Estimating the heat demand of a hypothetical community building

This quite technical exercise shows how to estimate the heat demand of a hypothetical community building and the typical carbon emissions and costs associated with meeting this demand.

Allow **70 minutes** to complete this exercise

Films that accompany this exercise
The facilitator should be familiar with the various films in this resource relevant to the heat technologies, all (disc 1).

Number of people or groups
In groups small enough so that they can share handouts and calculators – probably six people per group.

Materials needed
- Calculator for each group
- Copies of handouts 1 and 2

Running the exercise

Stage 1) Grouping and explaining (10 minutes)

Split the audience into groups with a maximum of 6 in each group. Hand each table a calculator, Handout 1, and some blank paper for calculations

Begin by explaining to everyone that you are going to look at simple ways to estimate the heat demand of a building. You should be clear from the start that the methods are **approximate** only based on **rules of thumb** and that even though you hope to carry this out for your own buildings, they will still be surveyed by specialists before specifying any equipment.

Explain that the first aim of the exercise is for the audience as a whole to understand how the Peak Heating Demand and the Annual Heating Demand for a building is worked out, and how the costs and CO_2 emissions vary over the range of fuel options available.

The second aim of the exercise is to recruit a small group of people who would be willing to help collate the data and do the calculations on one or more of your real community buildings, to report back at a later date. If you are going to investigate solar water heating, biomass heating or a heat pump (or any combination of those three), you will need this data for your own buildings.

Explain that the first bit of calculating they will be doing is to estimate the Peak Heating Demand and the Annual Heating Demand. Definitions of these terms are given on Handout 1 – give them 5 minutes to familiarise themselves with the contents of Handout 1.

Stage 2) Estimating Peak Heating Demand (20 minutes)

Explain to the groups that the Peak Heating Demand of a building, in kW, can be estimated by multiplying the volume of heated space in the building (in m3) by a given factor, which differs depending on how well insulated the building is. Peak Heating Demand is a sort of instantaneous figure – the maximum demand for kW of heat at any given moment.

Then write up onto a flipchart sheet:

Poorly insulated building – 0.033
Good level of insulation in building – 0.022
Building constructed to 2010 Building Regs – 0.013

Then write this worked example onto your flipchart:

Decent building constructed in 1995, having 5,000m³ of heated space

5,000 x 0.022 = 100kW

Then explain that, if the boiler was installed by someone who knew what they were doing, the capacity of the boiler (shown on the nameplate) will probably be close to that figure. But if the building has been extended since then, the boiler might now be undersized. Alternatively, if the building has had extra insulation put in, then the boiler might now be oversized.

Now hand each table a copy of **Handout 1** – the details of the hypothetical 'Symes Village Hall'. Give them 10 minutes to read it, and to work out in their groups:
1) The Peak Heating Demand of the building
2) Whether the current boiler is about the right size,

oversized or undersized
3) What boiler size they would recommend

You will need to circulate, preferably with helpers, to make sure that the groups do the initial calculations that work out the cubic volume of heated space (see box).

Stage 3) Estimating Annual Space Heating Demand (15 minutes)

Explain that the Annual Heating Demand is made up of space heating and water heating. Whereas Peak Heating Demand is the highest instantaneous demand, Annual Heating Demand is a quantity over time (one year), so the units are kWh, not just kW.

The first task is to work out the space heating demand over a year – water-heating comes later. They will do this by looking at the Symes Village Hall graph, which shows kWh of energy delivered to the building every month for the whole two years of 2010 and 2011. In June, July and August of each year the heating is obviously switched off. But April 2011 has no entry as someone forgot to read the meter. An educated guess has been put in, based on the same pattern of use in 2010.

Ask the groups to work out the total annual energy demand for both years, and an average which they should fill in on table 1 of their handout (see table below for facilitators crib sheet).

Now explain to them that the annual energy demand is not the same as annual heat demand – this is because the boiler won't be 100% efficient.
Write up onto your flipchart:

Boiler up to 5 years old = 90% efficient
Boiler more than 5 years old = 60-70% efficient

Our average annual energy demand is 33,169 – but our boiler is more than 20 years old (see Handout 1)

Therefore 33,169 x 60% = 19,901 kWh Annual Heat Demand

Stress that the *heat* demand of the building is actually much lower than the *energy* demand – the difference is the efficiency of the boiler.

Stage 4) Estimating Annual water heating demand (5 minutes)

Write up on your flipchart, explaining as you go:

The standard conversion factor for water heating is 0.0585, which assumes that you need to heat water from 10ºC to 60ºC.

Symes Village Hall uses 500 litres per week
500 x 52 = 26,000 litres per year
26,000 x 0.0585 = 1,521 kWh per year

Stage 5) Comparison of fuel costs and CO_2 emissions (20 minutes)

Onto a flipchart, you first need to collate all the results that have been worked out:

Peak Heating Demand	*25.9 kW*
Annual space heating demand	*19,901 kWh*
Annual water heating demand	*1,521 kWh*
Total annual heating demand	*21,422 kWh*

Then hand each group a copy of **Handout 2** – Costs and CO_2 emissions of various fuels. *(For the sake of simplicity ask the group to assume that the same system provides both the space and water heating for the building.)*

They are to spend a couple of minutes filling in the tables for costs and CO_2 emissions, and then you should spend 15 minutes facilitating a discussion with the whole group on any of the issues that arose from the exercise or to flag areas for further investigation. These could include:

- To what extent could the heat demand be reduced in the building through energy efficiency measures such as insulation? E.g. insulating a roof could save up to 20% of space heating energy
- The likelihood of longer term changes to the building and how this may affect heat demand
- How complete or reliable is the fuel consumption data? What can be done to improve this?
- Are the cost differences for the different fuel types a surprise? How will stakeholders perceive the relative importance of cost vs CO_2 savings?
- How would the RHI affect the likelihood of installing a biomass system?

Finally, you now need to ask for volunteers to help do these calculations for the community building(s) you have in mind. Further, detailed instructions that will help them do this can be found at **planlocal.org.uk/downloads**

Notes on the Peak Heating Demand calculations for Symes Village Hall

The groups will need to do the following:

Work out the cubic metres of heated space –

390 m^2 in total, of which 118m^2 has a 'double height' ceiling

390 – 118 = 272 m^2 with a ceiling height of 2.6m

And 118 m^2 has a ceiling height of 4m

272 x 2.6 = 707.2 m^3
118 x 4 = 472 m^3
Total heated space is therefore 707 + 472 = 1179 m^3

Although the building is old, it had a good insulation overhaul in 2010, so we'll use the 0.022 factor

1179 x 0.022 = 25.9kW

The current boiler, at 45kW rating, seems to be oversized, probably as a result of the insulation and glazing works carried out. A boiler of 25-30kW would now be adequate.

Month 2009	Delivered energy	Month 2010	Delivered energy
Jan	5213	Jan	4520
Feb	5708	Feb	4047
March	5213	March	4025
April	4740	April	3622
May	3915	May	2012
June	0	June	0
July	0	July	0
August	0	August	0
September	1044	September	1605
October	2650	October	2826
November	2628	November	3761
December	3607	December	5202
Total	**34,718**	**Total**	**31,620**
Average	**33,169**		

They should return an average annual energy demand of 33,169

Symes Village Hall is a highly regarded asset for the local community. Owned by the Village Hall Charity, it is used most weekdays and occasionally at weekends for toddler groups, ballet, sports and drama, parties, meetings, wedding receptions, training events, etc.

The hall was built in 1939 and has a total floor area of 390m^2, all of which is heated. Most is single-storey (ceiling height 2.6m), but the main hall (118 m^2 floor area) has a flat roof and a ceiling height of 4m. New double glazing, cavity-wall insulation and roof insulation were installed during the summer of 2010. The current heating system dates from 1988 and consists of a 45kW gas boiler which supplies space heating only. Water heating is provided by three point-of-use electric heaters – two for the toilets and one for the kitchen. The average weekly consumption of hot water is thought to be around 500 litres.

Gas consumption has been plotted from regular monthly meter readings over a recent two-year period (apart from April 2011, when a reading wasn't taken). The plot and a table of values are shown below.

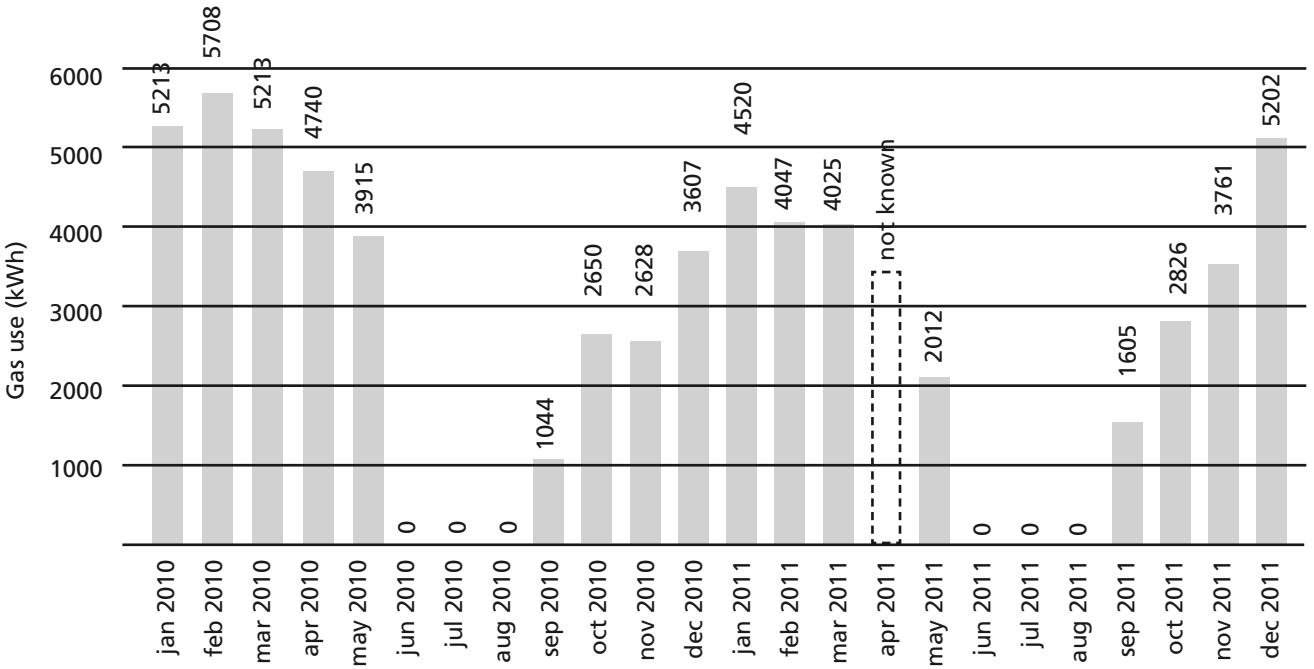

Table 1: Energy consumption over 2 years

Month 2010	Delivered energy	Month 2011	Delivered energy
January		January	
February		February	
March		March	
April		April	
May		May	
June		June	
July		July	
August		August	
September		September	
October		October	
November		November	
December		December	
Total		**Total**	

Average of 2010 and 2011:

Handout 2 costs and CO_2 emissions of various fuels

Approximate costs of various fuels							
Building name			Assumed efficiency factor for heating system		Fuel cost £/kWh*		
Gas	Total annual space and water heat demand of building _____ kWh	x	1.143	x	0.035	=	£ _ _ _ _ _ _ _
Oil		x	1.143	x	0.045	=	£ _ _ _ _ _ _ _
LPG		x	1.143	x	0.069	=	£ _ _ _ _ _ _ _
Electricity		x	1.0	x	0.14	=	£ _ _ _ _ _ _ _
Woodfuel**		x	1.143	x	0.03	=	£ _ _ _ _ _ _ _

* Fuel costs will need to be periodically updated – information on domestic fuel costs can be found at www.sutherlandtables.co.uk

** The cost of a biomass installation is likely to be partly offset through the government's Renewable Heat Incentive scheme due to be introduced in summer 2011.

CO_2 Emissions							
Building name			Assumed efficiency factor for heating system		Carbon emission factor tCO2/kWh		
Gas	Total annual space and water heat demand of building _____ kWh	x	1.143	x	0.000185	=	_ _ _ _ _ _tonnes CO_2/yr
Oil		x	1.143	x	0.000246	=	_ _ _ _ _ _tonnes CO_2/yr
LPG		x	1.143	x	0.000214	=	_ _ _ _ _ _tonnes CO_2/yr
Electricity		x	1.0	x	0.000542	=	_ _ _ _ _ _tonnes CO_2/yr
Woodfuel		x	1.143	x	0.000025	=	_ _ _ _ _ _tonnes CO_2/yr

Useful definitions

Peak heating demand (kW)
This is a way of describing the rate of heat input that a building needs in order to maintain a comfortable internal temperature on a cold winter day. In most cases a heating system will be sized to meet the peak heating demand, regardless of whether or not it also provides water heating. The water heating requirement will not necessarily require a bigger boiler, it just means that it will be on for longer periods and will use more energy in total.

Annual energy demand (kWh)
This is the quantity of fuel energy required by building in the course of a year, i.e. the energy contained within fuels such as gas and oil as delivered to the building. As with heat demand, it can either refer to the space heating demand or water heating demand, or the summation of both. Whereas the annual heat demand is dependent on the fabric and construction type of the building, the annual energy demand needed to supply the heat demand will depend on the efficiency of the heating system.

Annual heat demand (kWh)
This is the quantity of heat required by a building during the course of a year. Can refer either to space heating demand or water heating demand, or both.

Heat demand profile
This describes the way in which a building uses heat over the course of a year, month, week or day. It illustrates how the heat demand changes over time.