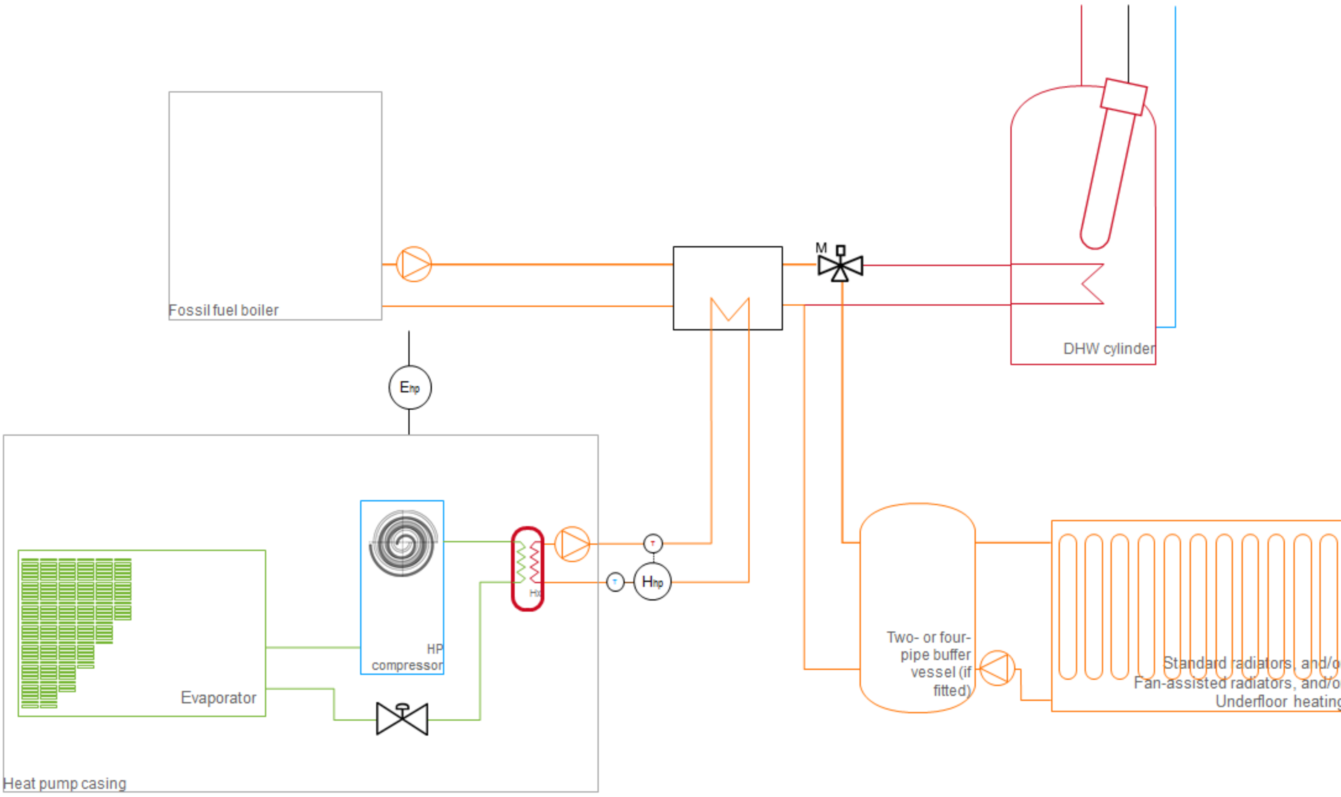


Figure 9: Air-source heat pump with back-up fossil fuel boiler showing metering option 1: 1 heat meter and 1 electricity meter

An alternative method of metering this system is shown in Figure 10 where a manufacturer has integrated the heat meter into their product:

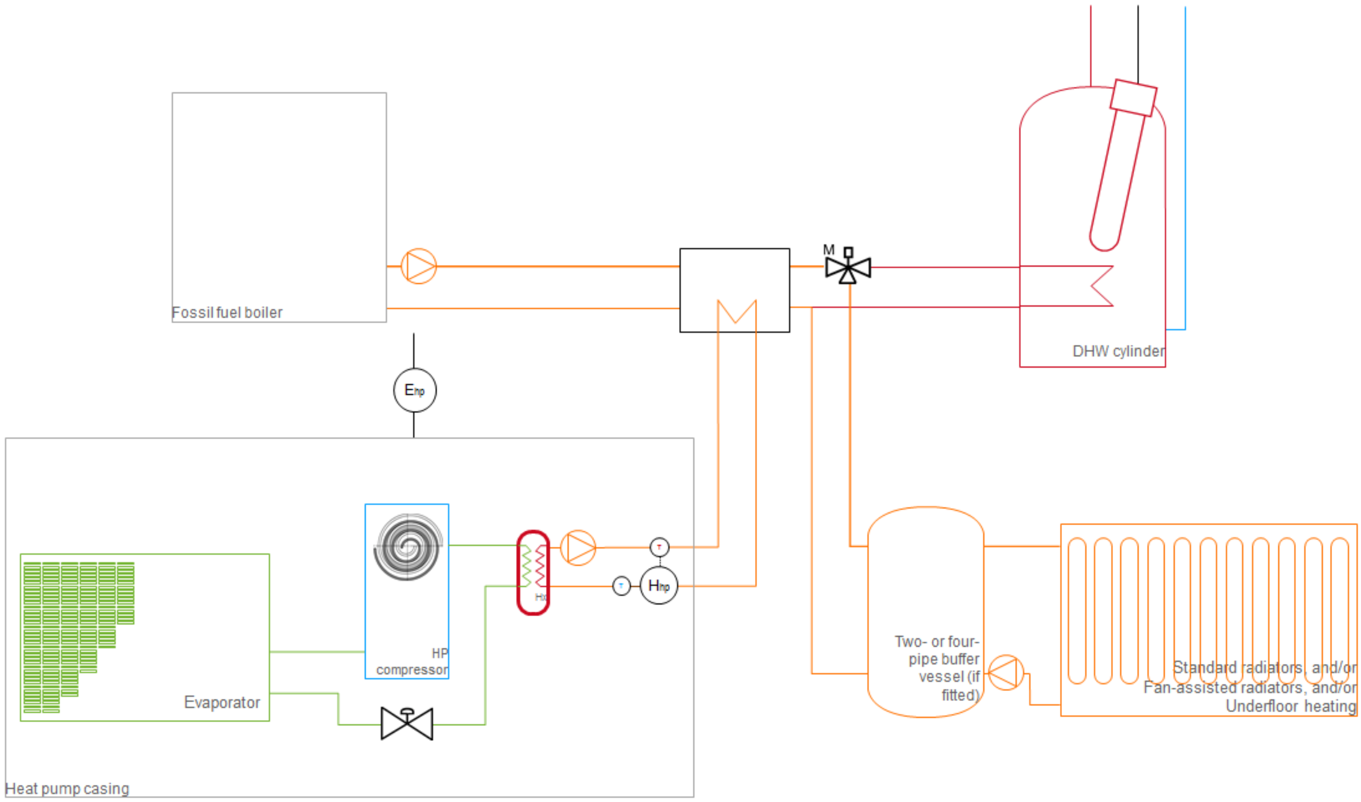


Figure 10: Air-source heat pump with back-up fossil fuel boiler showing metering option 2: 1 heat meter (integrated) and 1 electricity meter

Manufacturers integrating metering into their products can simplify metering arrangements and reduce the risk of meters being specified or installed incorrectly.

In each of the examples, the electric power consumed by the circulation pump must be included in the electricity meter reading since the heat created by the circulation pump has been included in the heat measurement.

As discussed, heat output can be measured for any combination of components so long as energy input to those components is also measured. The flexibility of this approach means that a wide range of approaches to metering are possible to allow for a wide range of household plumbing scenarios.

Worked Example 3: A ground-source heat pump with integrated domestic hot water cylinder

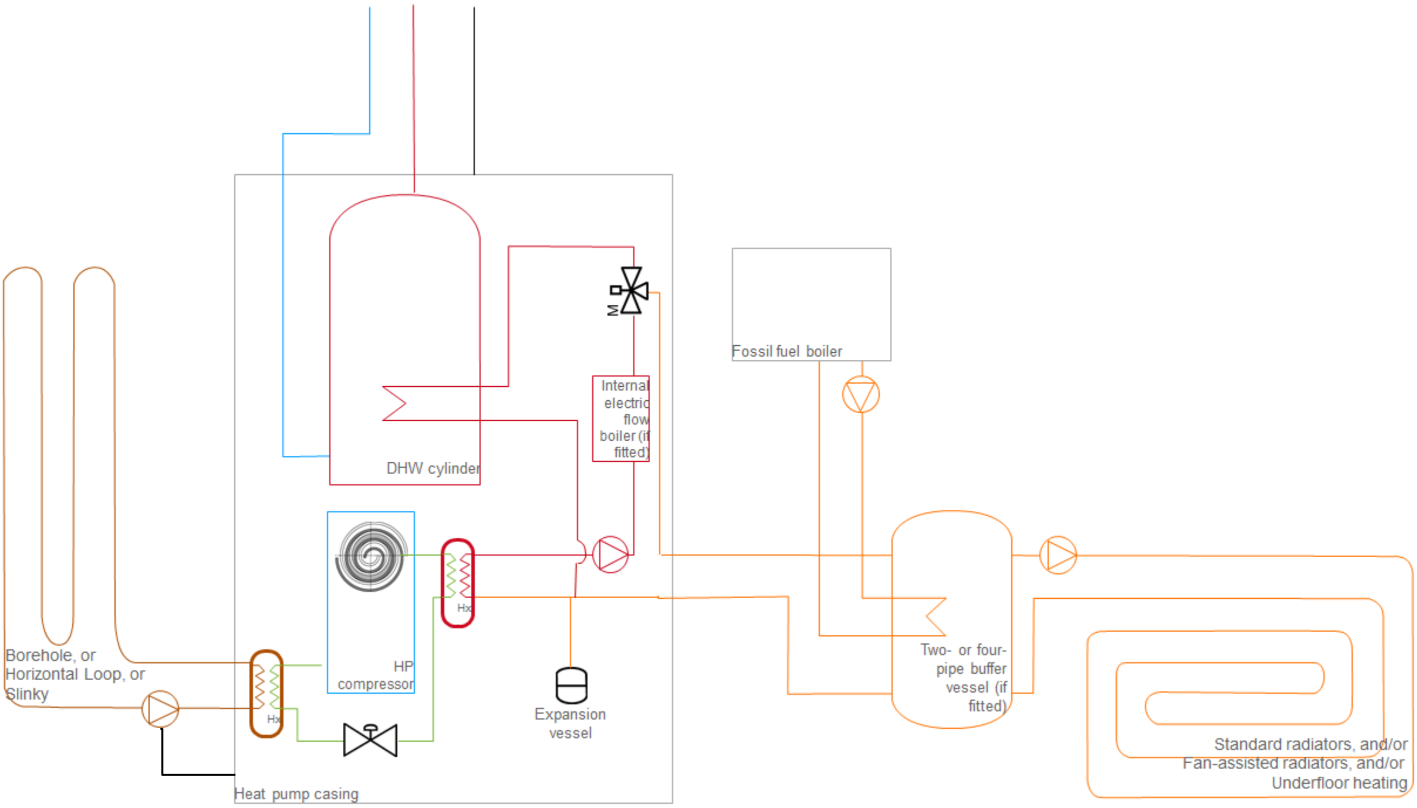


Figure 11: Ground-source heat pump with integrated domestic hot water cylinder

Considering the requirement to make sure that where heat output is measured from a component then energy input to the same components is also metered, the schematic in Figure 12 shows one possible approach to metering that would be compliant for the system in Figure 11. Note that the ground loop circulation pump and the load-side circulation pump integrated into the heat pump are included in the electricity measurement.

The approach in Figure 12 requires Ofgem to make assumptions for losses from the domestic hot water cylinder in order for the metering to be comparable to that for Worked Example 2. Domestic RHI regulations provide further detail about assumptions that Ofgem will make to account for cylinder losses in this situation.

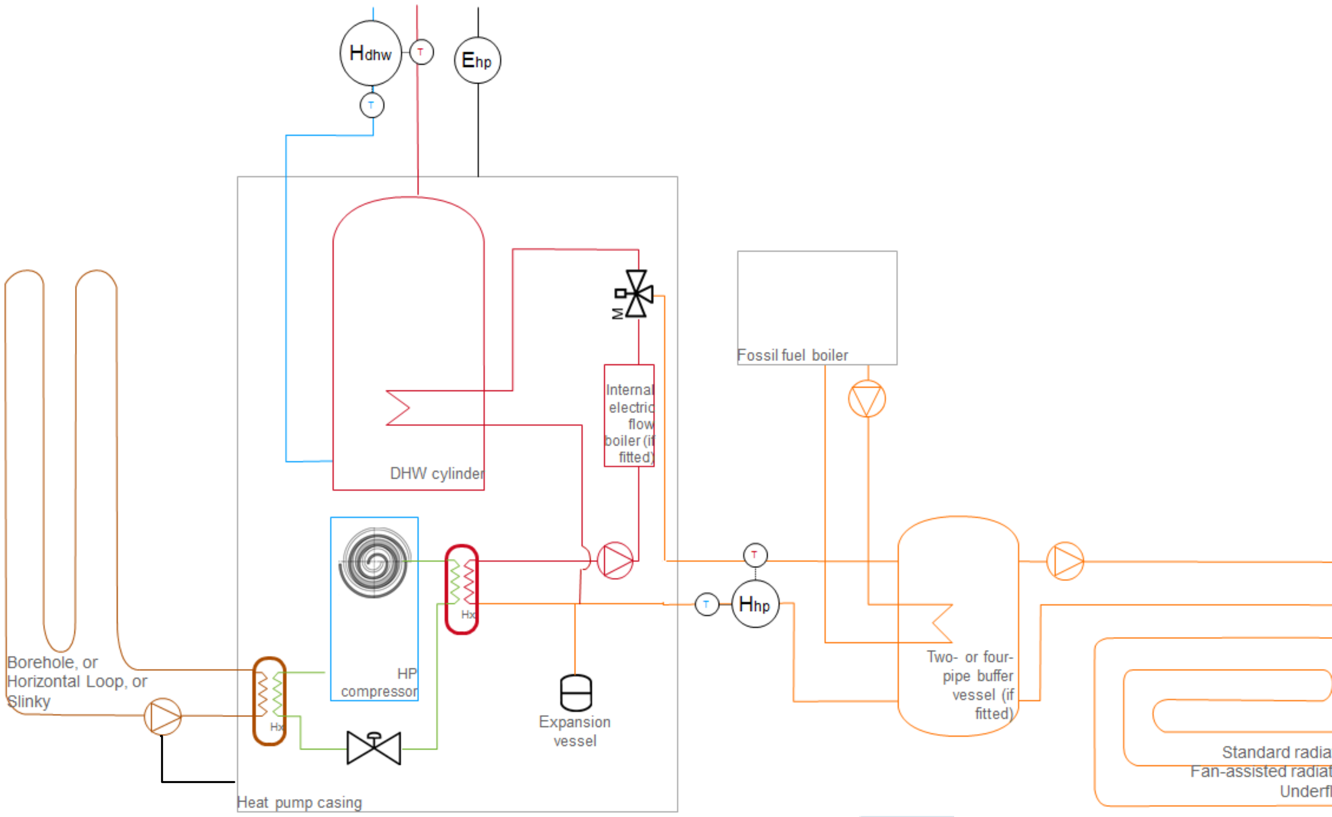


Figure 12: Ground-source heat pump with integrated domestic hot water cylinder and metering option 1: 2 heat meters, 1 electricity meter

If a manufacturer is able to integrate the metering then the metering arrangement in Figure 13 would also be possible, though it should be noted that in this case, the internal electric flow boiler should not be included in the electricity measurement since its output has not been included in the heat measurement. (Including the electricity consumed by the internal electric flow boiler without measuring heat output from it would penalise the RHI applicant in any case by lowering their overall renewable heat measurement). The electricity consumed by the ground loop circulation pump is still included in the electricity meter reading.

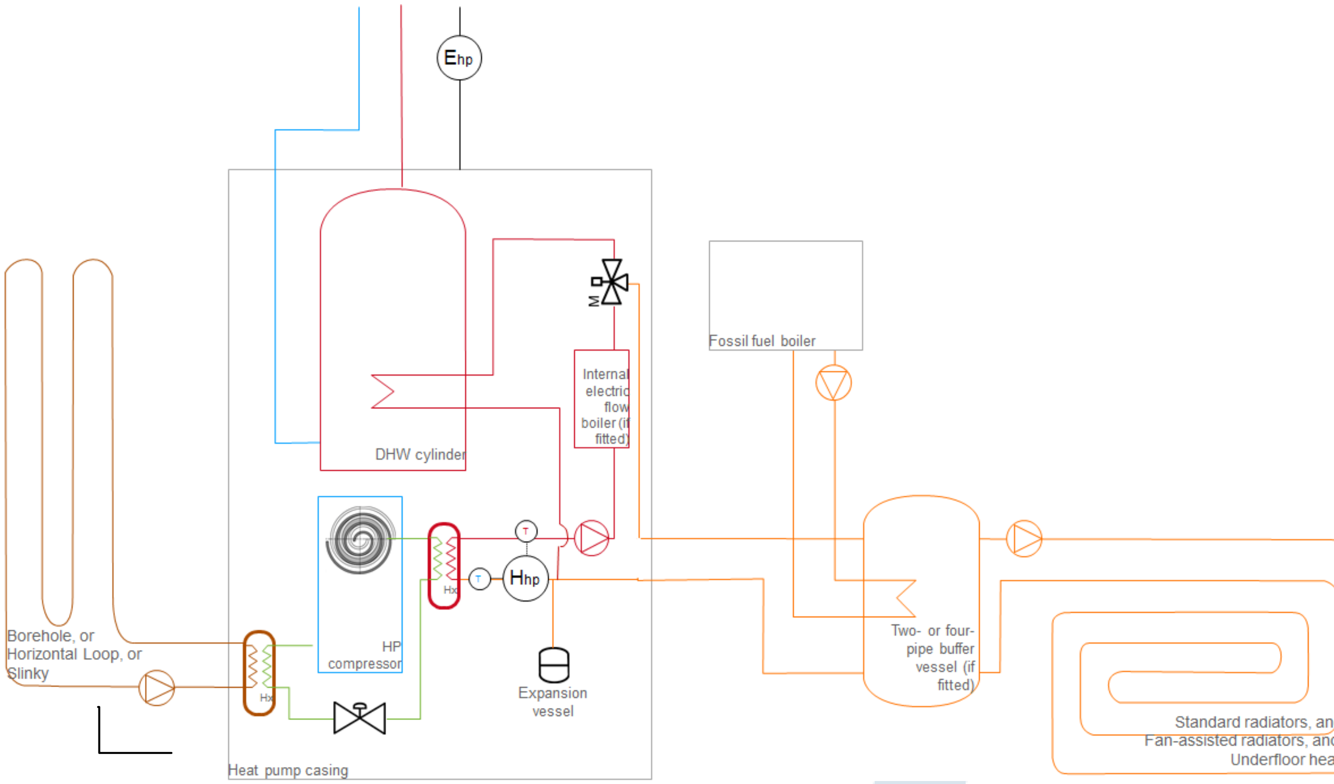


Figure 13: Ground-source heat pump with integrated domestic hot water cylinder and metering option 2: 1 heat meter (integrated), 1 electricity meter

In the above example, metering has been conducted on either side of a circulation pump. Where the heat generated by a circulation pump is included in the heat output measurement, the energy input to the circulation pump shall be included in the overall energy inputs measurement. This is only required for heat pumps.

Worked Example 4: A split-system air-source heat pump providing space heating and domestic hot water

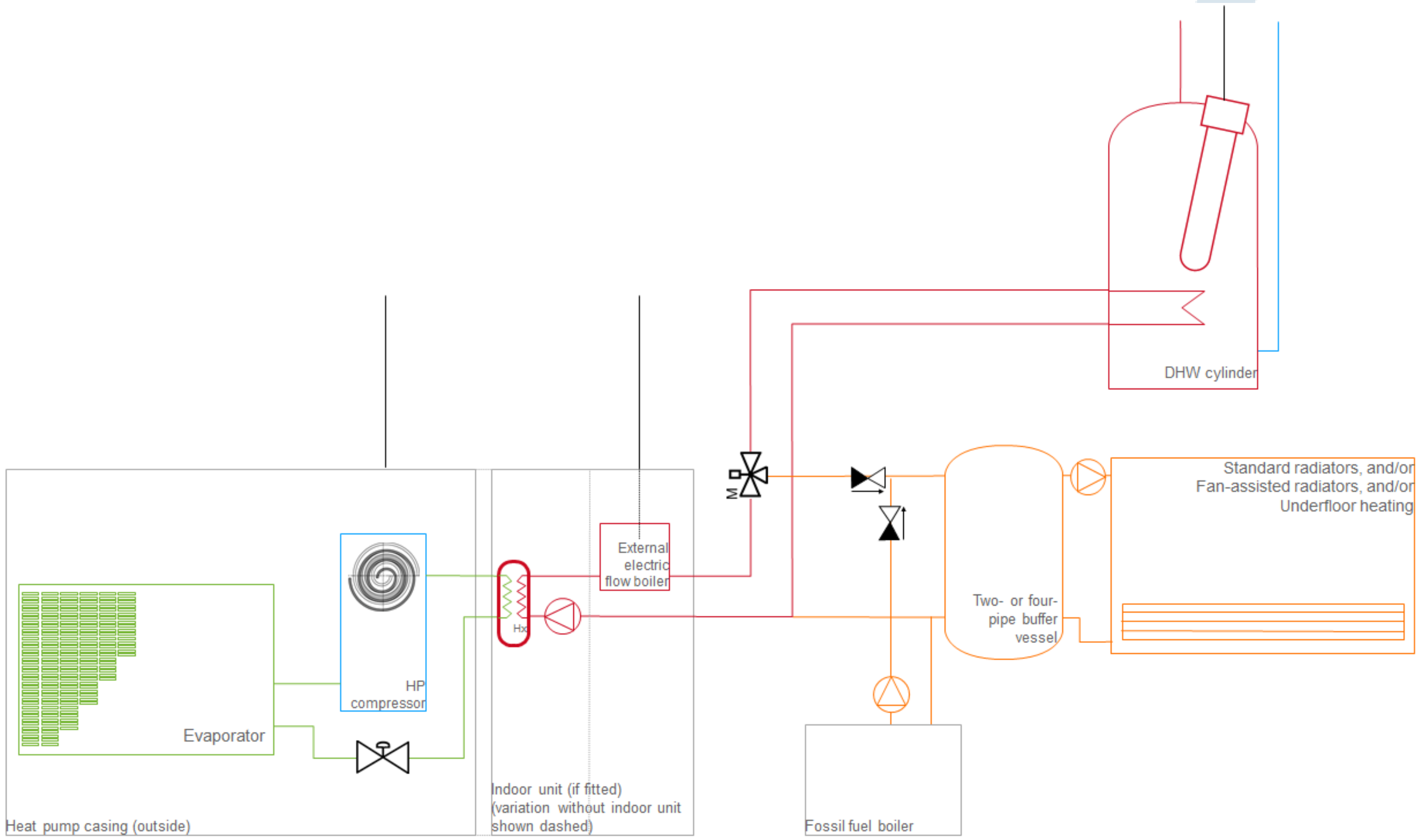


Figure 14: Split-system air-source heat pump providing space heating and hot water

The split-system air-source heat pump in Figure 14 can be measured in a number of ways. Firstly, the electrical supply to the two units could be measured separately (E_{hp} and E_b) as shown in Figure 15:

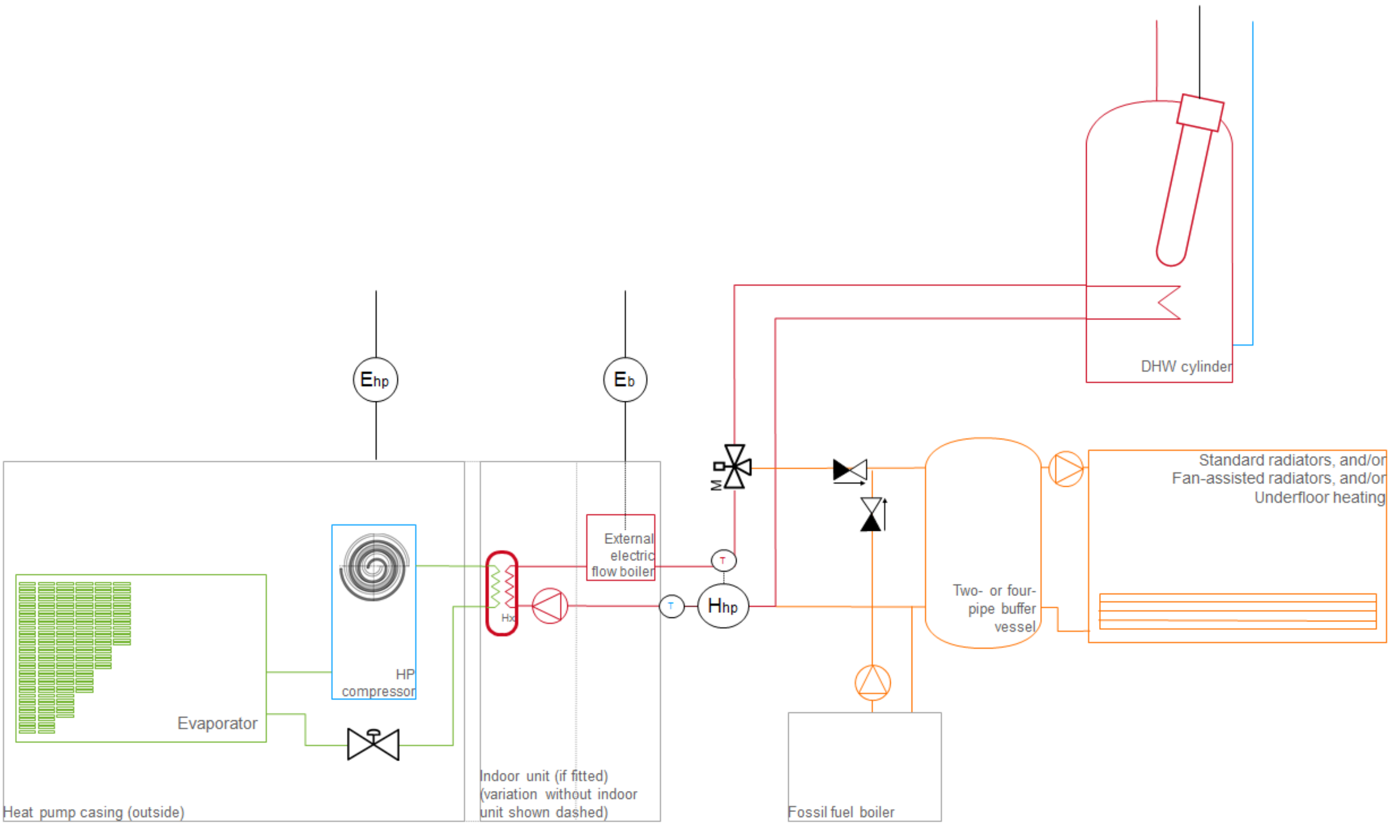


Figure 15: Split-system air-source heat pump with metering option 1: 1 heat meter, 2 electricity meters

Crucially, the heat measured by H_{hp} captures energy from both electrical supplies, meaning that electric power consumed by both the internal and external unit *must* be measured.

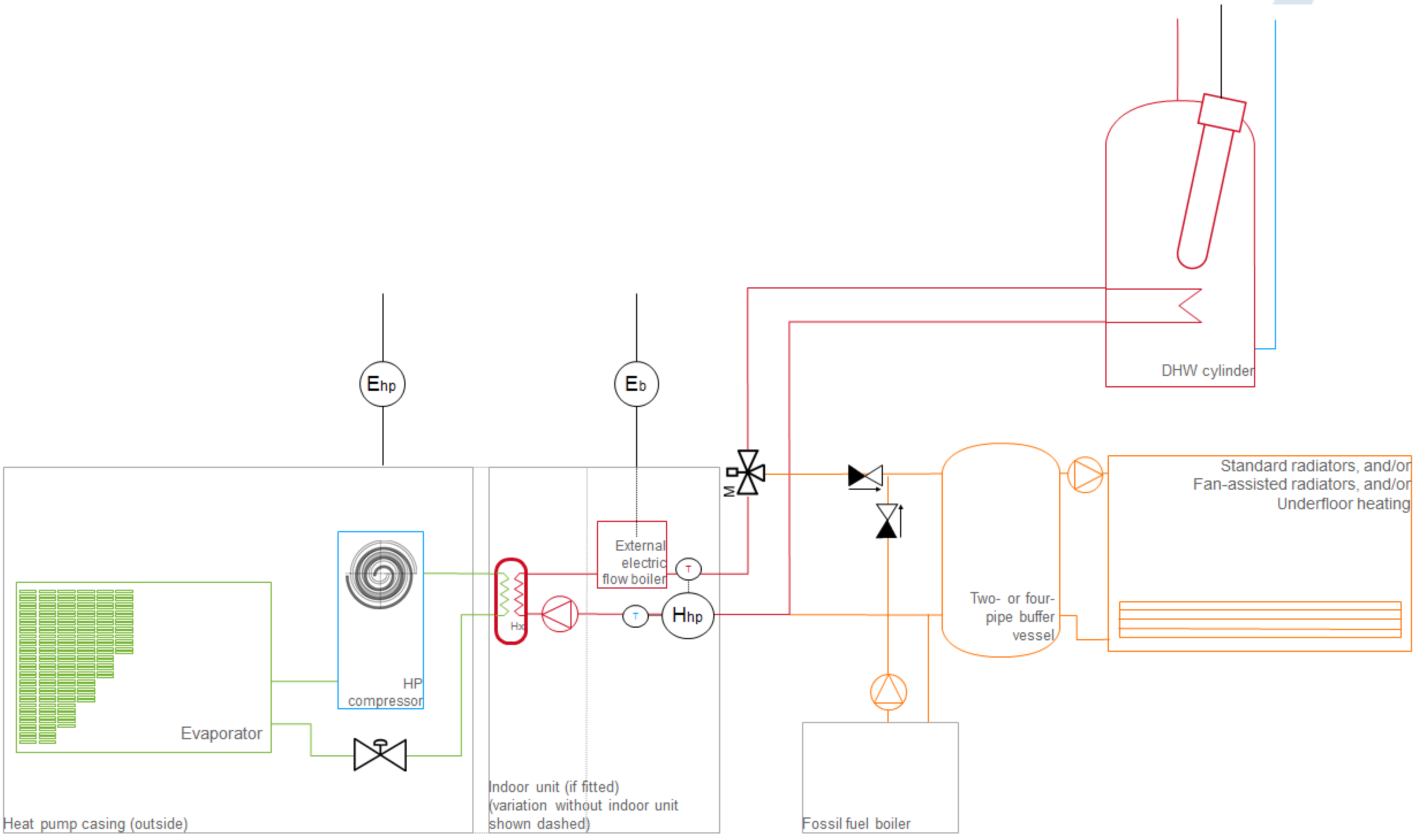


Figure 16: Split-system air-source heat pump with metering option 2: 1 heat meter (integrated), 2 electricity meters

Alternatively, in the example in Figure 16, the heat measurement could be integrated into the internal unit by the heat pump manufacturer. The electricity measurement continues to be collected with two electricity meters in Figure 16. This could be further simplified as shown in Figure 17, where the electrical supply to both parts of the heat pump has been combined into a single measurement. Where possible, this approach is recommended as the simplest way to meter this system, which reduces the possibility of error and complexity and cost for customers.

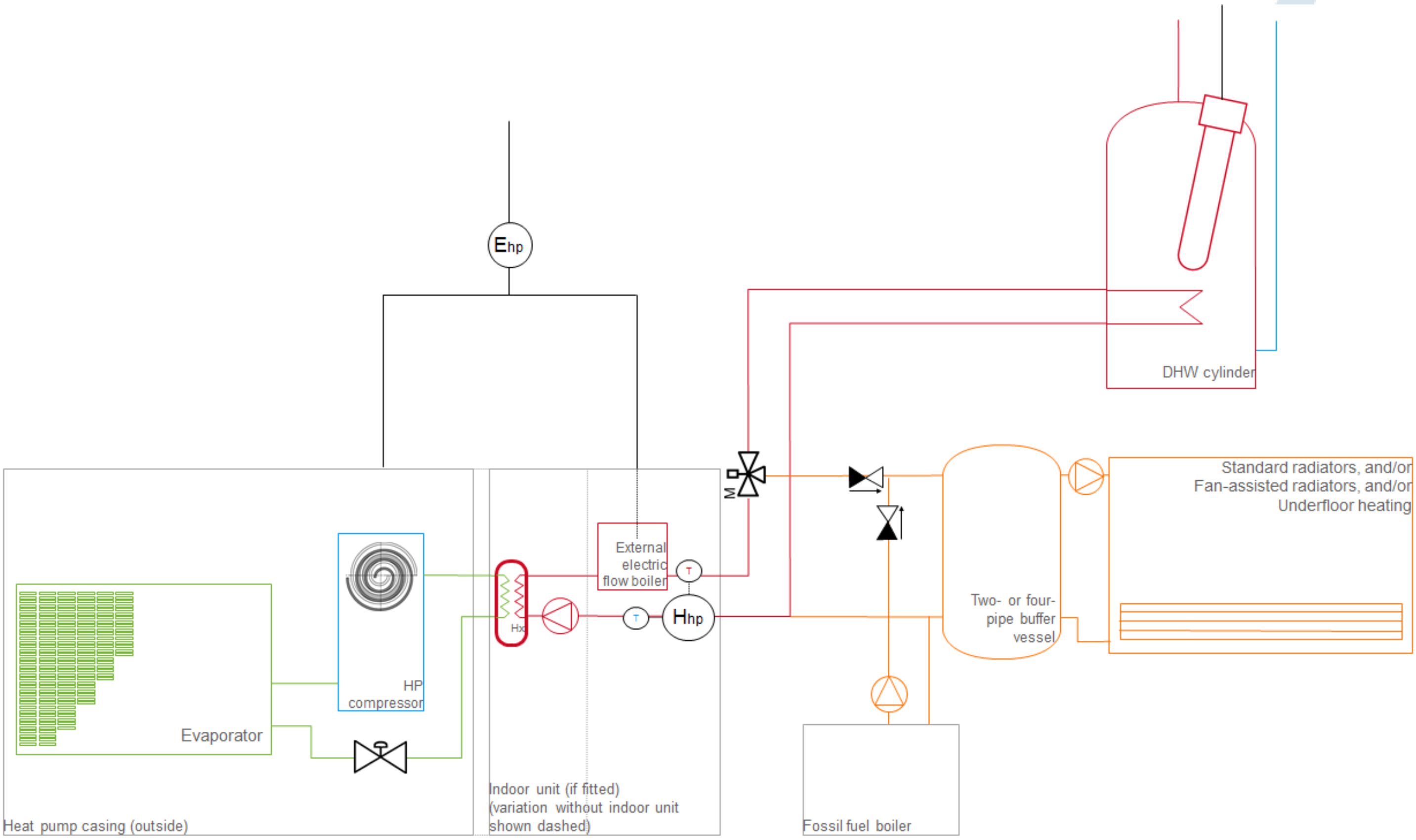


Figure 17: Split-system air-source heat pump with metering option 3: 1 heat meter (integrated), 1 electricity meter

Annex D: Fundamentals of heat metering and key points to consider

Heat meters, as specified under the Measuring Instruments Directive [[2]] have three components; a flow measuring device, a pair of temperature sensors (to measure the temperatures in the flow and return pipes) and a calculator or integrator.

Meters can be sold as combined units where all three components have been matched by the manufacturer or as semi-combined where the components are separate but sold as a kit. Alternatively individual components are sold that are matched and integrated on-site by the installer, though this makes the installer liable for ensuring that all components have been specified by a manufacturer as compatible.

Flow meters can be designed to record flow using several different techniques. Some of the most common include turbine flow meters which measure the rate of rotation of a turbine placed within the flow; ultrasonic meters which record the speed of sound within the flow or vortex meters which detect oscillations as a result of vortices formed by forcing flow past a bluff body. Other models of flow meter are available on the market.

A matched pair of temperature sensors are required to calculate the temperature difference between two points. This is commonly achieved through matched pairs of platinum resistance thermometers fitted into pockets within the flow. It is very important that the temperature pair selected for a site is designed to measure temperature differences expected at the specific points of heat measurement in order for the measurement error not to exceed manufacturer's designs.

A calculator unit processes the temperature and flow values using physical properties of the fluid stored within the unit. Typically, this could include specific heat capacity of the fluid, density of the fluid or other parameters as appropriate for the flow meter

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[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:135:0001:0080:EN:PDF
Directive 2004/22/EC of the European Parliament and of the Council of 31 March 2004 on measuring instruments

in question. The calculation unit may also be responsible for storing data and displaying readings to the customer and therefore should be placed in a location where a customer can view the display panel.

When installing heat meters or selecting locations for isolation valves as part of making a system meter-ready, there are several key points to consider.

Flow meter:

1. Is the flow meter sufficiently far from pumps or other features that will have a significant impact on the flow?

Different types of flow meters have different sensitivities to pumps, double bends or other flow disturbances. Meter manufacturers will provide guidance to support the installation of their meters.

2. Is the orientation of the flow meter correct?

3. A flow meter must be selected with careful consideration so that qp (the highest value of flow rate of the heat conveying liquid that is permitted permanently for the heat meter to function correctly), and qi (the lowest value of flow rate that is permitted for the heat meter to function correctly) and qs (the highest value of flow rate that is permitted for short periods of time for the heat meter to function) are appropriate for the system being measured.

4. Pay particular attention to the impact on system pressure as a result of flow meter selection and installation of isolation valves.

Temperature sensors-

1. Temperature sensor pairs cannot be separated. Do not shorten or extend the temperature sensor cables. This will change their electrical resistance and have an impact on the readings that come from them.

2. Are the temperature sensors installed appropriately within the flow, e.g. within a pocket in the pipework?

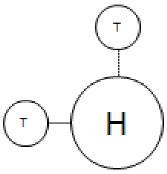
3. Are the cables of the temperature sensors exposed to sources of electromagnetic interference, beyond the design specifications?

Calculation unit-

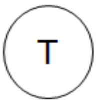
1. Is the calculation unit recording in the appropriate units for a Customer?
2. Does the Customer know how to read the heat meter to enable them to submit meter readings for the RHI?
3. Is the calculator unit exposed to sources of electromagnetic disturbance beyond the specifications?
4. If the calculator unit is outside then is it installed in accordance with manufacturer’s instructions?

Annex E: Worked examples of requirements for Metering and Monitoring Service Packages

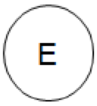
In the following, there are a number of simplified examples to illustrate the sensor requirements for potential Metering and Monitoring Service Packages. A key for the types of meters and sensors is shown below:



Heat meter, including flow meter (H part) and two temperature sensors



Temperature sensor



Electricity meter

Worked Example 1: An air-source heat pump providing space heating and domestic hot water

The following example works through the required Metering and Monitoring Service Package for a 10 kW air-source heat pump that is capable of modulating its heat output to a minimum of 4 kW. The system is connected to a domestic hot water cylinder with a 2 kW immersion element for the domestic hot water. The heat pump has a design SPF of 2.7:

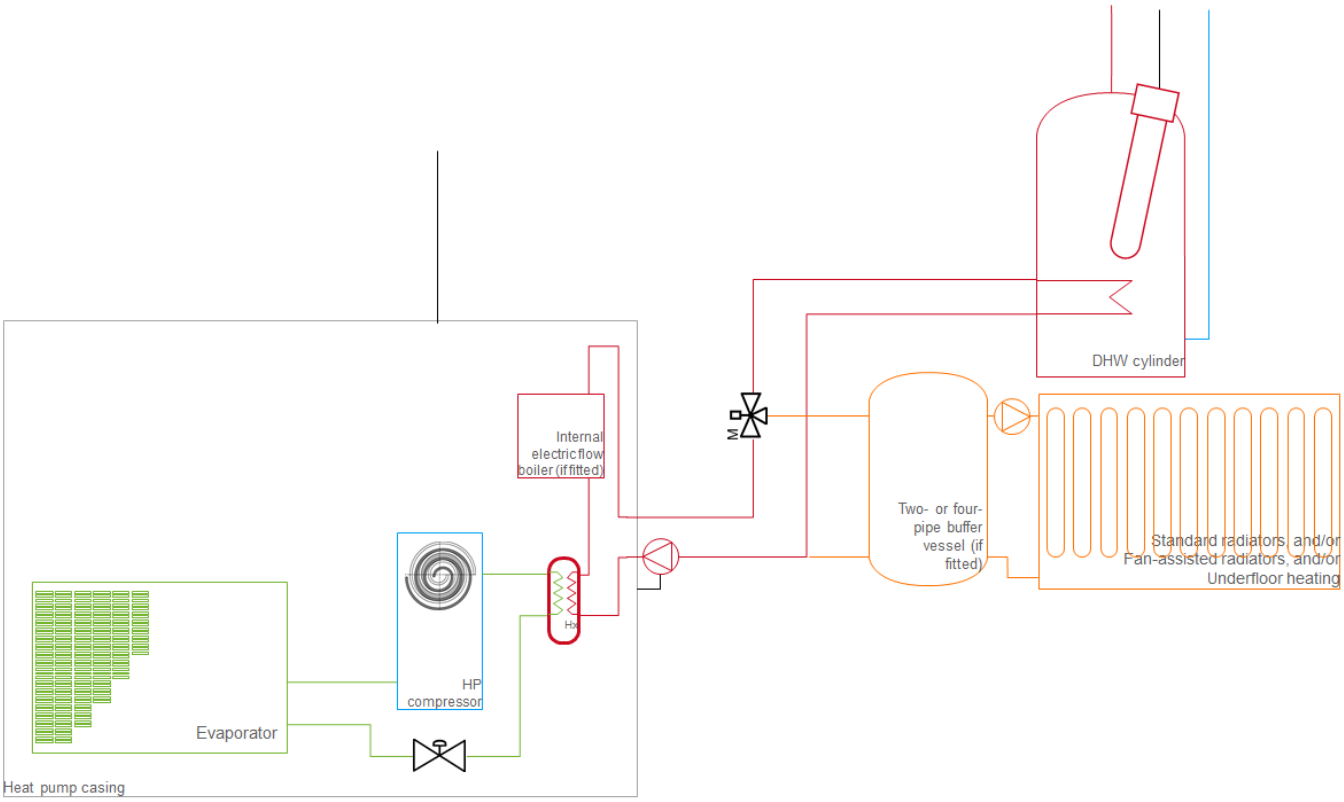


Figure 18: Worked Example 1: ASHP

One metering arrangement that fulfils the specified criteria is shown in Figure 19.

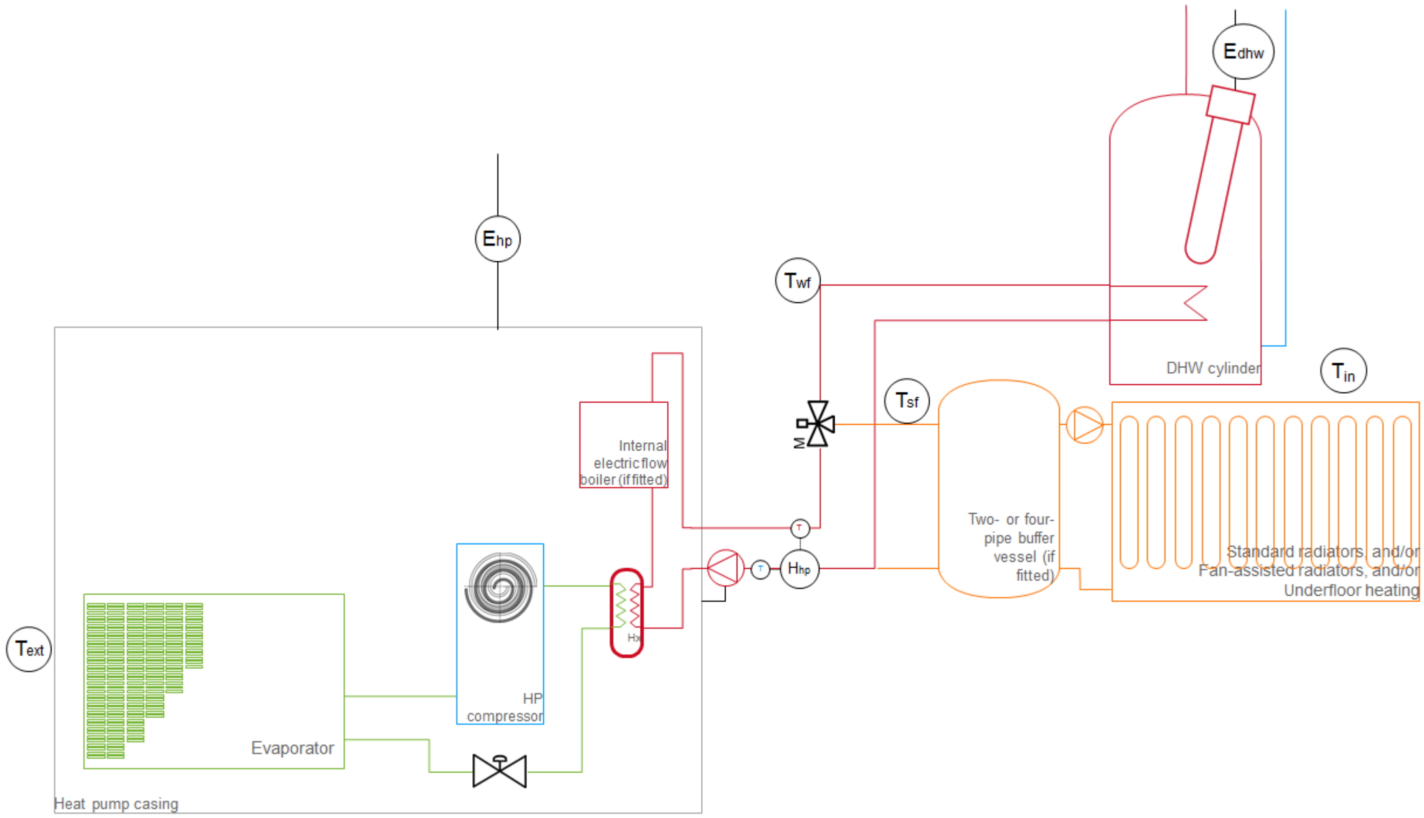


Figure 19: Worked Example 1: ASHP with metering option 1

Where:

E_{hp} = electrical supply to the heat pump;

E_{dhw} = electrical supply to immersion heating in domestic hot water cylinder;

H_{hp} = heat output from heat pump

T_{sf} = space flow temperature;

T_{wf} = domestic hot water flow temperature;

T_{in} = internal air temperature in at least one location in the dwelling;

T_{ext} = external air temperature.

There is no gas or oil input so no gas or oil metering is required.

<u>All data must be logged on at least a 2-minute time period.</u>

Alternatively, the manufacturer may be able to integrate some of the metering in Figure 19 into their unit, in which case the metering arrangement in Figure 20 may be feasible.

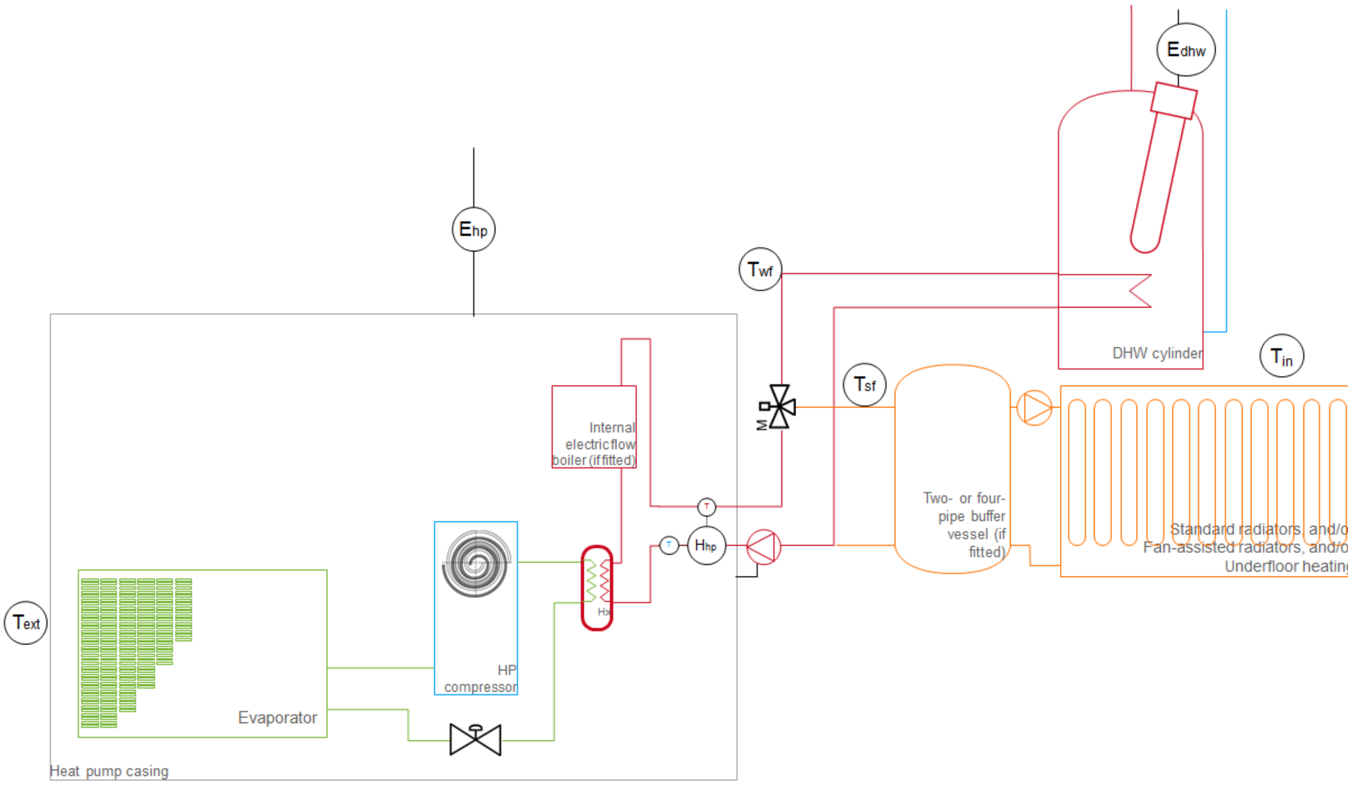


Figure 20: Worked Example 1 - ASHP with metering option 2

Given that excessive electricity demand by a circulation pump can be expensive and wastes energy, it is recommended that the electricity supply to the circulation pump is measured even when it is not included in the heat meter reading.

Meter resolution

The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring.

The minimum resolution of heat meter required for space heating (H_{hp} in the diagram in Figures 19 and 20) would be (using the resolution requirement expressed in Wh):

$$[Resolution\ of\ heat\ meter] \leq 3\ \% * [\min non - zero\ heat\ output\ in\ 2\ minutes]$$

Here, the air-source heat pump has a minimum capacity of 4 kW. This means that in 2 minutes, the heat pump can output approximately 133 Wh of heat:

$$[Resolution\ of\ heat\ meter] \leq 3\ \% * [133\ Wh]$$

$$[Resolution\ of\ heat\ meter] \leq 4\ Wh$$

This means that the required resolution of the heat meter is at least 4 Wh. A meter resolution of 1 Wh would also fit this specification.

Using the table shown in Section 7 (copied below), we could alternatively have noted that the minimum capacity of the heat pump is 4 kW and then used the table below to pick out that the meter resolution required is likely to be 1 Wh.

Min non-zero heat output (Min. H) (kW)	**Smallest change that must be measurable**	**Example heat meter display**
Min. H < 10 kW	1 Wh	00000**.000** kWh
10kW ≤ Min. H < 100 kW	10 Wh	000000**.00** kWh
100 kW ≤ Min H.	100 Wh	0000000**.0** kWh
[All meters measuring draw-off from a DHW cylinder]	10 Wh	000000**.00** kWh

The minimum resolution of the electricity meter can be calculated in a similar manner. Taking the design SPF of 2.7 and a heat output of 133 Wh in 2 minutes, the electrical supply over 2 minutes can be estimated as 49 Wh. Putting this into the equation below:

$$[Resolution\ of\ electricity\ meter] \leq 3\ \% * [\min non - zero\ electrical\ input\ in\ 2\ minutes]$$

the minimum required resolution is 1.5 Wh. Therefore, a meter resolution of 1 Wh would fit the criteria.

Similarly, the electricity meter for the immersion heating would need a meter capable of resolving 2 Wh as a minimum resolution (making a 1 Wh meter resolution eligible).

Worked Example 2: A ground-source heat pump with integrated domestic hot water cylinder

The following works through the specification for a (fixed-speed) 15 kW ground-source heat pump (design SPF = 4.1) represented by the schematic shown in Figure 21:

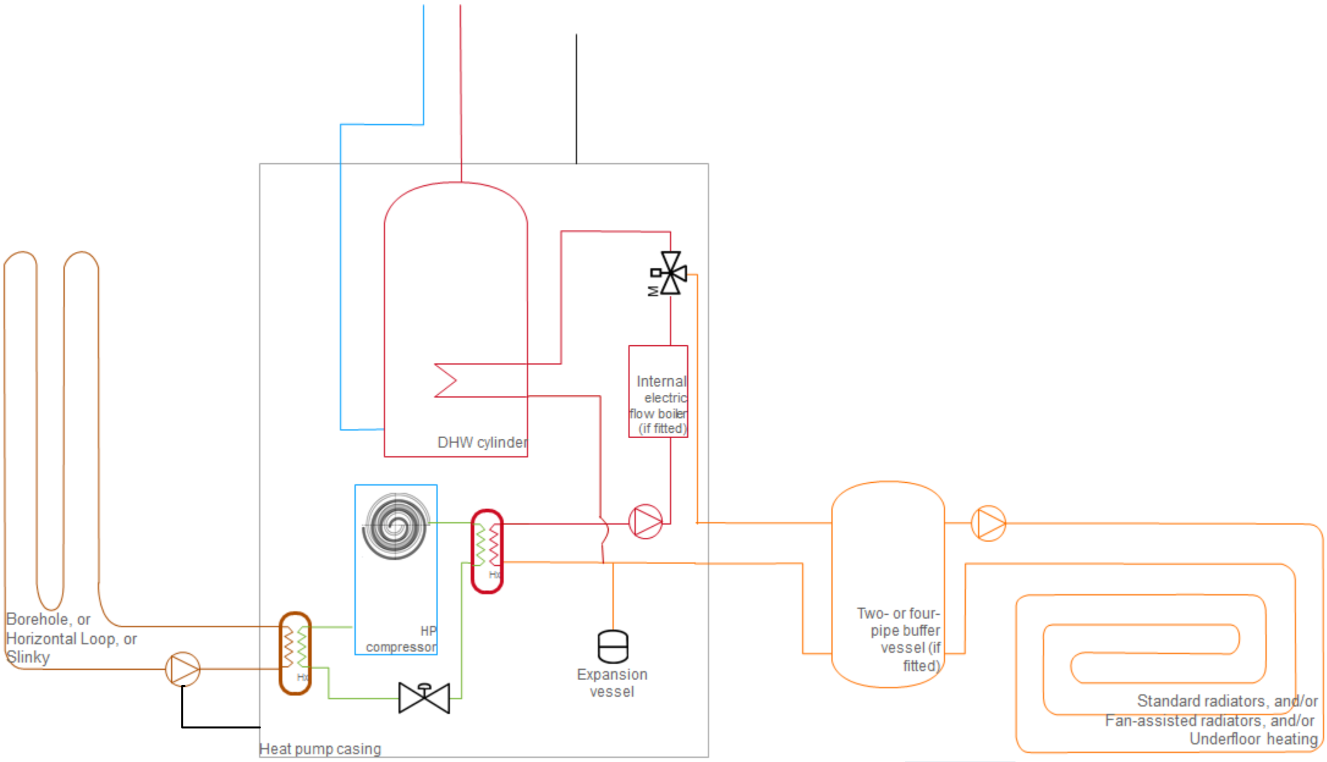


Figure 21: Worked Example 2 – GSHP with integrated cylinder

One way to meet the eligibility criteria for MMSPs would be through the metering arrangement shown in Figure 22:

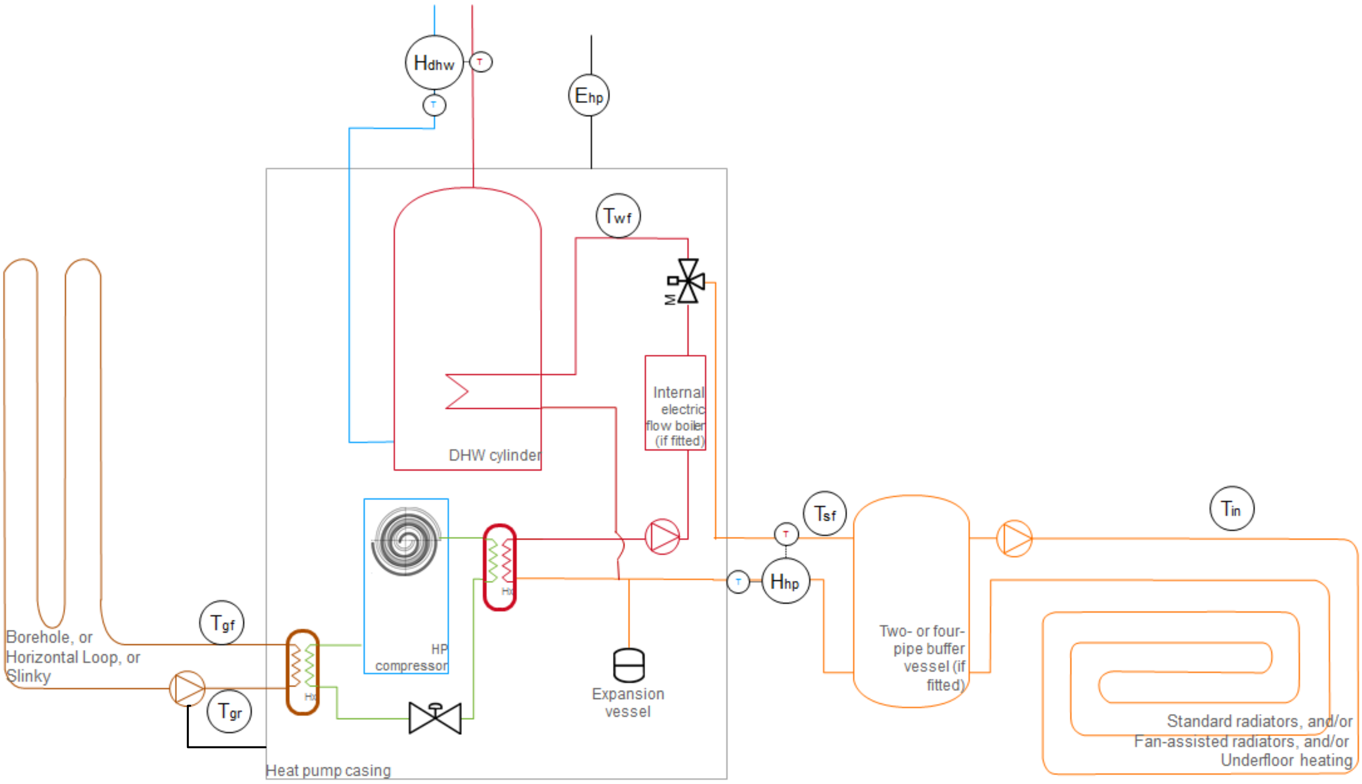


Figure 22: Worked Example 2 - GSHP with integrated cylinder and metering option 1

Where:

E_{hp} = heat pump electrical supply;

H_{dhw} = domestic hot water heat output;

H_{hp} = space heating heat output;

T_{gf} = ground loop flow temperature;

T_{gr} = ground loop return temperature;

T_{wf} = domestic hot water flow temperature;

T_{sf} = space heating flow temperature;

T_{in} = internal temperature in at least one location in the dwelling.

There is no gas or oil input so no gas or oil metering is required.

An alternative arrangement, where the manufacturer has been able to integrate the heat meter into the heat pump unit is shown below:

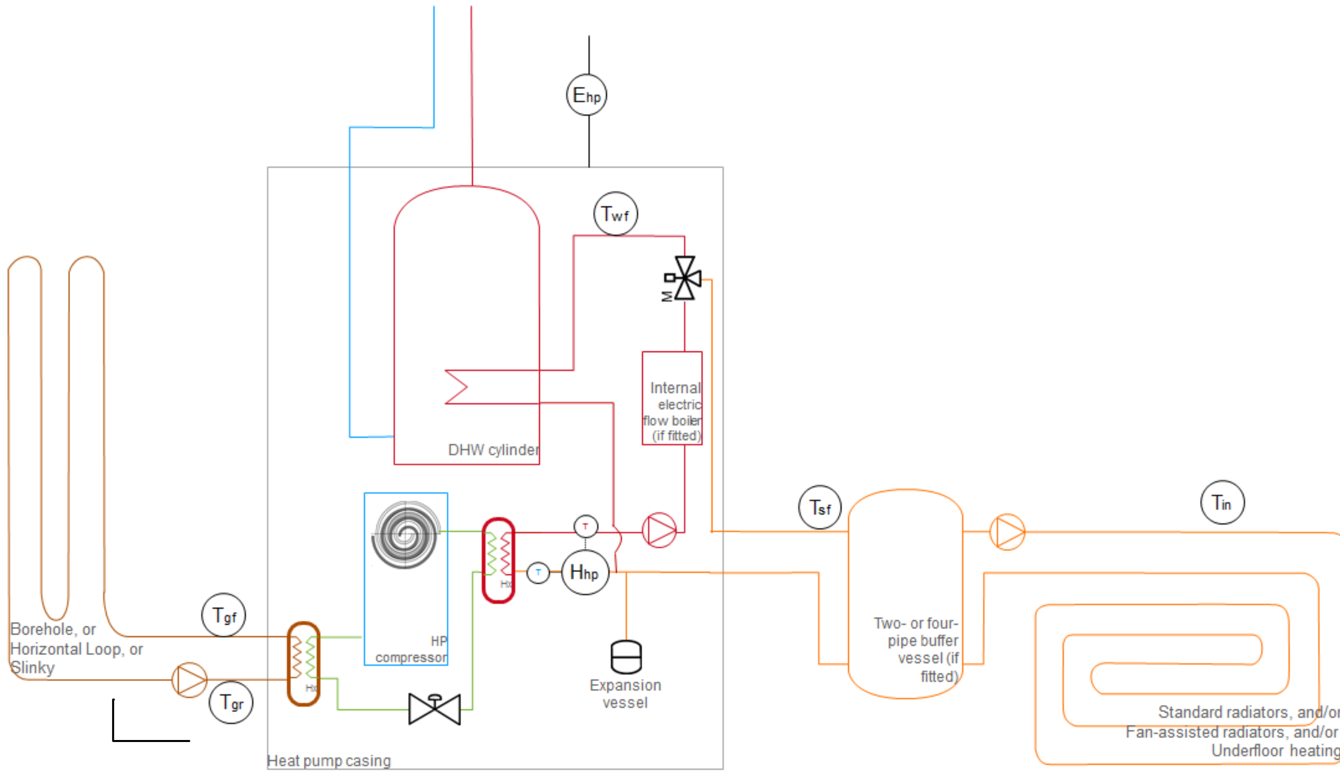


Figure 23: Worked Example 2 - GSHP with integrated cylinder and metering option 2

In order for the package in Figure 23 to present the most useful information to customers, it is recommended that the electrical supply to the internal electric flow boiler is measured as this provides very useful information to understand how well the heat pump is operating and to explain a customer's bills.

<u>All of the data must be logged on at least a 2-minute time period.</u>

Again, the example fulfils the main criteria of the metering system which is to record energy flows and provide key diagnostic temperature data to understand how well the system is operating.

Meter resolution

The minimum resolution of the space heating heat meter (H_{hp} in Figures 22 and 23) would be (using the resolution requirement as expressed in Wh):

$$[Resolution\ of\ heat\ meter] \leq 3\ \% * [\min non - zero\ heat\ output\ in\ 2\ minutes]$$

Here, the ground-source heat pump has a (non-modulating) 15 kW capacity. This means that in 2 minutes the heat pump can output approximately 500 Wh of heat:

$$[Resolution\ of\ heat\ meter] \leq 3\ \% * [500\ Wh]$$

$$[Resolution\ of\ heat\ meter] \leq 15\ Wh$$

This means that the required resolution of the heat meter is at least 15 Wh. A meter resolution of 10 Wh or 1 Wh would fit this specification.

Using the table shown in Section 7, we could alternatively have noted that the minimum capacity of the heat pump is 15 kW and then used the table below to pick out that the meter resolution could be 10 Wh.

Min non-zero heat output (Min. H) (kW)	Smallest change that must be measurable	Example heat meter display
Min. H < 10 kW	1 Wh	00000**.000** kWh
10kW ≤ Min. H < 100 kW	10 Wh	000000**.00** kWh
100 kW ≤ Min H.	100 Wh	0000000**.0** kWh
[All meters measuring draw-off from a DHW cylinder]	10 Wh	000000**.00** kWh

This is a simplified example where the ground-source heat pump is not inverter-driven and therefore is not capable of modulating its output. For a modulating output, the minimum non-zero heat output in 2 minutes should be entered into the equation to determine the required heat meter resolution instead of the heat that would be output at the nominal capacity as shown in Worked Example 1.

The smallest change the heat meter for the domestic hot water (H_{dhw} in Figure 22) shall be capable of detecting is 10Wh with the aim of recording short hot water draw-offs as described in section 7.1.

The minimum resolution of the electricity meter can be calculated in a similar manner. Taking the design SPF of 4.1 and a heat output of 500 Wh in 2 minutes, the electrical supply over 2 minutes can be estimated as 122 Wh. Putting this into the equation below:

$$[Resolution\ of\ electricity\ meter] \leq 3\ \% * [\min non - zero\ electrical\ input\ in\ 2\ minutes]$$

the minimum required resolution is 3.66 Wh. Therefore, a meter resolution of 1 Wh would meet the eligibility requirements.

Worked Example 3: A split-system air-source heat pump with back-up fossil fuel boiler and immersion heating

The following works through an example of the Metering and Monitoring Service Package specification for a (fixed-speed) 4kW split-system air-source heat pump with a design SPF of 2.7. It has a 3kW auxiliary electric heater with its own separate electricity supply. In addition, the system has a 24 kW back-up gas boiler (that is capable of modulating down to 8 kW) and a 2 kW immersion heater for the domestic hot water.

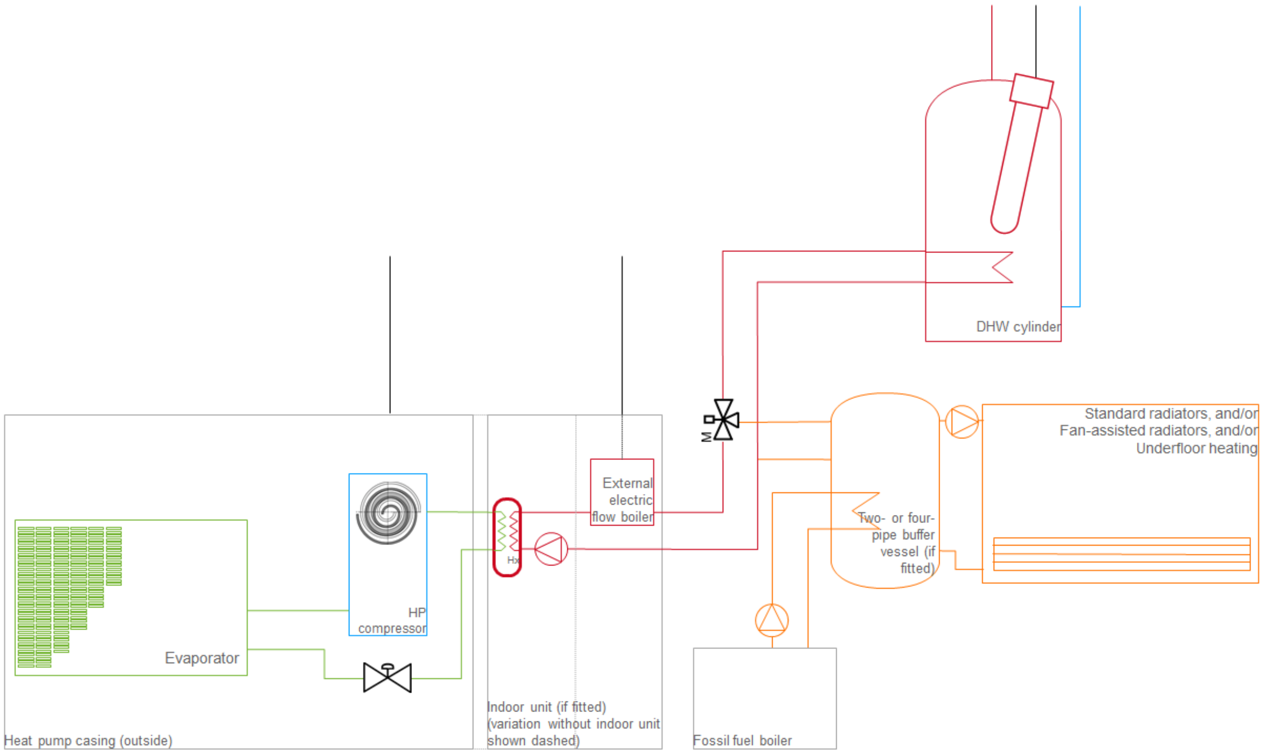


Figure 24: Worked Example 3 – Split-system ASHP with back-up fossil fuel boiler and an immersion element in the domestic hot water cylinder

The minimum intended criteria for this package includes the metering shown in Figure 25.

<u>All data needs to be logged on a 2-minute time period.</u>

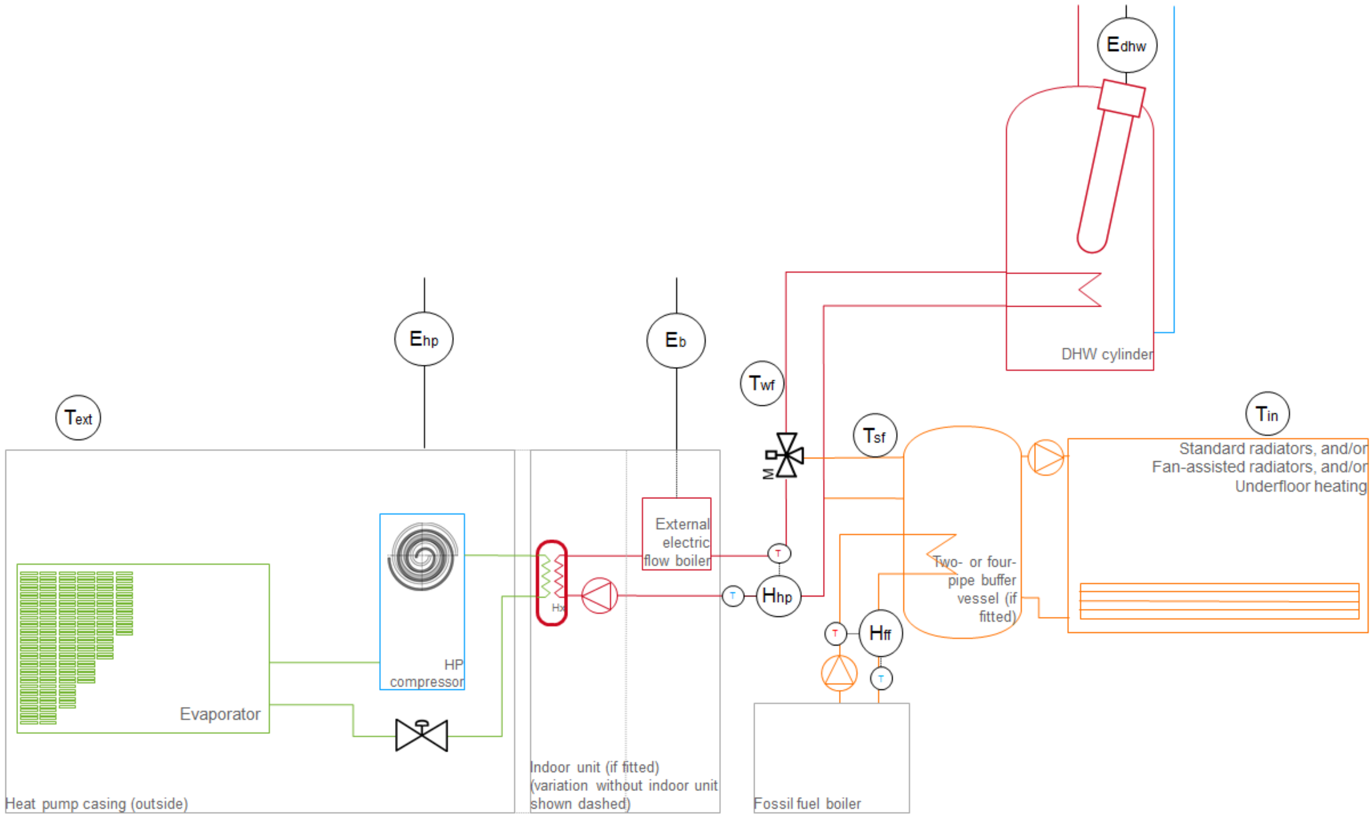


Figure 25: Worked Example 3 – Split-system ASHP with back-up fossil fuel boiler and possible metering

Where

E_{hp} = electrical supply to heat pump;

E_{b} = electrical supply to auxiliary electric boiler;

E_{dhw} = electrical supply to immersion heating of domestic hot water cylinder;

H_{hp} = heat output from heat pump;

H_{ff} = heat output from fossil fuel system;

T_{sf} = space heating flow temperature;

T_{wf} = domestic hot water flow temperature;

T_{in} = internal temperature at at least one location in the dwelling;

T_{ext} = external temperature.

It would also be possible to combine the electricity measurements in this example so that they are recorded by a single electricity meter. This simplifies the metering arrangements. If the electricity meters are combined, the meter resolution would need to be the better of the two calculations shown below.

Meter resolution

It is intended that the minimum resolution of heat meter required for space heating (H_{hp} in Figure 25) would be (using the requirement as defined in Wh):

$$[Resolution\ of\ heat\ meter] \leq 3\ \% * [\min non - zero\ heat\ output\ in\ 2\ minutes]$$

Here, the air-source heat pump has a (non-modulating) 4 kW capacity. This means that in 2 minutes the heat pump can output approximately 133 Wh of heat:

$$[Resolution\ of\ heat\ meter] \leq 3\ \% * [133\ Wh]$$

$$[Resolution\ of\ heat\ meter] \leq 4\ Wh$$

This means that the required resolution of the heat meter is at least 4 Wh. A meter resolution of 1 Wh would also fit this specification.

Using the table shown in Section 7, we could alternatively have noted that the minimum capacity of the heat pump is 4 kW and then used the table below to pick out that the meter resolution could be 1 Wh.

Min non-zero heat output (Min. H) (kW)	Smallest change that must be measurable	Example heat meter display
Min. H < 10 kW	1 Wh	00000**.000** kWh
10kW ≤ Min. H < 100 kW	10 Wh	000000**.00** kWh
100 kW ≤ Min H.	100 Wh	0000000**.0** kWh
[All meters measuring draw-off from a DHW cylinder]	10 Wh	000000**.00** kWh

The lowest heat power output of the fossil fuel boiler is 8 kW. Therefore, using the table above, this comes to a resolution of 1 Wh.

The minimum resolution of the E_{hp} electricity meter is calculated in a similar manner as in the previous example. Taking the design SPF of 2.7 and a heat output of 133 Wh in 2 minutes, the electrical supply over 2 minutes can be estimated as 49 Wh. Putting this into the equation:

$$[Resolution\ of\ electricity\ meter] \leq 3\ \% * [\min non - zero\ electrical\ input\ in\ 2\ minutes]$$

the minimum required resolution is 1.47 Wh. Therefore, it is anticipated that a meter resolution of 1 Wh would meet the eligibility requirements.

The auxiliary electric heater has a capacity of 3 kW and therefore, when operating, uses 100 Wh in 2 minutes. Therefore, using the same equation, the required resolution of electricity meter is 3 Wh (a 1 Wh electricity meter would also deliver the right resolution).

Similarly, the electricity meter for the immersion heating would need a meter capable of resolving a smallest change of at least 2 Wh (making a 1 Wh meter resolution also eligible).

Worked Example 4: A pellet biomass boiler providing space heating and domestic hot water

This example comprises a 24 kW pellet biomass boiler (electrical ignition) providing both space heating and domestic hot water. The system's minimum heat output is 8 kW.

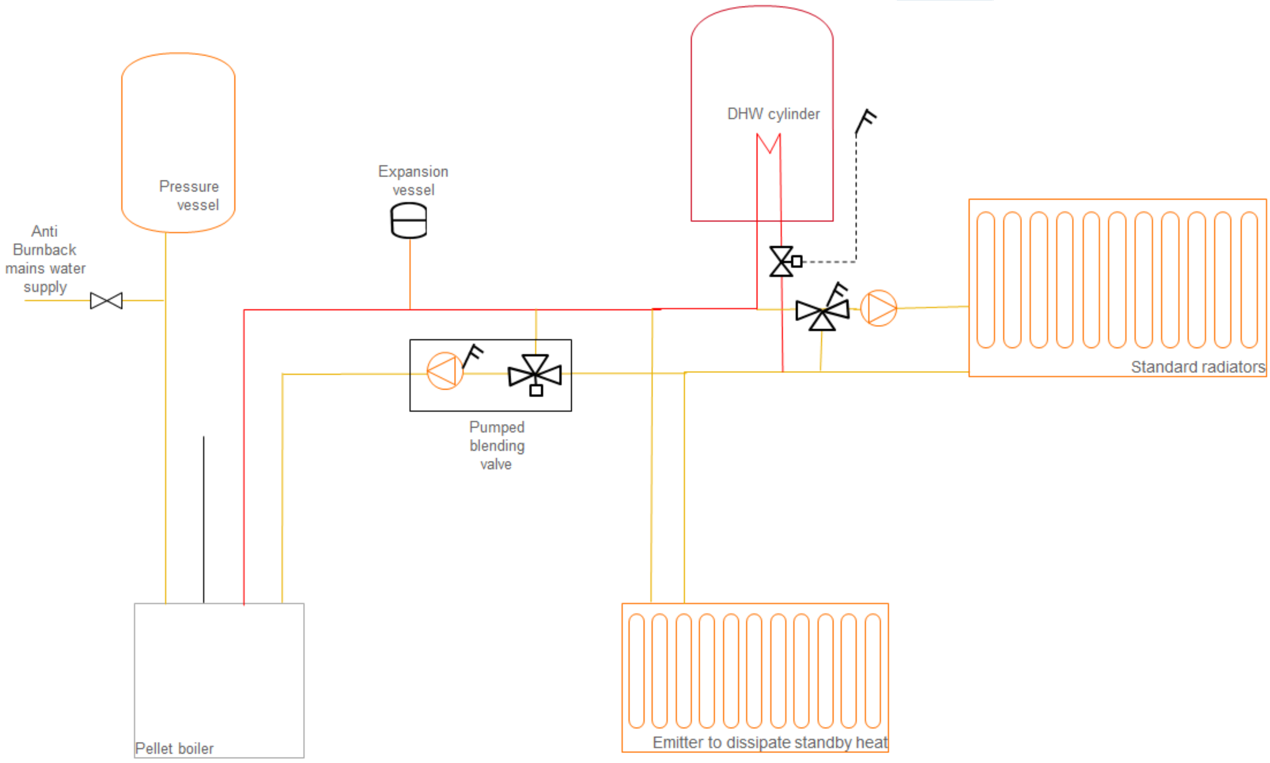


Figure 26: Worked Example 4 - Pellet biomass boiler providing space heating and domestic hot water

Based on the eligibility requirements, Figure 27 shows a possible metering arrangement for this system:

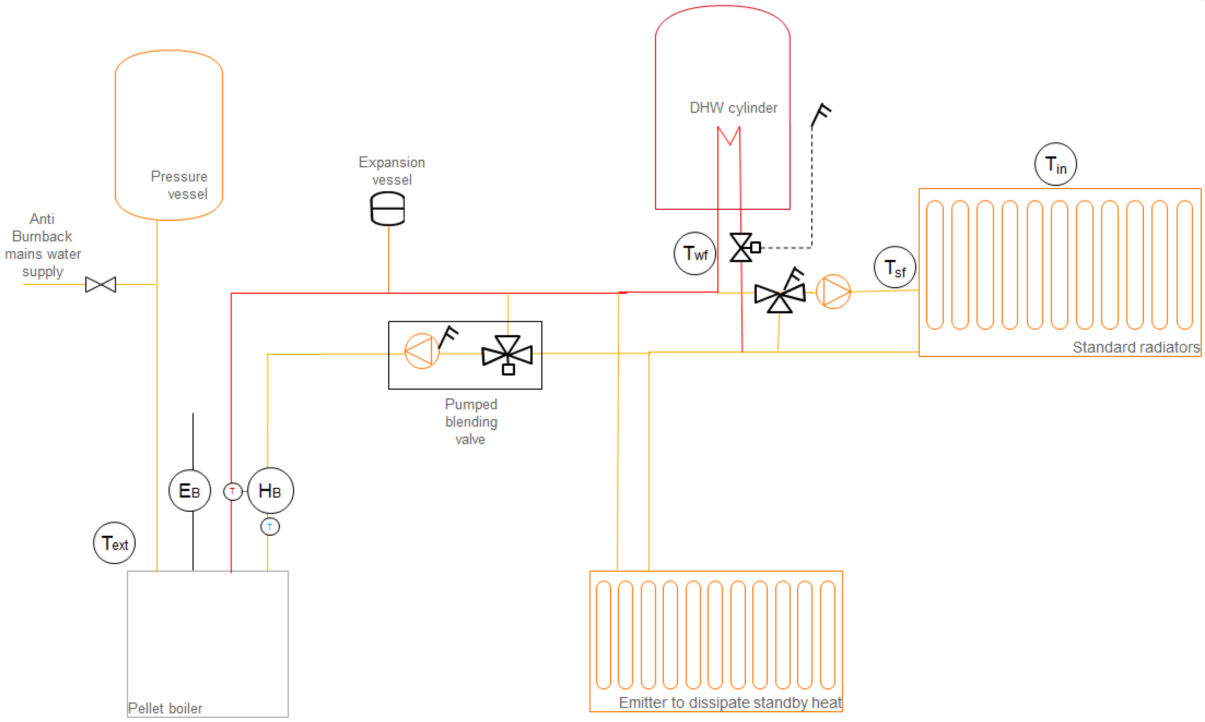


Figure 27: Worked Example 4 - Pellet biomass boilers providing space heating and domestic hot water with possible metering

Where

E_B = electrical supply to boiler;

H_B = heat output from boiler;

T_{sf} = flow temperature of space heating;

T_{wf} = flow temperature of domestic hot water;

T_{in} = internal temperature;

T_{ext} = external temperature.

<u>All data must be logged on at least a 2-minute time period.</u>

There is no gas or oil input to this system so no gas or oil metering is required.

Meter resolution

The minimum resolution of heat meter required for space heating (H_B in figure 27) would be (using the resolution requirement expressed in Wh):

$$[Resolution\ of\ heat\ meter] \leq 3\ \% * [\min non - zero\ heat\ output\ in\ 2\ minutes]$$

Here, the biomass boiler has a capacity of 24 kW and the lowest rate of heat output is 8 kW. This means that in 2 minutes, the minimum amount of heat that the boiler can output is approximately 267 Wh:

$$[Resolution\ of\ heat\ meter] \leq 3\ \% * [267\ Wh]$$

$$[Resolution\ of\ heat\ meter] \leq 8\ Wh$$

This means that the required resolution of the heat meter is at least 8 Wh. A meter resolution of 1 Wh will also fit this criterion.

Using the table shown in Section 7, we could alternatively have noted that the minimum capacity of the biomass boiler is 8 kW and then used the table below to pick out that the meter resolution could be 1 Wh.

Min non-zero heat output (Min. H) (kW)	Smallest change that must be measurable	Example heat meter display
Min. H < 10 kW	1 Wh	00000.**000** kWh
10kW ≤ Min. H < 100 kW	10 Wh	000000.**00** kWh
100 kW ≤ Min H.	100 Wh	0000000.**0** kWh
[All meters measuring draw-off from a DHW cylinder]	10 Wh	000000.**00** kWh

The minimum electrical load of this particular biomass boiler at any one time is that required to operate the circulation pumps that are integrated into the body of the boiler. If the system in Figure 27 has 2 high efficiency circulation pumps, this comes to approximately 80 W power consumption so the energy input to the system in 2 minutes is 2.7 Wh.

$$[Resolution\ of\ electricity\ meter] \leq 7.5\ \% * [\min non - zero\ electrical\ input\ in\ 2\ minutes]$$

Using the formula, the minimum required resolution is 0.2 Wh. It may not be practical to require metering at a resolution that is finer than 1 Wh and the most significant electrical energy consumption of the boiler will be when it is operating at substantially higher than this rate. Therefore, a meter resolution of 1 Wh is be the highest resolution required for such systems. It is expected that electricity meters with a resolution of 1 Wh will usually be required for biomass boilers.

AMENDMENTS ISSUED SINCE PUBLICATION

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1.0	First Issue	16/12/2013