1 Technical Annex 1 E – Evaluation of energy efficiency measures

The following potential measures and technologies have been reviewed to determine suitability and potential impacts on carbon emissions:

- Intelligent control systems
- Low energy lighting
- Lighting control systems
- Demand driven ventilation
- Heat recovery systems
- High efficiency plant and small power equipment
- Energy monitoring
- District heating
- Combined heat and power (CHP)

Each of these issues is addressed in detail in the following pages and referenced sections of this report.

1.1 Intelligent Control Systems

A Building Management System (BMS) controls most energy consuming actions within a building hence it can limit energy wastage. BMS controls are composed of sensors, actuators and software that take decisions on which the BMS can control plant timing, shading, lighting and ventilation running on a suitable hardware.

Zones of the building with different solar exposure, occupancy or use should have separate time and temperature control. Central plant would only operate when the zone systems require it. Sensors can be situated in windows, doors, plant equipment (e.g. boilers), rooms, etcetera and should measure temperature, humidity, light levels, etcetera. They can also provide state info: open/close, empty/occupied, etcetera.

Actuators can be 100% adjustable to accommodate partial loads (e.g. pumps) or with intermediate positioning (e.g. window openings, lighting appliances).

The chosen BMS software has to be able to process multiple inputs from the sensors and produce the desired outputs for the actuators so that energy consumption is minimised and optimum conditions are achieved in the building.

Training for the operators and maintenance of the BMS software has to be provided and skill levels maintained over time. Building users have to be encouraged not to override controls and constant monitoring and adjustments to the systems can improve operational efficiency significantly.

Building envelopes, internal environments and the processes within buildings all contribute to the amount of energy consumed. Examination of existing buildings indicates avoidable energy wastage can range between 25 to 50%. In well-managed buildings energy wastage can be reduced to 15 % (CIBSE, 2000).

The use of building management systems and other intelligent controls will be investigated and incorporated as appropriate during detailed design of the proposed development.

1.2 Low Energy Lighting

Lighting is one of the largest consumers of electricity in buildings. It can account for up to 40% of the total electricity cost in a naturally ventilated building. New 2006 Part L Building Regulations expect that at least 30% of the appliances and sources of light should be low energy and high efficiency to minimise energy consumption hence associated CO_2 emissions. External lighting is also a point to focus when aiming at CO_2 emissions reduction.

High efficiency lamps offer a higher level of illumination per unit of energy. Installation within luminaries that properly reflect the light produced by the lamp, can further save electricity and cut CO_2 emissions. The Commissioning Code L for lighting edited by CIBSE (CIBSE, 2003b) states that a value of 65 lumens per circuit-watt should be achieved well above the regulation. According to 2006 Part L Building Regulations, desired values of lighting efficacy in dwellings are 40 lumens per circuit-watt i.e. including lamps and their associated control gear and 45 lumens per circuit-watt in non-dwelling buildings. For display lighting, the values are not less than 15 lumens per circuit-watt

External lamps are usually lit for approximately 5,000 hours a year, so a small increase in effectiveness can yield a big decrease of the energy consumption (around 25%) per length of lit street. Streetlights should be controlled by light sensors and timing devices. 2006 Part L Building Regulations states that any fixed external lighting fitting should not exceed 150 W per fitting or it should have an efficacy above 40 lumens per circuit-watt.

The use of low energy lighting will be investigated and incorporated as appropriate during detailed design of the proposed development.

1.3 Lighting Control Systems

General lighting controls can be included in the form of manually operated switches no more than 6m (or twice the floor to ceiling height if greater) from the luminaries they control, and perimeter daylit space should be separately switched. Display lighting should be separately switched off at times when people will not be inspecting the display.

Lighting controls can be designed to take account of presence of people (e.g. pyroelectric infrared) in their area with photoelectric switching and dimming capacity. 2006 Part L Building Regulations assumes 10% reduction in carbon emissions in non-public buildings by implementing lighting controls that is assumed extendable to the rest of controls. However, not all buildings will be able to implement this measure on economical or technical grounds. Centralised lighting control systems also ensure that an overall control of the lighting is maintained and unoccupied areas are switched off providing the maximum benefit in energy terms. Case studies have shown that use of modern lighting controls, combined with natural lighting can result in a 30-40% reduction in the resultant lighting use (CIBSE, 1999)

The use of intelligent lighting controls will be investigated and incorporated as appropriate during detailed design of the proposed development.

1.4 Demand Driven Ventilation

Demand driven ventilation employs CO_2 sensors in occupied areas to control the amount of fresh air supplied, via variable speed fans, in response to varying occupancy and the actual need for fresh air. These systems give scope for energy savings in areas of variable occupancy and where ventilation demand is driven by specific activities such as car parking.

Demand driven ventilation will be reviewed at detailed design stage for areas such as enclosed car parks where it has the greatest potential to deliver energy consumption reductions.

1.5 Heat Recovery Systems

Heat recovery systems recover heat from exhaust air streams that would otherwise be wastefully discharged to the outdoors and use it to raise the temperature of incoming fresh air. The use of a heat recovery system makes it possible to use fresh air in significant quantities with a reduced level of carbon emissions. However, climatic conditions may limit the days in the year when this technology is useful. Energy is saved and emissions reduced as the energy required to heat incoming air is reduced.

According to 2006 Part L Building Regulations, expected efficiencies of heat exchangers would be above 66%. Fans supplying air in balanced systems should have a specific fan power of 2 W/l/s or less at 100% and 25% of the design flow rate. Fans for continuous supply (e.g. toilet rooms) should have specific fan power of 0.8 W/l/s.

When considering the application of heat recovery systems, the energy balance and running cost as well as capital cost must be considered. In addition to the operating cost of running wheels, pumps, fans, etc., consideration should be given to the flow resistance that heat recovery devices impose on systems thereby increasing the energy consumption of the fan system. Where the application of a heat recovery device proves to be advantageous in cost/energy terms, then it shall be incorporated into the relevant system's design.

Similarly to CO_2 savings by natural ventilation, once a building in the development is designed as mechanically ventilated with heat recovery, its CO_2 emissions cannot be further reduced on these grounds. Hence, this measure cannot be used to cut CO_2 emissions beyond 2006 Part L.

The use of heat recovery systems will be investigated and incorporated as appropriate during detailed design of the proposed development. There is potential to include heat recovery in the commercial elements of the development or to meet passivhaus standards for the residential areas.

1.6 High efficiency plant and small power equipment

The following minimum standards for mechanical and electrical systems would generally be applied. It should be noted that Part L 2006 refers to another publication (Non-domestic Heating, Cooling and Ventilation Compliance Guide) for the minimum plant standards on this section, which is not yet published. Nevertheless, these requirements will be incorporated in all types of buildings in the proposed development.

If plant equipment (e.g. pumps, fans, motors, boilers, chillers, etc.) efficiency is high, less energy will be required to produce the same effect thus minimising energy wastage and CO_2 emissions. For example:

- Gas fired condensing boilers achieving a seasonal efficiency of at least 86%

- High efficiency chillers with a minimum seasonal coefficient of performance (COP) of 3
- Fans rated higher than 1,100 W should be equipped with variable speed drives.
- Small power equipment like IT equipment, washing machines and small appliances with “A” energy ratings

The first two points are incompatible with a community/district heating/cooling scheme so both associated CO_2 emissions reductions cannot be accounted simultaneously.

If this option is used to comply with 2006 Part L Building Regulations requirement there is small potential for further CO_2 reductions by improving plant efficiency or by using low energy consuming small power equipment.

The use of high efficiency plant and small power equipment will be investigated and incorporated as appropriate during detailed design of the proposed development

1.7 Energy Monitoring

This task will not reduce energy use or CO_2 emissions by itself other than enabling the elimination of operating systems wastefully, not as designed or identifying faults within the design, installation and operation of the systems. These faults, which are common in all buildings to a greater or lesser extent, could be identified and remedied if monitored.

Energy monitoring is needed to prevent energy wastage and to have the possibility of knowing if other CO_2 saving measures are working properly. In the long term, it will provide energy trends and allow a better management of the energy. Consequently, 2006 Part L Building Regulations states that automatic monitoring and targeting of energy consumption with alarms for out of range values can achieve a reduction of up to 5% in carbon emissions according to table 3 in the approved document 2A of the 2006 Part L Building Regulations as it will enable the systems to be modified to operate at or near their optimum efficiency.

The use of energy monitoring will be investigated and incorporated as appropriate during detailed design of the proposed development

1.8 District Heating

A District Heating scheme is any scheme where there is centralised generation of heat which is then distributed to a number of buildings through a heating network (Rochas, 2004). This can vary in scale from links between two buildings, up to the provision of heat throughout a city.

The main benefits (Rochas, 2004) come from

- Reducing the cost of fuel infrastructure and maintenance (e.g. only one location needs gas connection),
- Efficiencies in technology from larger plant,
- Reduced cost compared to distributed boilers,
- The operator of the system may be able to secure a better tariff due to being a larger user of gas than each single residence.

The system does however bring disadvantages in that:

- A heat distribution system is needed,
- It reduces the financial viability of providing gas in flats for cooking,
- The operator of the system needs to organise billing for heat use.

It is interesting to note that Community Energy systems are very common in Northern European countries, where for example 98% of Greater Helsinki is supplied by community heating from a variety of sources (EST, 2002) and 60% of Danish space heating is from such systems (DBDH, 2004), but it is less common in the UK, providing heat to 1.8% of the building stock. However with the increasing tendency to building flats in the UK Community Energy it is becoming more common.

The availability of a community heating network will improve the economic viability of alternative heating technologies as it reduces the impact of sudden falls in demand and the network effectively acts as a thermal store. During the life of the district heating network, which may be in excess of 50 years, different heat generators or additional thermal storage can be added into the scheme as economics change. For instance a CHP engine or biomass boiler could be added at any time, or the network could be linked to another neighbouring scheme. In the same way the network can be adapted to include new clients whenever they arrive.

District or community heating schemes can be used with existing and new buildings but would require careful planning regarding flexibility to meet changes in future energy demands. A district heating scheme would serve to 'future proof' the development as it allows for review and addition of other renewable technologies as they become available. In such a system, only the central technology would need to be replaced rather than individual technologies within each building.

Using a District Heating system brings flexibility benefits to the proposed development. It can reduce the capital cost of construction due to the cost savings from not providing gas, gas boilers and flues to each property. It could allow for development through phases and for variations in future building designs and technology trends. District Heating will also provide operational savings for occupants through the bulk purchase of fuel and improved operating efficiencies.

A district scheme would promote community ownership and save space and energy but does require high densities to be viable.

1.9 Combined Heat and Power (CHP)

CHP is the simultaneous generation of useful heat and power, providing efficiency benefits over traditional forms of power generation (CIBSE, 1999 and Action Energy, 2004). For maximum efficiency CHP units generate to serve a steady load (Action Energy, 1996). Peaks and troughs in power demand are then met through imports or exports to the national grid; heat loads are matched through the use of additional boilers, and by using thermal storage or heat dumping.

When compared in simple payback terms CHP does not usually prove economic compared with traditional supplies unless there are at least 4500 hours of full load operation required over the course of a year (Action Energy, 2004). Typically CHP units are sized to meet base heating demands to ensure that running time is sufficiently high. It is traditionally only cost-effective to operate CHP units for 17 hours a day, avoiding the night-period when the price of electricity is very low.

A CHP scheme can be managed by an ESCO (energy services company), who provide the equipment and maintenance in return for an agreed price structure. This reduces the capital cost to the developer, but introduces different risks. The ESCO may provide power over ‘private wires’ as an exempt supplier, this would provide large cost savings and improve the economics for installing a CHP scheme (EST, 2003).

CHP is usually powered by gas, and therefore it is not considered a form of renewable energy, so does not contribute to meeting the 10% renewables target but is viewed favourably by KMBC as an energy efficiency method. CHP offers carbon savings, less reliance on the grid electricity supply and long-term cost savings (CIBSE, 1999) while gas prices remain significantly lower than electricity. Although the use of CHP reduces energy consumption on a macro scale, the amount of energy brought onsite is greater due to the increased gas use for electricity generation. As such, in the calculations of energy use, CHP will result in an increase in onsite energy use and a subsequent increase in the amount of renewable required.

CHP brings significant operational savings for mixed use developments such as the proposed development as they provide a more consistent energy load profile which in turn allows for a more efficient system. Using a model of energy consumption profiles for the building type breakdown we have estimated the most appropriate size of CHP system for the southern area of the site at 2MWt gas CHP system operating for 5110 hours annually. Extending this to the area north of Cherryfield Drive would require a 2350kWt gas CHP engine.

The integration of CHP in the proposed development would depend strongly on the implementation of a district heating scheme and is being considered for use in conjunction with renewable energy technologies. However, as renewable heat sources such as ground source heating and biomass heating have been found to be most appropriate for the site, the usefulness of CHP is reduced because some of the heat load is already being supplied by other means. As such, any CHP is likely to serve only a small proportion of the site. One option would be to install a trigeneration system for the supermarket, using waste heat from a 359kWt CHP engine in the summer to feed a 240kw absorption chiller for both space cooling and refrigeration. This increases the hours of use for the system and, improves its economic viability but would still impinge partially upon the output from a GSHP or biomass boiler system.