CHAPTER 5.0

BASELINE ASSESSMENT

5.0 Baseline Assessment

5.1
Baseline Assessment
This energy strategy considers as the starting point a baseline development that meets the requirements of ADL2A (2006) (Ref. 03) in relation to CO_2 emissions.

5.2
The baseline assessment of the regulated energy and associated CO_2 emissions was carried out using IES software based on the design of the Proposed Development, but without implementation of energy efficiency measures and without LZC technologies. The baseline assessment of the non-regulated energy uses was based on the assumptions on the building's operation provided by the design team.

5.3
The baseline scenario assumes the following conditions:

- Construction materials that comply as a minimum with ADL2A (2006) U-values (U-value represents heat transmission through a material or assembly of materials, the lower the U-value, the better the insulating value):
    - Walls – 0.22 W/m^2K (Calculated area weighted average)
    - Roof – 0.25 W/m^2K (Calculated area weighted average)
    - Ground floor – 0.2 W/m^2K (Calculated area weighted average)
    - Windows – 2 W/m^2K (Calculated area weighted average)
    - Roof lights – 2 W/m^2K (Calculated area weighted average)
- An airtight construction to control infiltration to below the requirement of 10 $m^3/m^2/hr$ at 50 Pa set out in ADL2A (2006);
- Minimum ADL2A (2006) efficiency gas-fired boilers for space and hot water heating and at least minimum ADL2A (2006) efficiency air-cooled electrical chillers for cooling to an extend allowing the building's BER to be equal or higher then the TER; and
- Energy efficient lighting and lighting controls in line with Building Regulations.

5.4
The baseline energy consumption and CO_2 emissions for each energy use are shown in Table 5.1. Figure 5.1 represents the breakdown of CO_2 emissions by regulated energy uses, i.e. heating, hot water, cooling, lighting and auxiliary energy. Graphical representation of baseline CO_2 emissions is shown on Figure 5-2.

UKCMRI - Baseline						
	Gas		Electricity			Sum
Regulated	Heating	Hot Water	Cooling	Lighting	Auxiliary	
Energy (MWh/year)	1,058	2,379	1,156	3,208	489	8,289
CO_2 Emissions (tonnes CO_2/year)	205	461	488	1,354	206	2,714
Non Regulated	Equipment, Cooking, BRF, Data centre etc.					
Energy (MWh/year)	83,563		31,148			114,711
CO_2 Emissions (tonnes CO_2/year)	16,211		13,144			29,356
Total	Regulated and Non-Regulated					
Energy (MWh/year)	87,000		36,000			123,000
CO_2 Emissions (tonnes CO_2/year)	16,878		15,192			32,070

Table 5-1. Baseline energy consumption and CO_2 emissions breakdown by use

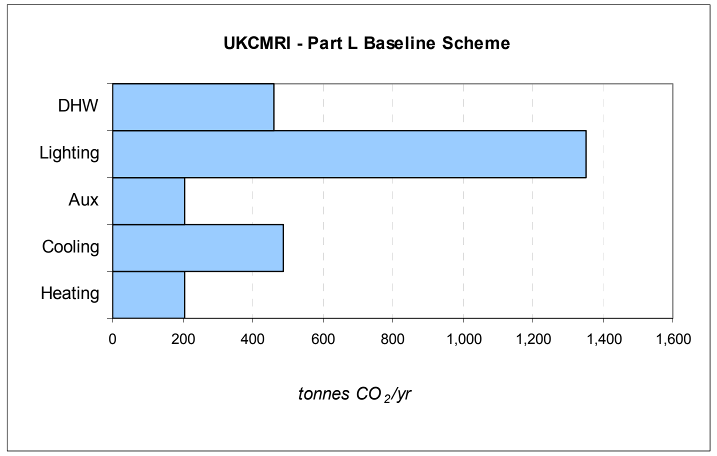

Figure 5-1. Baseline CO_2 emissions breakdown by use – regulated energy uses only

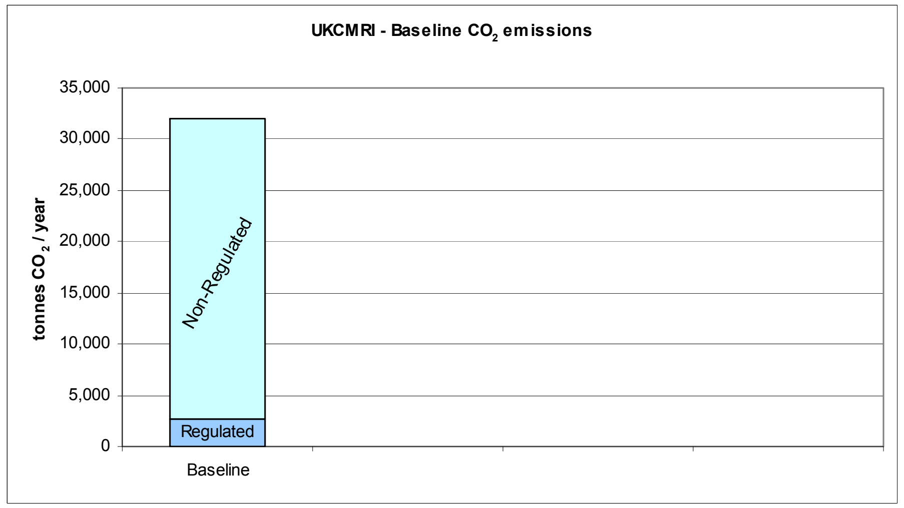

Figure 5-2. CO_2 emissions for baseline – regulated and non-regulated energy uses

CHAPTER 6.0

BE LEAN - PASSIVE DESIGN AND ENERGY EFFICIENCY APPRAISAL

6.0 Be Lean – Passive Design and Energy Efficiency Appraisal

6.1
Be Lean – Passive Design and Energy Efficiency Appraisal
The vision for the Proposed Development is to be a state of the art sustainable development, with sustainability principles embedded into its design and operational concept.

6.2
Passive Design
The fabric of the building has been designed to be airtight and well insulated in order to minimise heat loss in winter. Solar gain will be utilised to benefit the space in winter time therefore reducing space heating demand. At the same time the undesirable effect of excessive solar gains in summer time will be prevented to minimise additional energy consumption for cooling.

6.3
Natural lighting has been promoted throughout the design. Natural lighting will reduce the energy use and CO_2 emissions of the building by minimising the use of artificial lighting. Additionally, a naturally lighted environment will enhance the standard of indoor comfort for the end users.

6.4
The key passive design measures integrated in the Proposed Development include:

- Calculated area weighted average U-values of
  - Walls – 0.18 W/m^{2}K
  - Roof – 0.16 W/m^{2}K
  - Ground floor – 0.2 W/m^{2}K
  - Windows – 1.68 W/m^{2}K
- Bay facades shaded with a bris-soleil integrated into the curtainwalling system: horizontal extrusions at 1m spacing (projecting 240 mm on the south). The glazing of these facades is also treated with a graduated frit pattern, up to 75%;
- Recessed narrow windows (1 m wide) in the terracotta walls 200 mm into the deep walls, providing a vertical shading on the east and west facades;
- Shaded atrium roof glazing by the higher southern plant volume and cantilevered overhang of the southern roof louvres;
- High performance glass used throughout the building, with a shading coefficient of 0.39 (shading coefficient is a measure of the total amount of heat passing through a particular glazing - the lower the number, the better the performance of the glass);
- An airtight construction to control infiltration to 5 m^3/m^2/hr and minimisation of heat loss through the building fabric. The following measures will be specified:
  - Personnel doors installed between internal and external areas within proximity of any adjacent openings for goods delivery access;
  - Partitioned delivery loading/unloading areas and operational and/or storage areas;
  - Draught sealed vents in the roof and back draught dampers on extract fans;
  - Loading/unloading bay doors insulated to 0.6 W/m^{2}K;
  - Plastic strip curtains specified between internal delivery areas and operational areas; and
  - Rapid rise loading/unloading bay doors.
- Natural Ventilation: This is impractical in a large experimental research facility given the constraints of both the Home Office (with regard to BRF operational requirements) and general design standards for containment, barriers, and general laboratory ventilation to satisfy Containment Level (CL) 2 and CL3 standards.

6.5
Energy Efficient Design
The Proposed Development will include a central energy centre that will serve all areas. The proposed servicing strategy is as follow.

- Power System

  The main power to the building will be derived from the 11kV external EDF Energy (EDFE) network with the main incoming cables terminating in EDFE owned switchgear located at level -1 mezzanine. The EDFE switchgear will connect with the two main (UKCMRI owned) 11kV switchboards located at level -1. The two main (UKCMRI owned) 11kV switchboards will supply power to the five packaged substations located at level -1 and level 7 within the building and also the data centre located at level 7.

  The five substations will each consist of two transformers distributing power around the building via the vertical risers located in the building cores.

  Within the vertical risers at each floor level sub distribution boards will supply power to the laboratories, administration, ancillary and mechanical plant areas.

  Equipment or plant requiring essential power will be backed up by generators located on the roof.

  Critical power supplies such as the data centre will be maintained via Uninterruptible Power Supply (UPS) units.

- Heating System

  The heating system will be used to provide space and air heating, humidification, process steam and domestic hot water for the Proposed Development. Steam is required for the humidification and process loads, while Low Temperature Hot Water (LTHW) or steam may be used for other general heating loads.

  The main steam and LTHW boilers (i.e. three 3,100 kW LTHW boilers and two 6,500 kW steam boilers) together with the associated ancillary equipment are located at basement level -1.

  The boilers will be provided with high efficiency low NO_X burners with oxygen trim and variable speed drives to maximise the efficiency at all load conditions. A sequence controller will optimise the number of boilers operating.

- Cooling System

  A chilled water system will be used to provide the cooling and dehumidification required to treat the fresh air supplied to the facility and internal spaces.

  The main items of plant consist of the water cooled chillers (four 4,000 kW units) which are located at level -1 with the associated cooling towers (eight 2,500 kW units) located on the roof.

  A secondary chilled water variable speed pumping system will distribute chilled water around the building.

  Cooling towers are more thermally efficient than dry cooling towers and thus reduce overall energy usage and CO_2 emissions. As such the proposed servicing strategy includes water cooled chillers, which will save approximately 1,150 MWh of electricity per year. Water cooled chillers will save an estimated 485 tonnes of CO_2 per year over conventional air cooled chillers (Electricity and CO_2 savings calculated based on a preliminary analysis are as attached in Appendix C).

  Additionally air cooled chillers require more roof space and would need to be located on both north and south bars of the Proposed Development, which in turn would not only present a noise issue but would necessitate an increase in building height to fit them in. On the other hand, cooling towers require less space and can be located on the less noise sensitive south bar roof.

  All water and Heating, Ventilation and Air Conditioning (HVAC) systems will be designed to meet the requirements of Health and safety Executive's (HSE) Approved Code of Practice and Guidance, L8 (Ref. 28) to ensure the building services are designed to reduce the risk of legionellosis. An effective planned maintenance regime will be in place to address concerns relating to operating risk.

6.6
The key energy efficiency measures integrated into the Proposed Development include:

- Energy Efficient Lighting and Lighting Controls

  Where possible, central circulation spaces will be lit, at least in part, by daylight into the atrium. The lighting design for internal circulation areas will give the illuminance level required for safe passage and movement and could be a combination of direct and indirect lighting.

  The lighting control in the primary laboratory areas will be by means of local control for the ambient lighting with separate control for the task lighting on the benches in the laboratory space. The lighting control will incorporate an out of hours function which would operate at a pre determined time to reduce the lighting levels in the laboratory prior to them being automatically turned off. Any laboratory user will have the ability to override the out of hours function via the local control function. Support areas, meeting rooms, stores, toilets, plant areas etc would incorporate occupancy sensors with local control to override the sensors if required by the occupant. Lighting on the perimeter corridors will incorporate daylight dimming when adequate levels of daylighting are available

  High efficiency ballasts will be used where possible and a complete lighting control system will be provided to maximise operational efficiency serving as a tool for energy saving.

  Energy-efficient external lighting will be specified and all light fittings will be controlled for the presence of daylight.

- Ventilation Systems

  The fresh air supply rates to the different parts of the Proposed Development will be rationalised to ensure the minimum amount of outside fresh air is treated and distributed through the building to maintain the required environmental conditions.

  The air change rate per hour (acph) will be optimised from the traditional 12 acph to 8-10 acph in the laboratory areas. All ventilation systems will be variable volume flow, allowing variable speed drives to be fitted to fans to reduce power consumption. The fume extract systems will be linked to sash controls on the fume cupboards and night time set back setting will be used where possible (e.g. it could be possible to reduce the air change rate in the laboratories from 8acph to 2 acph overnight). Additionally the write up areas will be located outside the laboratory spaces, thus allowing air change rates in the write up areas to be reduced.

  Heat recovery systems will be used where possible. In areas such as the basement imaging, plant areas, atrium, Nuclear Magnetic Regulator (NMR), restaurant and auditorium, where cross contamination between the supply and extract air flows is not an issue, thermal wheels will be used. Elsewhere, in the BRF, laboratories and kitchens, heat recovery coils and run-around circuits will be used.

- Variable Flow Hydronic Systems

  Variable flow systems provide significant savings by reducing the flow in the system as opposed to a traditional constant volume system. The base cooling load for the variable flow systems system is significantly smaller than the peak load of the system, so for the majority of the year the system will operate at partial load. Using a 2 port valve control system with pumps controlled by Variable Speed Drive (VSD) will enable energy savings of around 525 tonnes of CO_2 per year to be made by reducing flow and pressure in the chilled water system at partial load. A further 75 tonnes of CO_2 per year can be saved by using a variable speed system for the LTHW distribution chillers (CO_2 savings calculated based on a preliminary analysis included in Appendix C).

- Economisers on Steam and LTHW Boilers

  To increase the efficiency of the steam and LTHW boilers, economisers are proposed. Waste heat in the boiler exhaust flues will be used to pre-heat the water entering the boilers. Economisers will be used to reclaim the heat without condensing water from the flues, which is highly corrosive. Hence employing economisers instead will overcome the issue of corrosive condensate.

- Reverse Osmosis (RO) Steam Boiler Feedwater Treatment

  As steam is generated, water evaporates and leaves behind dissolved solids in the boiler shell. These solids, if not removed, will scale the boiler surfaces causing loss of performance and potentially failure of the boiler pressure shell. To reduce the amount of scaling the standard boiler feed water treatment is to supply softened water to the system, however, this still contains dissolved solids. To stop these deposits building up, water is continuously ‘blown down’ from the boiler, thus losing a considerable amount of heat, energy and treated water with each ‘blow down’.

  Providing water treatment through a RO plant significantly reduces the amount of dissolved solids in the feedwater. Treating the boiler feedwater using RO instead of softened water reduces the required blow down rate. Based on current estimates this would realise annual savings of approximately 92 tonnes of CO_2 per year (CO_2 savings based on a preliminary analysis included in Appendix C).

- Data Centre

  UKCMRI will include approximately 165 m^2 of data centre, designed at a heat load density of 5.7 kW/m^2, giving a total Information Technology (IT) load of 940 kW. The data centre will run continuously and makes up a significant proportion of the annual cooling demand.

  An analysis of different data centre cooling systems options has been undertaken and the most energy efficient system has been selected (see Appendix C):

  - Option 1: Computer Room Air Conditioning (CRAC) Units

    This option assumes that cooling will be delivered to the space by a standard watercooled CRAC unit. Chilled water would be provided by the central chilled water system. This is the baseline for comparison with the other options.

  - Option 2: Water Cooled Cabinets

    Option 2 assumes that cooling will be delivered directly to the cabinets containing the IT equipment. Chilled water would be provided by the central chilled water system. Minimum fresh air would be supplied to the data centre to for pressurisation. This option gives annual CO_2 savings of approximately 13 tonnes CO_2/year against the baseline case (i.e. Option 1).

  - Option 3: Outside Air Free Cooling and Air Handling Units

    Option 3 assumes that cooling will be delivered to the space by AHUs rather than CRAC units. This would allow outside air to be supplied directly to the data centre space, significantly increasing the potential for free-cooling. This option gives annual CO_2 savings of 161 tonnes CO_2/year against the baseline case.

  - Option 4: Dual Coil Computer Room Air Conditioning (CRAC) Units using ‘Free’ Pre-cooling from the Condenser Water

    Option 4 assumes that cooling will be delivered to the space by a twin-coil watercooled local air handling units. The two coils in each CRAC unit will be served by two separate cooling systems, the first coil will pre-cool return air with a cooling tower water circuit, and the second coil would provide trim-cooling with chilled water provided by the central chilled water system when necessary. This system has a very high Seasonal Energy Efficiency Ratio of 29. This option gives estimated annual CO_2 savings of circa 253 tonnes CO_2/year against the baseline case and is the selected option.

- Energy Efficient Cold Storage Systems

  The specified cold storage refrigeration plant components will be on the ECA Energy Technology Product List (ETPL). The EPTL is part of the Government’ Enhanced Capital Allowance Scheme, a key part of the Government’s programme to manage climate change. The Scheme provides a tax incentive to encourage investment in low carbon energy-saving equipment that meets published energy-efficiency criteria.

6.0 Be Lean – Passive Design and Energy Efficiency Appraisal

- Energy Efficient Laboratory Instruments and Fume Cupboards

  The most energy-efficient strategy for ventilation of the fume cupboards, whilst maintaining adequate containment, will be implemented. The design of fume extraction systems will follow the guidance within Good Practice Guide 320 Energy Efficient Design and Operation of Fume Cupboards.

- Vertical Transportation

  The UKCMRI development will utilise a range of measures to help improve the energy efficiency of the lifts:

  - Lift traffic analyses are being performed to ensure that the number of installed lifts does not exceed the needs of the Proposed Development.

  - Energy efficient lighting such as LED lighting in the lift car. Energy efficient lighting will also be utilised in all display units associated with the lifts.

  - 'Standby mode'. When the lifts have been inactive for a specified time the internal car lighting and ventilation systems will shut down, resulting in energy savings.

  - Variable speed drives which will result in a reduction in energy used by the lift motors.

  - Regenerative braking unit. This unit will allow the recovery of energy as the lift brakes.

  Based on manufacturer's figures, employing the above energy saving measures will result in approximate annual savings of up to 75 MWh/year, and leading to CO_2 savings of up to approximately 32 tonnes of CO_2 per year.

- Power Factor Correction

  Power factor correction equipment will be provided as necessary to ensure a power factor correction value of > 0.9 is achieved.

- Metering

  Energy metering of all major equipment and sub-circuits will be provided. This data will be collated and warning alarms provided when equipment exceeds identified limits (e.g. plant operating out of hours) to enable the facilities management team to switch off unnecessary equipment.

- Water-Efficient Fittings

  Low water consumption sanitary appliances, such as dual flush WC cisterns, and low flow showers and taps will be specified to conserve water and reduce the hot water heating demand.

- Building Management System (BMS)

  The BMS will control and monitor the central plant to ensure an energy-efficient operation. Additionally, a comprehensive commissioning strategy and energy management and targeting system will be implemented to ensure that all systems are properly tested, commissioned and placed in service. This will significantly aid the efficient start-up of such systems and their ongoing efficient operation in use, reducing energy use and operating costs.

- Building Users Guide

  A guide will be produced giving the facility managers and occupiers information on energy-efficient features and strategies relating to the building, and also providing an overview of the reasons for their use, e.g. economic and environmental savings. The guide will include energy targets and benchmarks for the building type, and information on monitoring, such as the metering and sub-metering strategy.

6.7
Enhanced Baseline (Be Lean)
The enhanced baseline scheme considers the incorporation of energy efficiency and passive design measures into the baseline scheme. The resulting savings in CO_2 emissions for the Proposed Development are savings that exceed the requirements of Building Regulations ADL2A (2006).

6.8
Implementation of the proposed energy efficiency and passive design measures will result in a CO_2 emissions savings of 5,400 tonnes CO_2/year. This equates to approximately a 17% improvement in CO_2 emissions over the baseline scheme.

6.9
The enhanced baseline energy consumption and CO_2 emissions for the building are shown in Table 6.1. Figure 6.1 represents the breakdown of CO_2 emissions for regulated energy uses, i.e. by heating, hot water, cooling, lighting and auxiliary. Figure 6.2 illustrates an improvement in CO_2 emissions achieved due to incorporation of passive design and energy efficiency measures.

UKCMRI - LEAN						
	Gas		Electricity			Sum
Regulated	Heating	Hot Water	Cooling	Lighting	Auxiliary	
Energy (MWh/year)	801	2,351	639	3,208	489	7,488
CO_2 Emissions (tonnes CO_2/year)	155	456	270	1,354	206	2,441
Non Regulated	Equipment, Cooking, BRF, Data centre etc.					
Energy (MWh/year)	75,201		22,884			98,085
CO_2 Emissions (tonnes CO_2/year)	14,589		9,658			24,247
Total	Regulated and Non-Regulated					
Energy (MWh/year)	78,353		27,220			105,573
CO_2 Emissions (tonnes CO_2/year)	15,200		11,487			26,688

Table 6-1. 'Be lean' energy consumption and CO_2 emissions breakdown by use

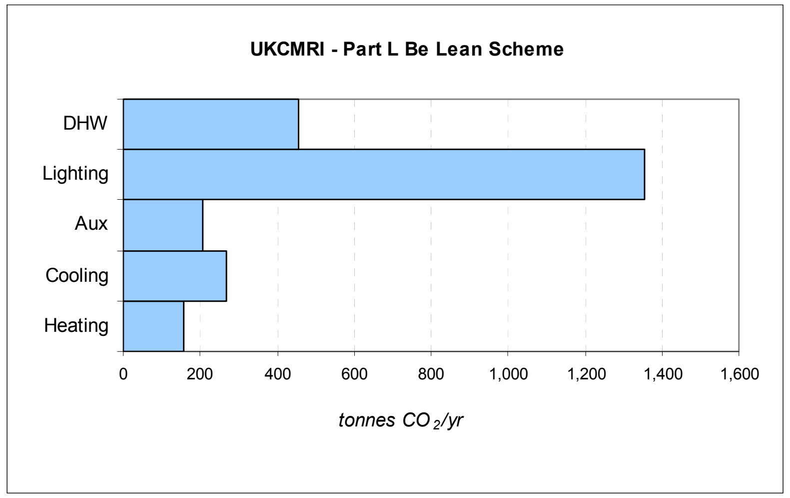

Figure 6-1. 'Be lean' CO_2 emissions breakdown by use – regulated energy uses only

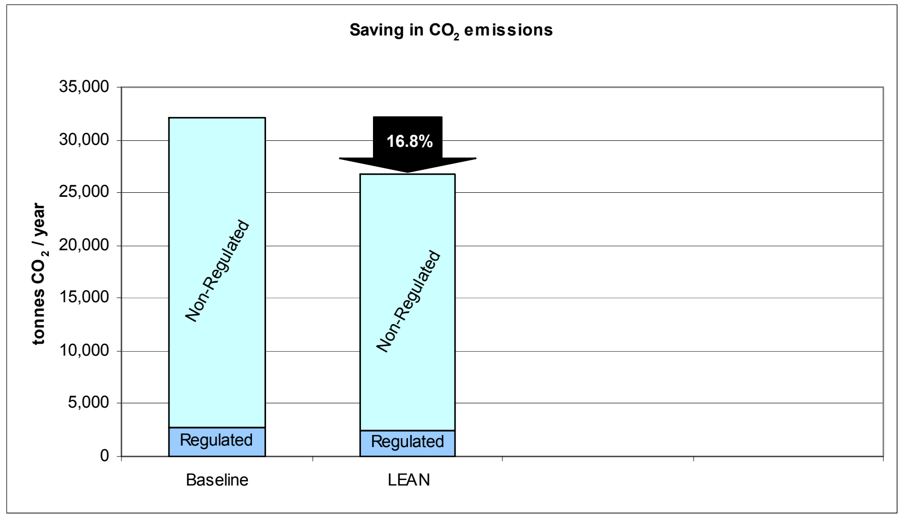

Figure 6-2. CO_2 emissions for baseline and 'be lean' – regulated and non-regulated energy uses

CHAPTER 7.0

BE CLEAN - CHP APPRAISAL

7.0 Be Clean – CHP Appraisal

7.1
Be Clean – CHP Appraisal
Introduction to technology
Conventional electricity generation is typically only 40% efficient. Almost all of the other 60% is dissipated in the form of heat at the generator before any power whatsoever is delivered to the distribution system, such as the national grid, where further grid losses are incurred. Overall, national electricity generation and distribution is only about 35% efficient.

7.2
CHP technology converts natural gas into both electrical power and heat in a single process at the point of use. CHP is highly energy efficient (see Figure 7-1) due to the utilisation of the waste heat by-product of the electricity generation process and minimal distribution losses due to its close proximity to the load, which results in CO_2 emissions savings and potential utility cost benefits.

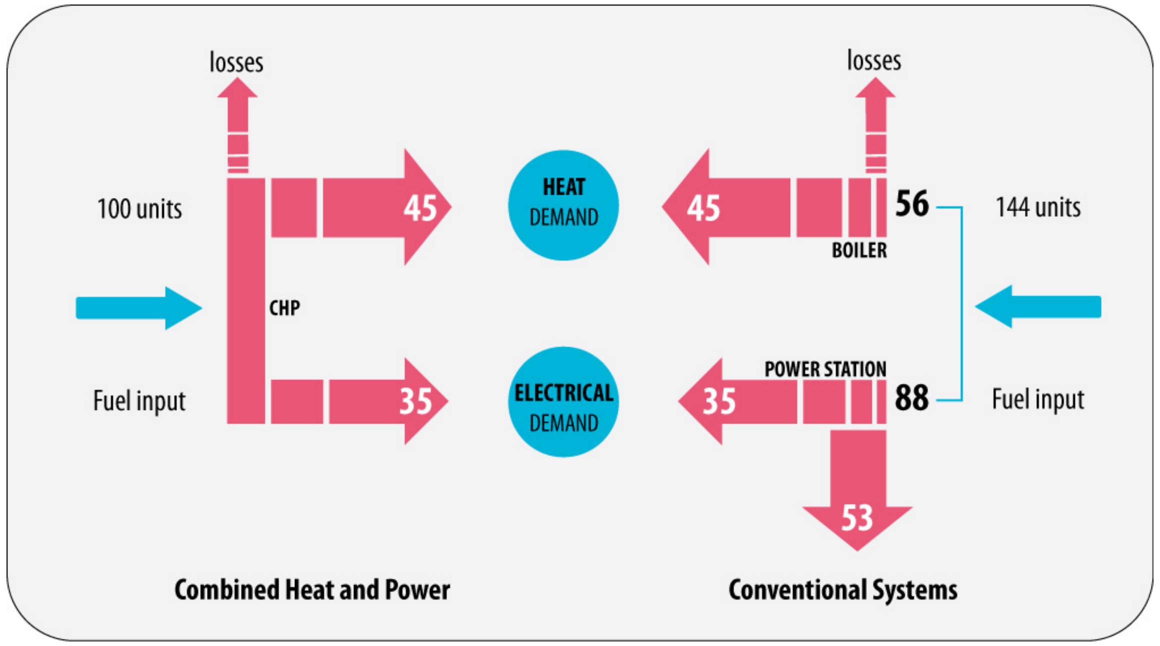

Figure 7-1. CHP energy flow diagram

7.3
A CHP system should be sized to use the full output of both electrical power and heat for an operational period of more than 5,000 hours/year, allowing for maintenance downtime, to achieve utility cost benefits. CHP operation is generally viable for developments with a constant, high heat demand (namely the hot water heating load), as the heat to electrical power generation ratio is typically 1.5, i.e. for every unit of electrical power generated, 1.5 units of heat are generated. Therefore CHP systems are normally sized to meet the continuous base load for Domestic Hot Water (DHW), rather than to meet the electrical load.

7.4
CHP also has the advantage of providing a partial backup electrical power supply and the generated power could be supplied in parallel to the supply system serving a development. The economics of CHP, however, are very sensitive to the price gap between gas and electricity.

7.5
Whilst CHP technologies simultaneously produce heat and power, trigeneration (i.e. CCHP) implies the simultaneous production of mechanical power (electricity), heat and cooling from a single fuel.

7.6
Applicability to UKCMRI
As required by the London Plan, consideration has been given to the use of a decentralised energy supply and connection to existing/proposed CHP distribution networks.

7.7
Euston Road District Heating Scheme and UKCMRI
The London Development Agency (LDA) is currently undertaking a feasibility study of an extensive district heating scheme in the area surrounding the UKCMRI site. This scheme is known as the Euston Road District Heating Scheme, and consists of expansion of the existing Argent scheme serving the King's Cross development, the development of a new scheme with an energy centre based on the British Library site, connection of these two schemes and possibly others to the east, west and south.

7.8
The UKCMRI team has extensively engaged with GLA, LBC and LDA through pre-application meetings to discuss the possible implications of the Euston Road District Heating Scheme for the Proposed Development.

7.9
It is the UKCMRI intention to make sufficient provision within the site planning to enable the connection of the building to any appropriately available (and commercially viable) district heating mains routed in proximity to the site.

7.10
The proposed CHP plant for UKCMRI has been sized to meet the baseload heat requirements of the Proposed Development. Due to space constraints (both in the basement for the CHP plant itself and at roof level for the heat dump radiators) and noise constraints it is not considered feasible to increase the CHP capacity in order to export heat to a potential district heating scheme.

7.11
Should a district heating scheme become available (and linked into by UKCMRI) it will require the removal of at least one LTHW boiler and its replacement with an appropriately sized heat exchanger linked to the district heating scheme, and the building LTHW system. Figure 7-2 shows schematically how a district heating system would be interfaced with the UKCMRI LTHW and steam systems; and Figure 7-3 shows that enough space is available in the energy centre located at basement level -1 to allow for the installation of the required infrastructure to permit connection to an external heat network (e.g. space for heat exchangers). The provision of the electrical infrastructure necessary to accept a high voltage feed from a CHP unit installed in the vicinity in the future will be included.

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7.0 Be Clean – CHP Appraisal

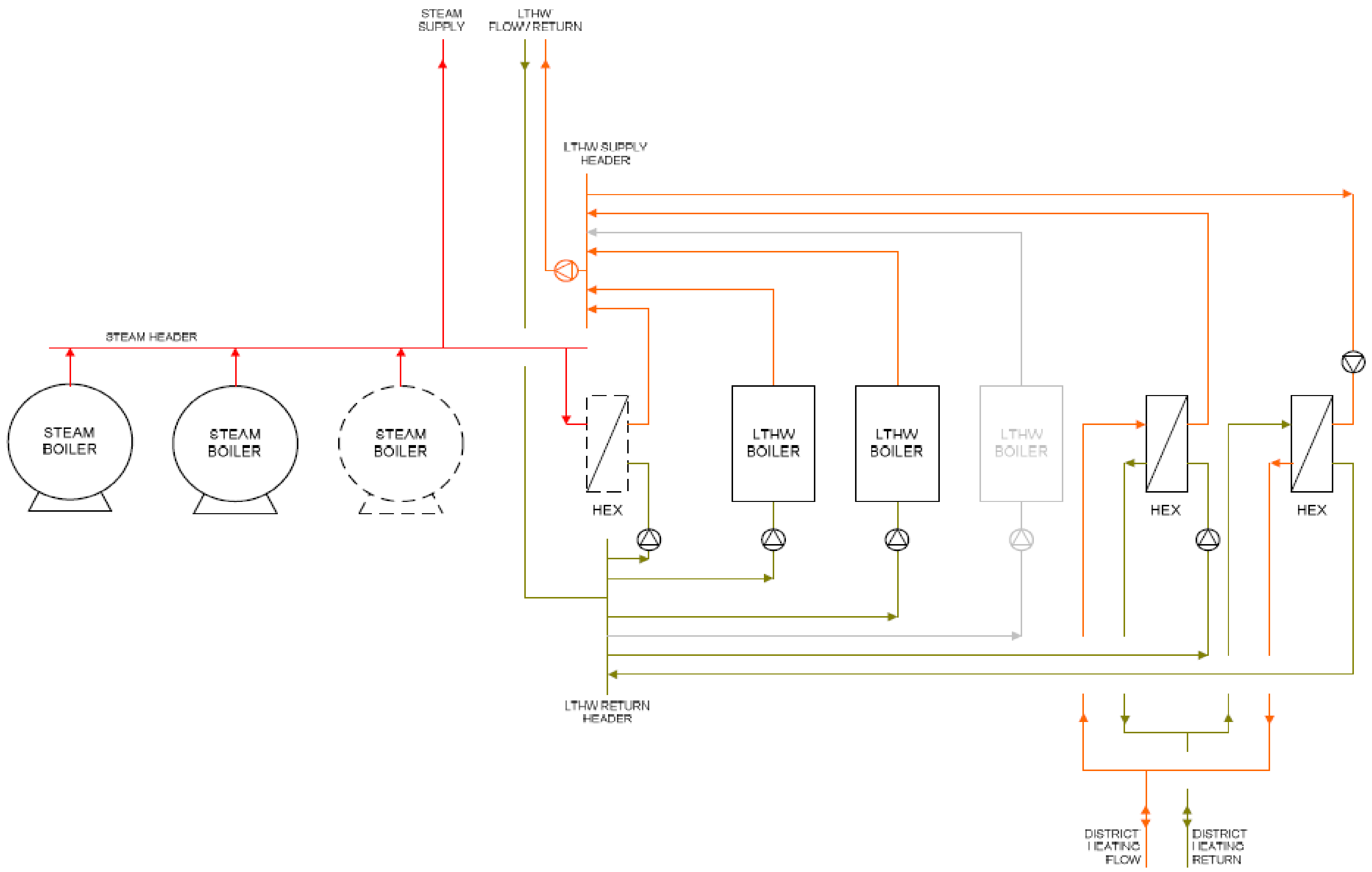

Figure 7-2. Schematics of interface between a district heating systems and UKCMRI LTHW and steam boilers

Figure 7-3. UKCMRI Level -1 Plant Layout illustrating space (red circle) available for connection to an external heat network

7.0 Be Clean – CHP Appraisal

7.12
Proposed CHP system for UKCMRI
Considering the context presented in the previous section, it is therefore proposed to implement an onsite CHP system sized to optimally service the Proposed Development.

7.13
It is proposed to incorporate a 1,822 kW electrical power output CHP unit in the energy centre, located at Level -1 (Refer to Figure 7-3). Details of the proposed CHP plant are as follows:

- Energy Input: 4,151 kW
- Useful Heat Output: 1,463 kW, from which 853 kW is LTHW recovery and 610kW is Steam recovery
- Electrical Output: 1,822 kWe
- Thermal Efficiency: 35.2%
- Electrical Efficiency: 43.9%
- Availability (Percentage of hours operating during a year): 90%

7.14
The CHP will provide both LTHW and steam. It is assumed that the CHP unit acts as the lead boiler and runs at full load 90% of the time (i.e. availability).

7.15
Operation of the CHP plant will result in CO_2 emissions savings of about 4,440 tonnes CO_2/year. This equates to approximately a 17% savings in CO_2 emissions over the enhanced baseline scheme.

7.16
It is anticipated that the electrical power output will meet approximately 53% of the electrical demand of the scheme.

7.17
Figures 7-4 and 7-5 show the annual LTHW and steam demand, respectively, for the Proposed Development The CHP performance has been overlaid to indicate the heat recovery, dumping and top-up for the CHP option. The red areas on the graphs represent heat recovered from the CHP; orange areas represent when the heat recovered from the CHP is insufficient to meet the demand and LTHW and steam boilers are required to make up the difference; and green area indicates when there is insufficient demand for waste heat and heat from the CHP plant is dumped.

7.18
The CHP plant has been sized to achieve the best balance between heat recovered and heat dumped. The space constraints of the plant have been also taken into consideration. If the size of the CHP plant was increased, the amount of heat reclaimed would increase but at the cost of dumping more heat, therefore reducing efficiency.

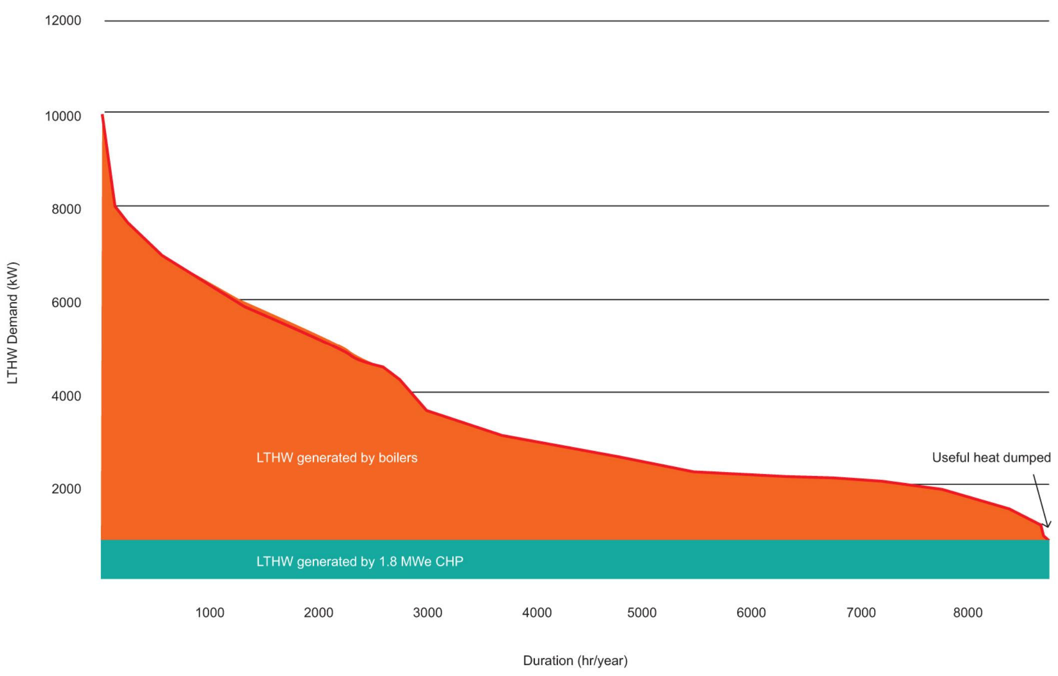

Figure 7-4. LTHW load profile overlaid with the proposed CHP

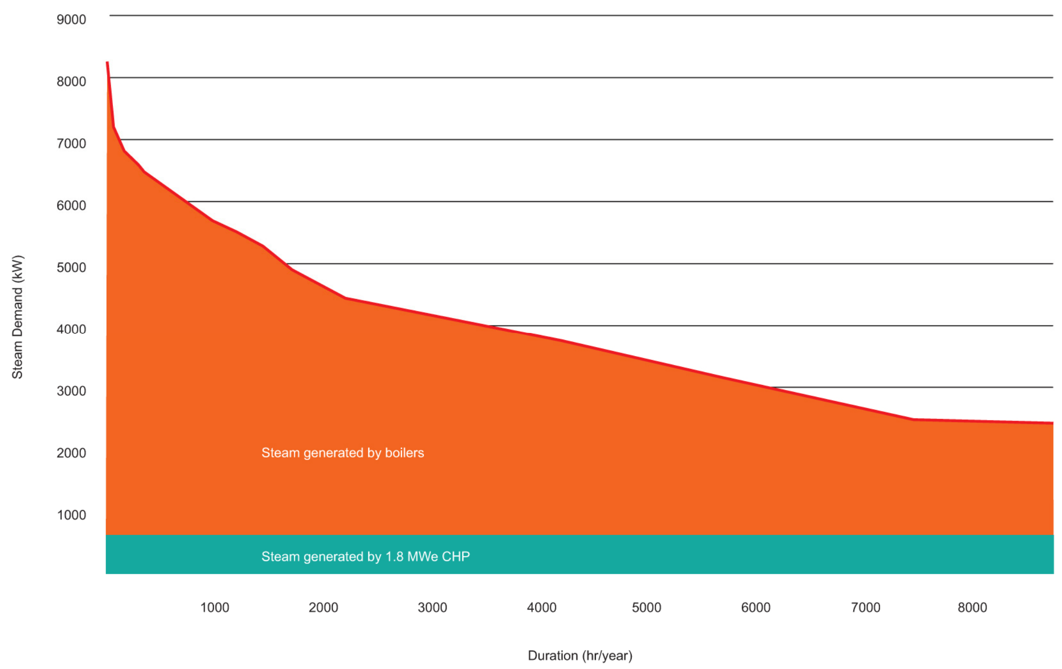

Figure 7-5. Steam load profile overlaid with the proposed CHP

7.19
Figures 7-6 and 7-7 show daily heating load profiles for a typical day in summer and winter, respectively. The heating load profiles include the LTHW boilers. Steam is used for the process requirements and humidification and is not included in the LTHW profiles.

7.20
The peak in the summer profile (Figure 7-6) is due to the external night-time temperature dropping to approx 11°C, which requires heating for the BRF to maintain the required 21°C (± 2°C). The external temperature rises during day time and the majority of the heating is used for the fresh air load. In the summer the CHP plant needs to either run at a reduced output or heat is dumped between 14.00pm–16.00pm. Generating both LTHW and steam from the CHP ensures that a large portion of useful heat generated is utilised all year round.

7.21
During winter (Figure 7-7) all the heat generated by the CHP plant is used. The vast majority of heating is for the large fresh air load.

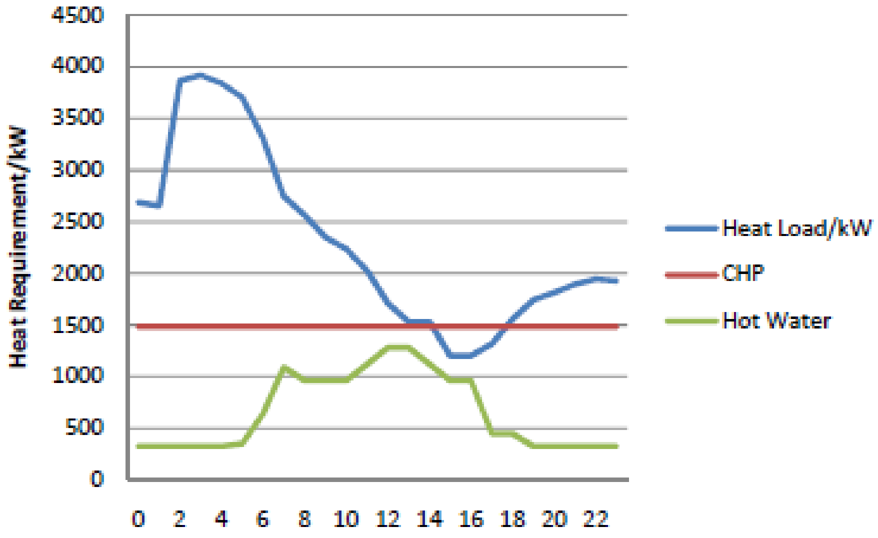

Figure 7-6. Typical daily (0 – 24 hours) heating load profile in July

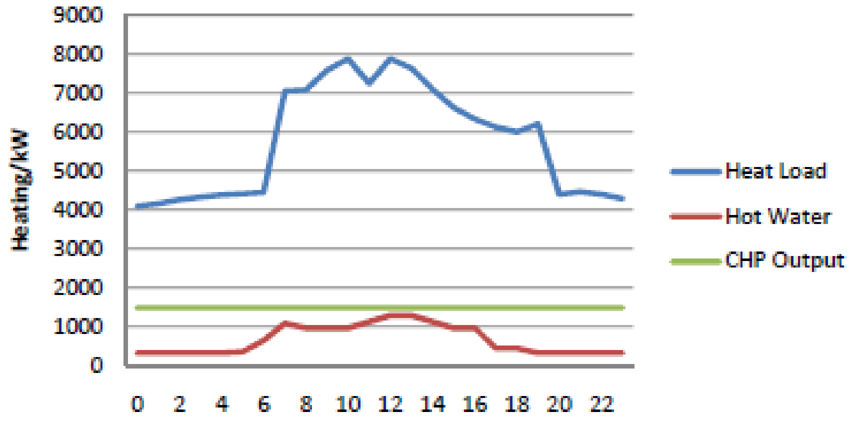

Figure 7-7. Typical daily (0 - 24 hours) heating load profile in January

7.0 Be Clean – CHP Appraisal

7.22
CCHP Feasibility Analysis for UKCMRI
The potential of incorporating a CCHP system into the Proposed Development has also been assessed. The proposed gas fired CHP engine could be over-sized to generate on-site electricity and heat, with the extra waste-heat used to fuel an absorption chiller, which can provide the development's cooling requirements.

7.23
A number of plant configurations of the CHP/CCHP for the Proposed Development (Refer to Table 7-1) have been considered and the most efficient has been selected:

- Option 1 includes LTHW and steam boilers and cooling provided by water cooled chillers. This is the baseline for comparison with the other options.
- Option 2 adds a packaged CHP unit, so one of the conventional steam boilers is replaced with a combination steam boiler to recover heat from the engine exhaust gases.
- Option 3 considers an increased absorption chiller to support the base cooling load of 500 kW. The CHP size is increased to 2,200 kWe to meet the increased steam demand. This is considered to be the maximum feasible CHP size for the Proposed Development.

7.24
Tables 7-2, 7-3, 7-4, and 7-5 show respectively:

- Estimated gas consumption of the different CHP and CCHP options;
- Annual utility costs of the different CHP and CCHP options;
- Estimated CO_2 emissions of the different CHP and CCHP options. The CO_2 emission calculations are for the heating and CHP system, for comparison purposes only, and not for the overall building emission which includes electrical consumption; and
- CHP Quality Index (CHPQI) of the different CHP and CCHP options. The CHPQI is a key indicator of true CO_2 emissions savings. This is an evaluation metric formulated by the CHP Quality Assurance (CHPQA) in line with the UK government and EU directives, and indicates primary energy savings. A CHPQI of above 100 indicated primary energy savings.

7.25
The tables above show that the CHP and CCHP systems enable annual CO_2 emission savings to be made due to the displaced grid power.

Option	LTHW Boilers	Conventional Steam Boilers	CHP Plant	Heat Dump Radiator	Absorption Chiller	Cooling Tower
1	3 x 3,100KW	3 x 6,500kW				
2	3 x 3,100KW	2 x 6,500kW	1,800kWe	1,700kW		
3	3 x 3,100KW	2 x 6,500kW	2.200kWe	1,200kW	500kWc	1,000kW

Table 7-1. CHP and CCHP configuration options

Estimated Gas Consumption (MWh/year)	1 Steam and LTHW Boilers	2 CHP (1,822kWe)	3 CCHP (2,200kWe/500kWc)
Steam Boilers	49,189	41,277	43,968
LTHW Boilers	32,740	27,082	25,441
CHP	-	32,726	39,516
Total	81,929	101,086	108,925
Net Increase	-	19,157	26,996

Table 7-2. Estimated gas consumption of different CHP and CCHP options

Estimated Utility Cost (£/year)	1 Steam and LTHW Boilers	2 CHP (1,822kWe)	3 CCHP (2,200kWe/500kWc)
Gas	2,985,000	3,682,956	3,968,564
Power Generated	-	-1,723,758	-2,081,376
Power Consumed	-	-	-42,000
CHP Maintenance	-	160,000	195,000
Total	2,985,000	2,119,198	2,040,188
Net Increase	-	865,802	944,812

Table 7-3. Annual utility costs of different CHP and CCHP options, including savings from displaced power

Estimated CO_2 Emissions ($kgCO_2$/year)	1 Steam and LTHW Boilers	2 CHP (1,822kWe)	3 CCHP (2,200kWe/500kWc)
Gas	15,894,226	19,610,631	21,131,406
Power Generated	-	-8,159,120	-9,851,846
Power Consumed	-	-	147,700
Net Emissions	15,894,226	11,451,511	11,427,259
Net Reduction	-	4,442,715	4,466,967

Table 7-4. Estimated CO_2 emissions of different CHP and CCHP options, including savings from displaced power

	1 Steam and LTHW Boilers	2 CHP (1,822kWe)	3 CCHP (2,200kWe/500kWc)
CHPQI		126	122

Table 7-5. CHPQI of different CHP and CCHP option

7.0 Be Clean – CHP Appraisal

7.26
The highest CHPQI shows that the 1.8 MWe CHP installation (i.e. Option 2) provides the most efficient machine. Additionally, the capital costs for CCHP option is significantly (> 50%) higher than for CHP:

- Option 2 (1.8 MWe CHP) costs £1,815,000; and
- Option 3 (2.2 MWe CHP and 500 kWc absorption chiller) costs £2,760,000.

7.27
Moreover, absorption chillers would require additional plant space, including space at roof level for cooling towers. Heat would be supplied to the absorption chillers at a comparatively high temperature (80 - 100°C) and rejected from the absorber at a comparatively low temperature (30 - 40°C). This low grade waste-heat needs to be rejected from the building either via dry air coolers or water cooling towers. The absorption chillers require extensive heat rejection, which could only be accommodated at roof level, involving extensive pumping and therefore electrical energy consumption, and adding complexity to the Mechanical and Electrical (M&E) plant systems.

7.28
Due to the above cost considerations, alongside the limited improvement in CO_2 savings for a larger CCHP configuration, and the level of technical complexity (for ongoing maintenance and support), additional plant space and system complexity of installing an absorption chiller, a CHP installation without cooling (i.e. not CCHP) is proposed for the Proposed Development.

7.29
Enhanced, Clean Baseline (Be Clean)
The 'enhanced clean' scheme considers the incorporation of the energy efficiency and passive design measures (described in Sections 6.1 and 6.2), and an on-site CHP plant into the baseline scheme.

7.30
The incorporation of 1,822 kWe CHP plant will reduce the development's CO_2 emissions by approximately 17%.

7.31
The 'enhanced clean' energy consumption and CO_2 emissions for the building are shown in Table 7.6 for regulated and for non-regulated energy uses. Figure 7.8 represents the breakdown of CO_2 emissions for regulated energy only, i.e. by heating, hot water, cooling, lighting, auxiliary energy and CHP. Figure 7.9 illustrates an improvement in CO_2 emissions achieved due to incorporation of CHP plant ('be clean' scheme) over the baseline and 'be lean' scheme.

UKCMRI - CLEAN						
	Gas		Electricity			Sum
Regulated	Heating	Hot Water	Cooling	Lighting	Auxiliary	
Energy (MWh/year)	7,187		1,312			8,499
CO_2 Emissions (tonnes CO_2/year)	1,394		112			1,507
Non Regulated	Equipment, Cooking, BRF, Data centre etc.					
Energy (MWh/year)	90,322					90,322
CO_2 Emissions (tonnes CO_2/year)	17,522					17,522
Total	Regulated and Non-Regulated					
Energy (MWh/year)	98,821					98,821
CO_2 Emissions (tonnes CO_2/year)	19,029					19,029

Table 7-6. 'Be clean' energy consumption and CO_2 emissions breakdown by use

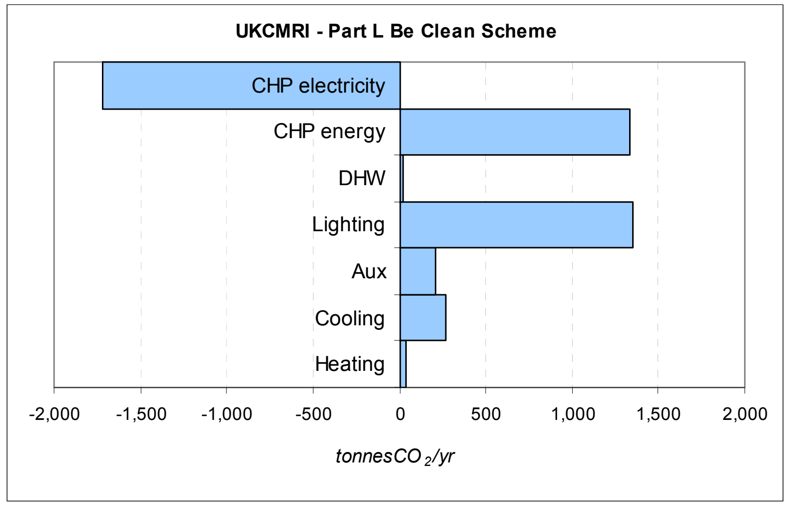

Figure 7-8. 'Be clean' CO_2 emissions breakdown by use – regulated energy uses only

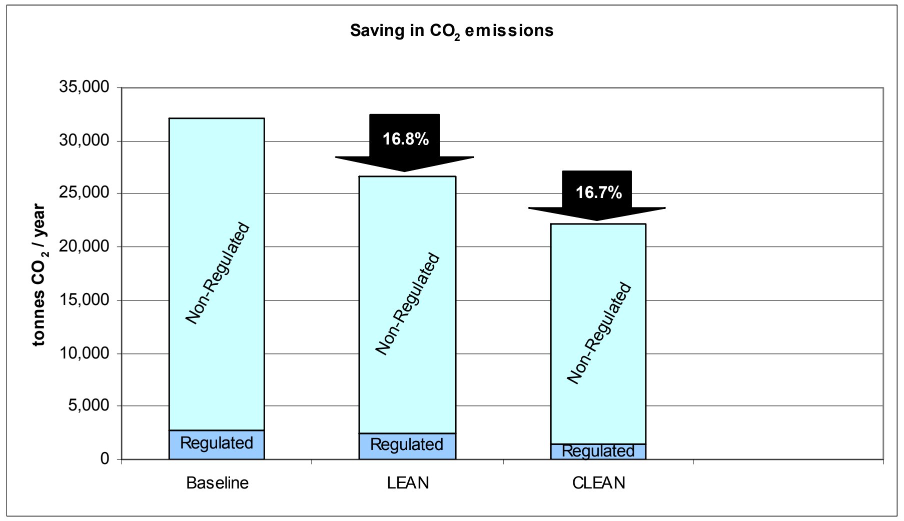

Figure 7-9. CO_2 emissions for baseline, 'be lean' and 'be clean' – regulated and non-regulated energy uses