Assessing a single building's potential for a biomass heating system

This exercise aims to assess the feasibility of a biomass heating system in terms of space and fuel requirements for a selected building and the likely costs and emissions of such a system.

Before doing this exercise, your group should have done the PlanLoCaL exercise 'Estimating heat demand of a community building'.

Allow **60 to 75 minutes** to complete this exercise

Films that accompany this exercise

- 'Biomass – an introduction'
- 'Starting an individual biomass boiler project'

Number of people or groups

If numbers allow, work in groups of between two and six.

Materials needed

- Plan of selected building showing rooms, floor areas and grounds
- Approximate peak heating demand (kW) and annual energy demand (kWh) of a selected building based on the 'Estimating heat demand of a community building' exercise (Handout 1 from this previous exercise will also be useful)
- Photos of building from various angles
- Print-outs of the tables/tasks for each group
- A calculator for each group
- Flip chart copy of final results table
- Copies of handouts 1 and 2

Arranging the room

Stick one set of building plans/photos up on the wall before the event starts. Arrange tables to suit the number of groups. A flipchart or white board is needed to present results.

Running the exercise

Stage 1: Grouping and explaining (5 minutes)

Begin by explaining to the group that you are going to look at the feasibility of a biomass heating system for the selected building in terms of space requirements, fuel requirements and the likely costs and emissions of such a system. There will be group work, with different groups looking at two different fuel types and time for a general discussion at the end.

Stage 2a) Identifing a potential location for a biomass boiler (10 minutes)

Ask the group to gather around the plans/photos (stuck on a flip chart or wall) and to initially consider where a biomass boiler and fuel store could be located and to **briefly** identify the key issues (which should then be listed on a flip chart).

The facilitator may need some prompts at this stage; they should make sure the following issues are highlighted as a minimum – space for boiler plant and fuel store, access for fuel delivery vehicles and location of flue.

Stage 2b) Group work: estimating the space requirements, fuel requirements, costs and emissions of a biomass boiler (30 minutes)

Depending on numbers, split the group into two or four sub-groups. One (or two) groups will be looking at options for woodchip and the other group(s) at pellets.

(NB you should probably acknowledge that other forms of biomass exist, but that these two are the most common types for modern wood boiler systems). Also point out that all results will be **approximate** based on **rule of thumb** and that equipment suppliers should be consulted to obtain more accurate figures.

Give print-outs of **tasks 1, 2, 3 and 4** (below) to each group and ask them to work through each of them. Explain that the shaded cells will contain the key figures that will be used in the final **results table** (overleaf). 20 minutes should be adequate for this.

Appoint someone to collate the key results from each group (either pellets or woodchip) on to the **results table** (below) and stick on a wall/flip chart:

Stage 3: Comparing results (15 minutes)

As a group, revisit the flip chart list and the initial discussion held in Part A. See if the results of the exercise have changed the thinking on boiler location and overall feasibility:

- Is there room for a biomass system?
- What are the pros and cons of woodchip vs pellets?
- Is there suitable access and manoeuvring space for delivery vehicles?
- Which fuel store design has been chosen and why?
- Where could the flue go?
- What are the pros and cons of a back-up heating system?

Stage 4) Optional discussion period (15 minutes)

Use this period to discuss further any of the issues that arose from the exercise or to flag areas for further investigation. Suggestions could be:

- Impact of the Renewable Heat Incentive scheme. Payments up to 9p/kWh (depending on scale) were proposed in DECC's consultation (see **www.decc.gov.uk**)
- Local sources of woodfuel and delivery methods available.
- Operation and maintenance issues including insurance
- Planning issues – is the location a Smoke Control Area? Is the building listed?
- On a practical level, how easy is it to integrate a new biomass system with an existing heating system?

Results		
	Woodchip	Pellets
Boiler plant room space requirement	_ _ _ _ _ _ m^2	
Annual quantity of woodfuel	_ _ _ _ _ _ tonnes	_ _ _ _ _ _ tonnes
Annual volume of woodfuel	_ _ _ _ _ _ m^3	_ _ _ _ _ _ m^3
Volume of fuel store	_ _ _ _ _ _ m^3	_ _ _ _ _ _ m^3
Suggested dimensions of fuel store (length x width x height)	_ _ _ _ x _ _ _ _ x _ _ _m	_ _ _ _ x _ _ _ _ x _ _ _ _m
Preferred design for fuel store		
Approx capital cost of biomass heating system	£ _ _ _ _ _ _ _	
Approx annual fuel cost	£ _ _ _ _ _ _ _	£ _ _ _ _ _ _ _
Annual CO_2 emissions	_ _ _ _ _ _ tonnes	

Reference table		
Woodfuel type	Energy content per tonne	Volume per tonne
Woodchip (35% moisture content)	3,000 kWh	4.0m^3
Pellets (10% moisture content)	4,700 kWh	1.5m^3

Task 1 Boiler and plant room sizing

To see how large a space is needed to accommodate the boiler, you must first estimate the capacity rating of the boiler in kW. You will need the estimated 'peak heating demand' kW figure for the building (as estimated in the exercise: 'Estimating heat demand of a community building').

Biomass boilers are rarely sized to supply the peak demand as in most cases they will have some form of heating back up e.g. small gas/oil boiler or electricity. So it is usual to size the boiler at somewhere between 50-90% of peak demand. This is done mainly to save on the increased capital costs of an overly large boiler to promote cost-effective carbon savings. (If a boiler is sized at say 50% of peak demand, it will still typically provide around 90-95% of the annual heat demand as there will only be a very short period during the coldest spells when it will be unable to meet the peak demand).

The size of the plant room will partly depend on whether a thermal store (also known as an accumulator tank or buffer tank) will be used alongside the boiler. This can allow the boiler to run for longer periods (and therefore more efficiently) rather than constantly cycling on and off, and also provides the flexibility to take the boiler off line for maintenance without interrupting the supply of heat.

Peak heating demand of building	_ _ _ _ _ _ kW	As estimated in the PlanLoCaL exercise 'Estimating heat demand of a community building'.
Size of biomass boiler (Peak heating demand x 0.5)	_ _ _ _ _ _ kW	Decide on the proportion of peak demand that the biomass boiler should supply. Generally, if a back-up heating system is likely to be available then use 50% of peak demand. If not use the actual peak demand.
Boiler plant room space requirement (Size of boiler, in kW x 0.192)	_ _ _ _ _ _ m^2	A rule of thumb for small to medium-scale installations is that $0.192m^2$ will be required for each kW of boiler capacity. The resulting area should be sufficient to accommodate the boiler, accumulator tank (if needed) and fuel transfer equipment, but this does not include the fuel store.

Task 2 How many tonnes per year of woodfuel will be needed?

Fuel type (chip or pellets) _ _ _ _ _ _ _ _ _ _		**Notes**
Annual space heating demand	_ _ _ _ _ _ kWh	This is the annual space heating demand for the building (as estimated in the separate exercise: 'Estimating heat demand of a community building')
Annual space heating demand to be met from biomass boiler (e.g. Annual space heating demand x 0.9)	_ _ _ _ _ _ kWh	If in Task 1 you sized the boiler at 50% of peak demand, then assume a figure here which is 90% of the annual space heating demand. Otherwise use the full annual space heating demand.
Annual water heating demand to be met from biomass boiler	_ _ _ _ _ _ kWh	Assuming the biomass boiler will also be used to supply domestic hot water (via a separate hot water tank), this is the annual water heating demand for the building, as estimated in the separate exercise: 'Estimating heat demand of a community building'.
Total annual heating demand to be met from biomass boiler (space + water heating demand)	_ _ _ _ _ _ kWh	Add together the space and water heating demand.
Annual input energy required (total annual heating demand to be met from biomass boiler x 1.143)	_ _ _ _ _ _ kWh	Assume a boiler efficiency of 87.5% i.e. multiply the combined annual space and water heating demand above by 1.143. This allows for energy (heat) loss through the boiler.
Annual quantity of woodfuel (= annual input energy required ÷ energy content per tonne)	_ _ _ _ _ _ tonnes	Calculate using the reference table energy content data for the woodfuel type being considered.
Annual volume of woodfuel (= Annual quantity of woodfuel x volume per tonne)	_ _ _ _ _ _ m^3	Calculate using the reference table volume data for the woodfuel type being considered.

Task 3 How big does the fuel store need to be?

Fuel type (chip or pellets) _ _ _ _ _ _ _ _ _ _		**Notes**
How long do you think a full fuel store should last during mid-winter before requiring a top-up?	_ _ _ _ _ _ days	Longer periods can mean larger (and higher cost) fuel stores. Shorter periods can mean more frequent (and higher cost) deliveries.
Amount of woodfuel required for this period (= Annual quantity of woodfuel x 0.005 x no. of days)	_ _ _ _ _ _ tonnes	Estimate the proportion from the total annual tonnage needed. Hint: you'd be likely to use around 0.5% of your annual total fuel requirement per day during cold spells.
Equivalent volume of woodfuel	_ _ _ _ _ _ m^3	Calculate using the reference table volume data.
Volume of fuel store (Add 20% to volume of woodfuel)	_ _ _ _ _ _ m^3	Rather than waiting until the fuel store is exhausted before the next scheduled delivery, this ensures there is some 'reserve' supply left in the event the delivery is delayed or the fuel is used unexpectedly quickly. It also allows for 'dead' space within the store (stagnant woodfuel that is out of reach of the automatic fuel feed mechanism).
Suggested dimensions of fuel store	width _ _ _ _ _ _ m length _ _ _ _ _ _ m height _ _ _ _ _ _ m	You may need to re-do the exercise in this table if you end up with an excessively large or small fuel store for the building being considered!

Now look at the main types of fuel delivery methods and fuel store design (**Handout 1**) and decide which may be the most appropriate for the building. (Note: you will also need to check later with local woodfuel suppliers that they have the right type of delivery vehicle to suit your preferred design).

Preferred design of fuel store _

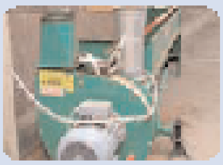
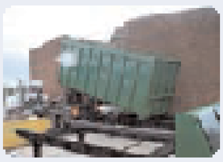
Task 4 What are the costs and CO_2 emissions?

Fuel type (chip or pellets) ___________			**Notes**
Approx capital cost of biomass heating system		£ __________	Take the kW boiler rating estimated in Task 1 and use the following guideline installed costs* (these are whole system costs including fuel store) <100kW: £500-£950/kW 200kW: £400-£800/kW 500kW: £330-£620/kW 1MW: £280-£520/kW
Annual input energy required		______ kWh	Previously calculated in Task 2 above.
Annual costs and comparison with other fuels (using annual input energy required)	Woodfuel	£ _______	Indicative costs: Woodchip 2.3 - 3p/kWh Pellets (loose) 3.9 - 4.7p/kWh Pellets (bagged) around 5.5p/kWh **NB** The cost of woodfuel is highly dependent on quantity used and method of delivery. Revenue from the Renewable Heat Incentive (once finalised) will also need to be considered.
	Gas	£ _______	Indicative cost: 3.5p/kWh
	Oil	£ _______	Indicative cost: 4.5p/kWh
	LPG	£ _______	Indicative cost: 6.9p/kWh
	Electricity	£ _______	Indicative cost: 14.0p/kWh (but first multiply kWh by 0.875 as the assumption is that electricity is 100% efficient i.e. no boiler losses)
Annual CO_2 emissions and comparison with other fuels (using annual input energy required)	Woodfuel	____ tonnes	Conversion factor: 0.025 $kgCO_2$ / kWh
	Gas	____ tonnes	Conversion factor: 0.185 $kgCO_2$ / kWh
	Oil	____ tonnes	Conversion factor: 0.246 $kgCO_2$ / kWh
	LPG	____ tonnes	Conversion factor: 0.214 $kgCO_2$ / kWh
	Electricity	____ tonnes	Conversion factor: 0.542 $kgCO_2$ / kWh (but first multiply kWh by 0.875 as the assumption is that electricity is 100% efficient i.e. no boiler losses)

* Costs taken from ‘Biomass heating – A practical guide for potential users’ Carbon Trust CTG012 (2008)

Handout 1 Types of fuel delivery method and/or vehicle, and typical payloads

Reproduced from 'Biomass Heating – A practical guide for potential users' (ref CTG012) with kind permission from the Carbon Trust

Delivery method	Example	Typical fuel type	Typical payload	Availability
Flexible hose from a blower tanker		Most commonly pellet but also chip	Pellet: c.15-20m³ (10-14 tonnes) Chip: c.10-20m³ (4.5-6 tonnes)	Pellet – common delivery vehicle. Chip – specialist delivery vehicle, not common.
Bulk bag deliveries		Pellet or chip	1-2m³/bag	Common in some areas (e.g. Scotland).
Tipper trailer		Pellet or chip	Chip: c.20-30m³ (6-9 tonnes) Pellet: c.20-30m³ (14-21 tonnes)	Tipper trucks widely available and common delivery method, particularly for chip.
Scissor lift tipping trailer		Pellet or chip	Chip: 20m³-30m³ (6-9 tonnes)	Specialist delivery vehicle required.
Blower trough and tipper truck		Chip	c.20m³ (6 tonnes)	Tipper trucks widely available but blower troughs are specifically purchased for site fuelling.
Hook lift bin/Ro-Ro bins		Chip	30m³-35m³ (9-12 tonnes)	Specialist delivery vehicle required.
Front loader		Chip and bales	c.1m³ (0.3 tonnes)	Common machinery for farm/estate application.
Walking floor trailer		Chip	60m³ (18 tonnes)	Specialist delivery vehicle required – suited to large scale deliveries.

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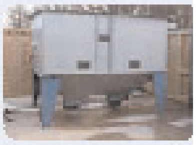
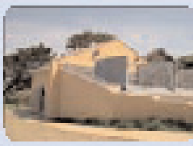
Handout 2 Types of fuel store

Reproduced from 'Biomass Heating – A practical guide for potential users' (ref CTG012) with kind permission from the Carbon Trust

Type of fuel store	
Purpose-built pre-fabricated bunker Typically filled pneumatically from blower tanker. Fuel extraction via straight auger or vacuum tube.	
Constructed bunker Possible forms are adapted grain silos, modified storage bunkers, existing cellars with wood panelling and basic concrete/brick covered spaces. Fuel extraction requires tapered floor to funnel pellets to a central auger. Typical fuel extraction via straight auger.	
Bag silo Flexible bag which sits in a support frame. Simple and cost-effective, avoiding need for civil/ construction works. But needs to be positioned in sheltered area or building, not exposed to rain. Typically filled pneumatically from blower tanker. Fuel extraction by straight auger or vacuum tube.	
Integrated storage hopper Most suitable for small systems where hopper is attached directly to plant. Usually filled manually using pellet bags. Fuel extraction by auger direct to plant.	
Purpose-built pre-fabricated or bespoke storage hopper Prefabricated steel structure or re-enforced plastic hopper. Usually available from plant manufacturer/supplier. Typically filled pneumatically from blower tanker. Fuel extraction via gravity: tapered floor to central auger.	
Storage container A shipping container, for example. Filled via blower unit or bagged or removable system to allow off-site refilling. Depending on the route from fuel store to plant unit, extraction can be via straight auger, vacuum tube or gravity fed (inclined floor with auger running along base).	
Bespoke internal structure Can be constructed from wide variety of materials, e.g. brickwork for main structure with wood panelled interior, or concrete. Filled by tipper trailer, pneumatically from blower tanker or front loader. Fuel extraction typically via straight auger.	
Purpose built external structure 'Shed-type' or 'lean-to' external constructions can be built from wide variety of materials; highly flexible.	
Constructed bunker Can be constructed from wide variety of materials, e.g. blockwork for main structure with wood panelled interior, or concrete. Typically filled by tipper trailer. Fuel extraction typically via walking floor or circular 'sweep-arm' agitator.	
Bespoke construction Can be constructed from wide variety of materials: blockwork with cladding, brickwork with cladding or steel structures (either purpose built or 'off-the-shelf' designs such as ISO container above). Highly flexible options available.	
Bespoke internal structure Typically suitable for retrofit site, with installation within existing building. Can be constructed from wide variety of materials, e.g. brickwork for main structure with wood panelled interior, or concrete. Filled by tipper trailer, pneumatically from blower tanker or from bags (automatically or manually lifted). Fuel extraction typically via straight auger.	

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