Appendix 1

Benchmark Methodology

Energy benchmarks provide a reference for comparing the energy characteristics of different building types. The benchmarks allow the energy consumption for different building types to be predicted at the outline stages of building design. This allows building designers to use the benchmarks as targets for achieving or exceeding existing energy efficiency standards. Benchmarks can also be applied retrospectively to investigate if the actual energy performance compares with the predicted energy performance.

In the context of this feasibility study the benchmarks used have allowed identification of the energy consumption levels of heating and power for proposed developments. They provide general guidance for expressing the demands associated with the individual uses of space heating, hot water requirements, lighting and appliance needs and so on, but are not a specification of a detailed condition.

The benchmarks used are based on the Simplified Building Energy Model (SBEM) developed by the BRE. It involves the analysis of the energy and carbon performance based on specified standard building fabric, glazing type, air tightness, and HVAC and lighting plant.

A more detailed explanation of the calculation methodology can be found below which explains how the benchmarks have been calculated in relation to the notional building standards.

Non-domestic (excluding car parks)

The baseline energy and carbon performance of the non-domestic buildings are based on the Simplified Building Energy Model (SBEM) developed by the BRE. This calculation module follows the Department for Communities and Local Government's (DCLG) National Calculation Methodology (NCM) and compares buildings on a standardised basis. The approach undertaken involves:

Generating the model of a notional building (roughly equivalent to 2002 standards) using the Integrated Environmental Solutions (IES) software.

The Integrated Environmental Solutions (IES) software uses the derived geometry, orientation and usage from architectural drawings to perform an SBEM analysis. This analysis involves the calculation of the energy and consequent carbon performance based on specified standard building fabric, glazing type, air tightness, and HVAC and lighting plant. These specifications generally comply with the 2002 building standard. However, this methodology as fully defined by the DCLG excludes services such as lifts, emergency escape lighting or specialist process lighting.

Calculating the 2006 baseline from the notional building

The Approved 2006 Part L2A document, Conservation of fuel and energy[1] defines the baseline using the Target Emissions Rate (TER). This definition is given below:

$$TER = (C_{notional} * (1 – Improvement\ factor) * (1 – LZC\ benchmark)$$

SBEM requires the definition of actual building strategy in order to calculate the 2006 baseline. For the purpose of this work, the baseline energy and carbon performance assumes that the actual building will employ an air conditioned or heated and mechanically ventilated strategy. The improvement factor and low and zero carbon (LZC) benchmark used are defined in the Approved 2006 Part L document as below:

Strategy for actual building	Improvement factor	LZC benchmarks
Heated and mechanically ventilated	0.20	0.10
Air conditioned	0.20	0.10

This will result in 28% improvement over 2002 standards as below:

$$TER = (C_{notional} * (1 – 0.2) * (1 – 0.1) = 0.72 * C_{notional}$$

However, should the proposed strategy be heated and naturally ventilated, the improvement factor will differ (0.15) and will result to ~ 25% improvement instead.

NB: Car parks
As a result of unavailability of the car park use type in the SBEM database, the CIBSE Guide F 2004 benchmarks have been used for open and closed car parks.

[1] http://www.planningportal.gov.uk/uploads/br/BR_PDF_ADL2A_2006.pdf

Appendix 2

Biomass

The following pages set out important further in depth and details about the supply and installation of biomass, and should be read in combination with individual site data.

Issues

Before installing a biomass energy system there are a number of considerations that should always be made:

- Is a biomass system suitable for this application?
- What are the local regulations surrounding biomass?
- Where will the fuel be supplied from, and what are its characteristics?
- Where can the fuel be stored and how can it be delivered to that store?

Regulations

There are a number of regulations relating to the installation of solid fuel heating systems that apply to biomass systems. Many are derived from those originally drawn up for coal and smokeless fuel systems and may be imperfectly suited for modern biomass systems, which can cause difficulties. These include:

- BS EN 303 Part 5:1999
- Building Regulations
- Clean Air Act 1993

Fuel type and specification

Biomass systems can be designed to make use of a very wide range of feedstock, and the wood fuels vary in size and type from logs to chips and pellets. Each type of fuel has it's own specific calorific value and burning patterns, as well as quality grading and these factors should be carefully planned at the design stage with specialist advice.

Supply of fuel

When a biomass installation is being considered, the intended fuel supply must be planned at the same time with careful consideration of what is available locally (preferably within 20-30 miles) in sufficient quantities

Moisture

Moisture content of wood chips is not easily gauged without using a specialist moisture probe, and the simplest method of ensuring a good quality, consistent supply is to find a reliable local supplier.

Size

The size and shape of chips is also important. Chippers designed for woodfuel use produce even chips of a well defined range of sizes; general purpose chippers can tend to produce long slivers that can cause blockages in fuel feed systems.

Standard

CEN TC 335 is working on the standardisation of solid biofuels derived from pure biomass

UK locally sourced biomass can offer regional business opportunities and support the rural economy.

Delivery of biomass into the storage facility

Modes of delivery.

As part of the design for a biomass store it is vital to consider the various modes of delivery into it. Depending on scale delivery may consist of:

- Manually tipping in a sack of wood pellets or a wheelbarrow of logs
- Tipping a truck
- A walking floor trailer
- Pumping pellets or slurry through a tube
- Dumping from a railway truck.

In many cases it is most appropriate to make use of gravity to assist delivery and design both the store, and access to it, to make best use of this. This might entail:

A ramp

Building the store partially or fully below ground (although this can bring other problems) or ensuring access from an existing structure.

Access to the storage facility

Convenient access for any potential delivery vehicles must be designed in from the outset, and access for any construction and maintenance equipment that might be required for the store or plant room, and other associated equipment or structures must be considered.

Extracting biomass from the storage facility

Ease of extraction

The design and siting of a biomass store must take account of ease of extraction of the content and supply to its next destination, whether this is a boiler, combustion unit, conversion plant or another site altogether. Use may be made of gravity, if this is convenient, thus reducing energy requirements.

The 'take off' point

It is important to design the store such that if the content is in a form that can flow, such as slurry, wood pellets or chips, this naturally brings the fuel to the take off point from the store. This take off point should not leave regions where the biomass can build up or get stuck, forming dead areas where it can stay indefinitely and potentially allow moulds to form.

Transferring biomass from the store

Biomass details adapted from the Biomass Energy Centre

There are many different methods for transferring biomass, and different methods will suit different materials, situations and throughput depending upon its form. Possible methods include:

Simply gravity feed or chute	Pumped flow
Screw type auger feed	Bucket conveyor
Conveyor belt	Front loader
Pneumatic blower	Bucket grab.

Woodfuel Options (3genergie.co.uk)

Correctly managed, biomass is a sustainable fuel that can deliver a significant reduction in net carbon emissions when compared with fossil fuels.

The biomass storage facility

Primary purpose
The primary purpose for the store will be to retain the biomass in good condition in a convenient place for it to be transferred to the next stage of processing, combustion or energy conversion. In many cases one of the primary concerns will be to keep it dry. This means protecting it from direct ingress of rain, but also from groundwater. It should also be protected during delivery of additional fuel, during transfer from the store to the next stage and also during access for maintenance.

Types of store
- A biomass store can be:
- A purpose designed and built structure, either above or below ground
- An adapted unit, such as a feed silo or shipping container
- An off the shelf, prefabricated unit designed for a specific range of fuels, such as pellets.

Fuel storage, delivery and extraction from the store

Good design of the biomass fuel store, considering delivery and extraction of the fuel, as well as access for maintenance, is very important to efficient, smooth operation of a biomass installation.

Storage
Biomass is a low energy density fuel, and consequently a large volume must be stored on site if unacceptable frequency of deliveries is to be avoided, and sufficient reserve safety margin maintained. There must therefore be a suitable area, sufficiently close to the intended site of the combustion equipment to avoid an unacceptably long fuel feed, creating increased risk of blockages or difficulties, and also accessible to the intended delivery vehicles.

Delivery
The intended delivery method should also be considered. If wood chips are to be delivered by tipper truck, the most efficient method is to tip them directly into the fuel store. This may require a ramp to allow the lorry to back up to the lip of the store, or a fully or semi-underground store.

If wood is to be chipped on site, however, it may be possible to chip directly into an above ground store.

Biomass can be sourced locally, from within the UK, on an indefinite basis, contributing to security of supply.

Ventilation

For most dry biomass stores good ventilation will be necessary to prevent the build up of condensation, allow additional drying, and to prevent the formation of moulds, the spores of which can present a serious health hazard if inhaled.
Good airflow can also help to minimise composting of the fuel, leading to loss of energy content, and prevent the build up of excessive temperatures with the risk of fire. Advice from the US and Denmark suggests that heaps of wood chips should not be built over 8 to 10m high for this reason.

Drainage
Some form of drainage should be included, both in case of inadvertent ingress of water, and also if it is necessary to clean out the store, such as in case of fungal contamination.

Below vs. above ground storage
Building the store below ground may have a number of advantages, including ease of delivery from tipper type vehicles, the removal of the necessity for an additional, above ground structure, thereby potentially easing space requirements, and offering aesthetic benefits. It is, however, likely to cost more than many above ground store designs, and it is particularly important to ensure that it does not suffer from damp from the surrounding ground. Ventilation and a drainage facility will be both harder to incorporate, and be more important.

Storing biomass

Factors to consider
- Biomass does not generally flow as freely as oil or natural gas.
- It will usually absorb moisture if exposed to it.
- It may naturally biodegrade in storage through a number of mechanisms, particularly if not absolutely dry. This will lead to loss of energy content and potentially the formation of moulds.

Design of the storage facility
- The storage of biomass must be well designed and constructed for a number of functions.
- It must keep the fuel in good condition, particularly protecting it from moisture.
- It must also be possible to deliver the fuel into an appropriate receptacle for transport, and convey it from there to its next destination conveniently and efficiently and requiring the minimum of additional energy input.

Biomass plant and delivery options (3genergie.co.uk)

Appendix 3

Modelling Assumptions

Combined Heat & Power Assumptions

Heat

- All modelling for CHP has been based on the CHP unit being controlled by heat demand. This way the excess electricity can be exported to the national grid to generate an income.
- The removing of waste heat would require the installation of cooling fans at additional capital cost and would reduce the overall carbon savings of the CHP engine.
- Heat stores could be installed to provide some smoothing of the demand and potentially improve the running of a CHP engine, however, the preliminary modelling is based on the predicted energy demands of the buildings only, with no provision for heat store. This is to give a useful indication of which sites may be viable for the installation of CHP.
- Certain technologies such as solar thermal are not compatible with CHP units as they compete for heat demand.

Cooling

- For the purposes of this preliminary modelling it has been assumed that conventional electrical chillers provide building cooling loads.
- On production of more detailed cooling profiles once the site plans are worked up in detail, absorption cooling can be considered, which may increase the viability of CHP on some sites by increasing the summer heat demand.

CO_2

- The CO_2 savings are calculated based on the outputs of the CHP unit compared to those of conventional methods of heat supply from gas fired boilers and electricity from the national grid.
- The thermal efficiency of CHP is used to provide the CO_2 output from the heat supply and the electricity supplied directly from the CHP is assumed to be zero carbon, since the CO_2 emitted by the CHP unit is already counted in the heat production.
- The CO_2 emissions associated with electricity imported from the grid and those avoided by exporting electricity to the grid are then taken into account to give the overall carbon saving.
- CO_2 savings are highly dependent, not just on the size of the CHP unit, but also on the heat demand provided. Therefore the CO_2 savings with schemes using the same size of CHP will not necessarily be comparable.

Costs

- No costs have been included for heat and electricity distribution networks internal to the buildings.
- Costs for heating and private wire connections to buildings have been estimated based on the layouts of the buildings modelled.
- Costs do not include any amounts for a specific energy centre and assume that the CHP plant is located within the development.
- CHP costs include indicative costs for district heating pipework and private wire networks at a nominal amount for each site based on the information provided.
- All costs are indicative only and will depend on the final configuration of the site and the size of heat and power loads required by each building.
- Heat exchangers and electrical connections to each building are also included as is the provision for back up and top-up boilers in the energy centre to provide heat to the system.

General

- It should be noted that CHP needs to be integrated into a development before the 10% renewable energy target is applied. Therefore, the installation of CHP will reduce the overall renewables target.
- All CHP modelling is based on gas fired CHP.
- Biofuel CHP could potentially be utilised should market conditions allow a supply of fuel at a comparable cost.
- Biomass boilers could be used to provide backup and top-up heat to community energy schemes subject to a secure supply and storage and delivery factors being assessed early.

Appendix 4

General Assumptions for Renewable Energy Sizing

The notes on this page are general considerations, which are often factored into the decision making process for the sizing and selecting of viable renewable technologies. They are in no way exhaustive and users should bear in mind that there may be a multitude of further factors that affect viability, along with the inherent differences of a site-specific nature. To this end it is important to note that these lists should not be used without further specialist guidance at an early stage.

Biomass

- Can be used in community heating systems
- Need to check for local source of supply
- Delivery of biomass requires space for large vehicle
- Storage facilities must be large and secure for excess wood fuel
- Management of boiler as regular checking/emptying/filling etc
- Flue height will not significantly affect visual impact

Photovoltaic

- Panels can be oriented vertically as well as at 30° angle
- Excess electricity can be exported back to the grid
- Good for locations with high daytime electricity as save on peak energy
- PV creates electricity through the conversion of light
- Optimal efficiency requires unshaded roof area
- Favourable orientation is South East to South West
- Most effective in the summer months
- Less efficient at other less favourable orientations e.g. East or West facing but still viable

Ground Source Heat Pump

- Land must be free from rocks, pipes, tree roots etc to allow for pipes to be safely laid
- Will normally need geological survey to check land
- Vertical bore holes possible
- Extensive additional costs for trench digging, surveys, pipe laying etc
- Good for use in flood plains as unaffected by flooding
- Underfloor heating is the most appropriate heating method to optimise heat pump efficiency
- Need commissioning on installation by a qualified agent
- Can get grants to offset capital cost of heat pump
- Part of the 'Enhanced Capital Allowance' scheme
- May need 3 phase electricity
- Can provide cooling as well as heating

Solar Thermal

- Should to be angled at 30° for optimal output
- Mainly useful in locations with high hot water demand
- Optimal efficiency requires unshaded roof area
- Favourable orientation is South East to South West
- Most effective in the summer months
- Less efficient at other less favourable orientations e.g. East or West facing but still viable
- Flat plate and evacuated tube collector varieties available
- Efficiency coefficients alter with type of collector

Appendix 5

Heating	Avoid simultaneous heating and cooling				
Lighting	Reduce incidental gains from lights to minimise cooling loads	Include contribution of lighting towards heating			
Glazing	Minimise solar gains to reduce cooling loads	Minimise heat loss and maximise useful heat gain through glazing	Use suitable switching and daylight thinking controls to minimise use of electric lighting		
Ventilation	Consider mixed –mode to use natural ventilation and avoid mechanical cooling where possible	Account for effect of open windows		Balance solar gains from glazing with increased natural ventilation. Avoid conflicts between window opening and blinds	
MVAC	Use free cooling and ‘coolth’ recovery	Use heat recovery	Reduce electric lighting to reduce loads on air conditioning	Solar gains from glazing may increase loads on air conditioning. Heat loss may require simultaneous perimeter heating	Use natural ventilation instead of air conditioning where possible, or consider mixed-mode
	Cooling	Heating	Electric Lighting	Daylight/glazing	Natural ventilation

The interaction between building services
CIBSE Energy Efficiency in Buildings -Guide F

GLOSSARY

Array	Collection of panels (either solar thermal or PV)
Absorption cooling	
Biomass boiler	A boiler that burns fuels such as wood chips, straw and agricultural residues.
Building-mounted wind turbine	A small wind turbine that is mounted on a building, usually attached to the building roof.
CHP	Combined Heat and Power
Evacuated tube	A type of solar collector for a solar thermal system.
ESCO	Energy Services Company
Feasibility study	A study undertaken to determine the technical, economic and environmental viability of a project.
Ground-source heat pump (GSHP)	A pump system that takes the low-level heat occurring naturally underground and raises its temperature to a level that is sufficient to heat a building.
Hydro-electric power	The use of fast-flowing water to drive a turbine to generate electricity.
Payback period	The length of time taken to recover the cost of an investment through the returns attributable to it.
Photovoltaic cells (PV)	A silicon-based material that uses the energy in sunlight to create an electrical current.
Renewable energy (RE)	Energy that occurs naturally and repeatedly in the environment.
Renewables obligation	A Government initiative requiring electricity suppliers to source an annually increasing specified percentage of electricity from renewables.
Roof mounted	Fitting equipment onto an existing building.
Solar thermal	
Solar water heating	A method of heating water using the sun’s thermal energy.
Wood Chip	Wood reduced to small pieces.
Wood Pellet	Sawdust compressed into uniform diameter pellets to be burned in a heating stove.

TABLE OF ABBREVIATIONS

CHP	Combined Heat and Power
CO_2	Carbon Dioxide
EA	Environment Agency
EE	Energy Efficiency
GF	Ground Floor
GSHP	Ground Source Heat Pump
Kg	Kilogram
KWh/yr	Kilowatt hour per year
KWe	Kilo Watt electricity
MWe	Megawatt
MF	Mid Floor
TF	Top Floor