UNEP / DFS / UNMIS
Technical Report

Assessment of Energy and Water Reduction Options for the Proposed UN House

Juba, South Sudan

UNEP

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Executive Summary

Rationale

The Environmental Policy for the Department of Peacekeeping Operations (DPKO) and Department for Field Support (DFS) came into effect on 1 June 2009. This policy, developed in cooperation with UNEP, provides a minimum set of environmental standards for UN Field Missions. These standards have been developed to minimize the environmental footprint of peacekeeping operations while maximizing the efficient use of natural resources. Application of these standards should reduce the overall consumption of natural resources and production of wastes, thereby reducing potential conflicts with local communities and enhancing the reputation of the UN as a leading organization in environmental sustainability. The application of sustainable technologies and practices also improves the self-sufficiency of bases, for example through energy production and water treatment, thereby reducing dependency on external supplies.

Given its environmental mandate, UNEP was requested by DPKO and DFS to provide technical assistance in the implementation of this policy.

Previously UNEP in co-operation with UNSOA, undertook an assessment of the resource-demand and operating practices of two proposed African Union Mission to Somalia (AMISOM) camps, in Mogadishu, Somalia and Mombasa, Kenya in June 2009. Building on this work, UNEP and UNMIS have collaborated to recommend sustainable technologies and operating practices to be included in the design and construction of the proposed UN House built in Juba, South Sudan, under UNMIS' supervision.

Using the same methodology as for the work done with UNSOA, each option has been ranked using a traffic light system of green (immediate adoption), yellow (further study) and red (not feasible) according to practicality, technical robustness and financial implications.

This report details the outcomes of this assessment and provides a set of immediate-, medium- and long-term recommendations for reducing energy and water footprints. Furthermore calculations have been completed assessing the contribution of the UN House to Greenhouse Gases.

Findings

Energy: A total of thirty-three energy efficiency measures were identified for the residential units with seventeen ranked as green, twelve as yellow and four as red. For the offices forty-nine energy efficiency measures were identified for the offices units with thirty-four ranked as green, thirteen as yellow and two as red. These are a range of measures to reduce cooling demand, lighting energy consumption, reduce hot water demand and energy, generate energy from low carbon technologies, improve controls, and provide metering to reduce the energy consumption of the building. Based on the calculated reduction in energy consumption from a baseline thermal model, the carbon footprint of the 358 residential units could be reduced by 775 tonnes of CO_2 (27 percent) while the six new offices could be reduced by 243 tonnes of CO_2 (36 percent).

Water: A total of fifteen technology options and best practices were considered in order to reduce water consumption. Ten were ranked as green and five as yellow. Of the green options, the analysis found that water consumption could be reduced by 37 percent in the residential units and 46 percent in the office units, through the adoption of recommended technologies. The most significant savings come from the adoption of technologies for urinals, toilets, showers, and hand washing. Importantly for the offices, significant savings come from the incorporation of measures that are aligned with the occupancy profile of the offices.

Greenhouse gas emissions: The total estimated emissions for UN House in Juba once operating at full capacity is 19521 tonnes of carbon dioxide equivalent (CO_2 e) per annum of which 16553 tonnes per annum is derived from electricity generation and the bulk of the remainder from vehicle usage

Priority recommendations

This assessment provides a series of immediate-, medium- and long-term recommendations, which reflect the commitment to ongoing reductions in resource-consumption and carbon emissions. There is a single immediate recommendation:

Conduct a review of the herewith proposed resource-reduction measures by UNMIS/DFS experts to enable the adoption of specific measures for inclusion into the design. This could be as, for example, performance specifications. This should be undertaken in line with the programme for contractor assessment and appointment. The effectiveness of this recommendation is controlled by the programme for contractor appointment; for full potential to be realised detailed communication between UNMIS and contractor's is required prior to final appointment.

Particular focus is required on the following recommended measures, with "green ranked" solutions presented in Appendices 2, 3, and 4. These recommendations reflect the current fluidity that exists in the design and construction of the remaining units--both office and residencies--and the need to alter design or seek additional emphasis on aspects that may not be reflecting its true potential efficiencies. All energy demand measures will later need to be underpinned by information and education to all staff on the site to ensure that energy good practice is built into daily life staff behaviours.

For the offices:

Air tightness: significant savings in overall energy use can be gained by improving the air tightness of the buildings. However, this will require additional local or centralised mechanical ventilation to deliver sufficient fresh air for the office areas.

Central Cooling: Centralised cooling can improve efficiency and improve service control. Importantly centralised cooling allows for the connection with low carbon technologies at construction or in the future.

Combined Heat and Power with Absorption Cooling: Diesel generators produce electricity and heat. With the existing design only the electricity is captured and the heat is wasted. The process to produce electricity is only 35-40 percent efficient. Significant energy savings at the site will be realised if the diesel generators can be made to be more efficient. Combined heat and power units (CHP) are like generators but enable the heat to be utilised as well as the electricity, increasing the overall efficiency of the unit. The waste heat can be used to generate cooling within an absorption (or adsorption) chillers. This can either be from a centralised chiller (from one or two CHP units) or packaged absorption chillers available for each building.

Low energy lighting: Install LED or low wattage lights where feasible with occupancy sensors for relevant areas

Building Management Systems: These provide additional control with provision of half hourly metering for cooling, lighting and small power (discussed separately in Appendix 5)

Renewable technologies: Photovoltaic's and solar thermal should be maximised where economic and feasible.

Urinal controls and dual flush toilets: The installation of an appropriate urinal flushing system (operator activated or dry flush) – continuous flush urinals operate even at times when the offices are unoccupied significantly wasting water.

For the residences:

Efficiency of air-conditioning unit: Specification should require seasonal efficiencies of at least 3.5 COP as this has a significant impact on energy consumption.

Insulation: Add insulation to improve the thermal performance of the wall to reduce the cooling load.

Renewable technology: Solar thermal should be specified for each unit and photovoltaics if cost effective.

Controls: Adding a last man out switch for all electrical demand in the unit (or include a key card occupancy control) will reduce energy demand.

Low energy lighting: Low energy LED lighting should be specified for internal lights and occupancy and daylight timers for external lights.

De-centralised power: It would not be possible to distribute chilled water from the existing location of the energy centre. However it is recommended that the feasibility should be considered of a localised energy centre with diesel generators and one or two CHP units, the residential units could benefit from the waste heat from electrical generation used within an absorption chiller.

Aerated Showerheads and taps: The provision of aerated units will substantially reduce the water consumption.

Future test units

Orange and red ranked initiatives and technologies while not considered relevant within the context of the immediate- to short-term build profile of the Juba camp could become more relevant over time. The development of test units within the camp would offer the facility for innovation to be tried on a practical level. It is recommended that a residential unit be constructed with metering installed that could allow for measurement of water and energy reduction initiatives – metering would be installed on the main power and water incomers with submeters installed where detailed assessment is required for any equipment specific measures.

Acronyms List

AC:	Air Conditioning
AMISOM:	African Union Mission in Somalia
BMS:	Building Management System
CEB:	UN Chief Executive Board
CHP:	Combined Heat and Power
DFS:	Department of Field Support
DPKO:	Department of Peacekeeping Operations
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Plan
FOI:	Swedish Defence Research Institute
GHG:	Greenhouse Gas
GRI:	Global Reporting Initiative
REAP:	Re-engineering Assessment Practices
REEIO:	Regional Economy Environment Input Output model
LED:	Light-Emitting Diode
LEED:	Leadership in Energy and Environment Design
BREEAM:	Building Research Establishment Environment Assessment Method
CASBEE:	Comprehensive Assessment System for Building Environmental Efficiency
HLCM PN:	High-Level Committee on Management Procurement Network
HQ:	Headquarters
IT:	Information Technology
LED:	Light Emitting Diode
MSW:	Municipal Solid Waste
Pa:	Per annum
PIR:	Passive Infra-red
PV:	Photo-voltaics
UNEP:	United Nations Environment Programme
UNHCR:	United Nations High Commissioner for Refugees
UNMIS:	United Nations Mission in Sudan
UNSOA:	United Nations Support Office for AMISOM
VSD:	Variable Speed Device

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1 Introduction

UN peacekeeping camps make an important contribution to the recovery and sustainability of zones impacted by conflicts. However, the introduction of people and support infrastructure can place considerable demands on local, regional, and national ecosystems and communities. Ranging from environmental pollution to resource degradation, additional stress can also be placed on the poverty and health of local populations if environmental impacts are left unmanaged.

DPKO and DFS are keen to develop a practical approach to peacekeeping camp design, installation and operation that will protect the environment while also enhancing the lives of people living in these areas.

In response to a growing recognition of the importance of environmental management in peacekeeping operations, the Environmental Policy for the Department of Peacekeeping Operations (DPKO) and Department for Field Support (DFS) came into effect on 1 June 2009. The policy, developed in cooperation with UNEP, was intended to minimize the environmental footprint of UN Field Missions and maximize the efficient use of natural resources within each phase of a mission. These include initial planning, construction, operation and closure. Given its environmental mandate, UNEP has been requested by DPKO and DFS to provide technical assistance in the implementation of this policy.

In 2009, an initial pilot study to assess the impact of two proposed UNSOA/AMISOM camps one in Mogadishu, Somalia and the other in Mombasa, Kenya confirmed that significant savings for both power and water consumption (and from this reduction in greenhouse gas emissions) could be achieved by influencing both the design and operation of the camps with practical technological and behavioural change options. A number of recommendations have been made for inclusion of resource saving measures into the camps.

This study for UNMIS follows the same format as that adopted successfully for UNSOA/AMISOM. However, it is to be noticed that in view of the different nature of the UN House to a traditional peacekeeping camp, with long-term presence and reduced constraints over mission readiness, applicable environmental sustainability options are generally greater. The overall intention remains to provide recommendations for the inclusion of resource (power and water) saving and liquid waste management technologies and practices into the design and operation of the camp. Also, it is to be noted that, differently from the UNSOA/AMISOM study, the solid waste management aspects were not part of the Terms of Reference of this work.

The first objective of the assessment is to determine baseline figures for energy and water consumption based on the existing designs and standards. Using the model adopted for AMISOM the profile of camp occupation and subsequent power and water consumption has been assessed in line with provisioning requirements as detailed by DFS convention. The baseline assessments are presented in chapter 3. In addition to this an assessment has been made of the greenhouse gas emissions from the proposed camp using the UN Greenhouse Gas calculator.

A second objective is to review the energy efficiency of the designs proposed for the office and residential accommodation using computer modelling. The output of this will allow for alterations to the design to promote further efficiencies.

The third objective of the assessment is to review and identify resource efficiency measures and technologies that could be applied during the design, construction and operation of the camps to achieve a reduction in energy and water consumption. A similar study completed for UNSOA/AMISOM adopted three criteria for assessment of resource efficiency options - practicality (ease of use), technical robustness and financial implications. These have been retained in this study for UNMIS. A 'traffic light' categorisation system was adopted to rank measures and technologies. Within the grading system, initiatives ranked as 'green' are those considered to be applicable in the immediate-term and are detailed further within chapter 3 of this report. Initiatives categorised as 'yellow' require further assessment and may be applicable under different operating environments. Finally those classified as 'red' are deemed as not applicable. All of the technology options and best practices considered are listed in annexes 2, 3, and 4.

The fourth objective of the assessment was to calculate the potential savings that could be achieved from the application of the measures and technologies ranked as green. The carbon footprints of the camps were also calculated for the existing camp design and for the revised design incorporating the proposed resource-efficiency measures. These calculations are presented in chapter 4.

The main conclusions and recommendations of the report are presented in chapter 5. They are intended to support the effective implementation of resource-efficiency measures and practices and have been presented mindful of two main issues:

1. The need to influence the design of the proposed development – so that significant savings that can be achieved by altering the way that buildings are constructed and effectively operate
2. The need to offer recommendations that are practical and effective mindful of the operating environment.

2 Assessment methodology

2.1. Step 1. Development of 'baseline' datasets

Step 1 of the assessment was to obtain and analyze the design specifications and operational parameters of the proposed development.

Baseline datasets were calculated for energy and water consumption using as a principal basis the provisioning requirements as detailed by DFS and adopted for the UNSOA/AMISOM report. Any assumptions within these datasets have been given 'reality checks' through discussions with UNMIS engineers. Assessment and analysis of the baseline datasets allow potential resource-efficiency measures to be identified, evaluated and ranked in Step 2. The amount of potential reductions from the adoption of "green ranked" resource-efficiency measures can then be calculated in Step 3. The baseline datasets that were generated and the assumptions that were used are described in the following section.

The detailed design specifications and operational parameters are listed in Table 1. These parameters are the standard baseline against which all camps are constructed. They are the basis for the baseline energy and water consumption calculations found in chapter 3.

Table 1- Design Specifications and Operational Parameters

Design Feature	
Phasing	An important aspect to the construction and occupation of the site is the phasing or time-related programme which is linked to the expected input of UN agencies other than UNMIS. Unlike conventional peacekeeping camp, with a 'lifetime' of between 5 and 10 years, the UN House complex has a life expectancy up to 25 years, perhaps more. In this respect the operational control is likely to pass from DPKO/UNMIS to another agency.
Occupancy	1000 people – residential 1500 people – workers on site during the day **Fully occupied after 5 years**
Compound	Secure compound.
Offices	11 office blocks in total; four of the office blocks have been built (as of October 2010). These are steel and concrete construction over two floors. A suspended ceiling provides void space for utilities. The intention is to open plan the offices and cool them with split AC's located above the windows. The orientation of the buildings is on a square format and so those aligned north east and south west will catch the prevailing winds. No ventilation is available in the roof.
Living Accommodation	This takes the form of two domestic units of three rooms each– living space, bedroom and wash room. Orientation will generally be in the direction of prevailing winds. Roof is pressed aluminium/steel curved to provide an overhang to shade the windows from midday sun. They are of single brick construction and over a single floor however a significant roof void has been created by the curve of the roof –this space is vented with air holes/air bricks but separated by a suspended ceiling. A single split AC will be provided per domestic unit – two per accommodation block. Insulation will be provided on the suspended ceiling

	Living accommodation is provided for 1000 people -phased construction and occupation over 5 years.
Catering	Two outdoor-type restaurants and two messing halls.
Offices	Office blocks are of 120 people capacity - each block to be serviced with 1 computer per individual (120 per block total), supported with 6 copier / printers. These will run for 12 hours per day
Water supply	To be provided through abstraction from the ground followed by treatment
Water treatment	To be provided from a series of potable treatment unit of 5000 litres per hour maximum capacity. Final discharge following treatment will be to an evaporation pond 4.5l/d consumption of potable water, 80l/d chlorinated water for washing will be allotted
Liquid waste	To be treated using an on-site sewerage treatment plant and then disposed of in evaporation ponds or discharged to local water courses. Some grey water will be re-used for non-sensitive purposes. Total liquid waste equates to 84 litres per day with an additional 2580 l/d originating from each office block (63% grey water from ablutions etc), 37percent blackwater (toilets)
Vehicle fleet	SUV vehicles – 5.4 million km per year Buses – 96000 km per year Helicopters – 100 000km per year
Other	Not considered within this study are the clinic, cottage industries, as well as the few two storey residential units.

Energy assumptions

Two main profiles for energy consumption exist within the proposed camp – offices and residential. Assumptions relating to design and servicing arrangements are detailed for the both of these profiles below in table 2. Energy assumptions are based on designs, specifications and drawings and specifications provided by UNMIS.. Where information is not available assumptions have been based on previous designs as detailed by DFS and used in the UNSOA study. Any additional assumptions have been, where feasible, based on CIBSE (UK Chartered Institute of Building Service Engineers) and ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) guidelines and design standards set out in the Estidama Pearls for Sustainable Design of buildings Abu Dhabi.

Thermal Modelling: Baseline assumptions have been assessed using IES Dynamic Thermal Modelling Software. This software calculates hourly energy consumption based on the provided geometry, designs and assumptions on building services and occupancy against the standard annual weather profile for Juba. This software provides a sophisticated baseline model against which to test energy efficiency measures.

For both residential and office energy demand calculations, it is assumed that primary energy demand will be affected by the generating of electricity at 38 percent (efficiency) from diesel generators i.e. for every 1000 litres of fuel put into the generator only 380 litres if it will be used in the provision of electricity – the rest is wasted. This therefore has a significant impact on primary energy supply.

Table 2- Baseline Design Assumptions – residential and office

	Residential	**Offices**
Design Feature	**Based on UNMIS specifications**	**Based on UNMIS specifications**
Occupied period	6pm to 8am	8am – 6pm
Area	36.44 m2 (excluding veranda area)	964.8m2
Power generation	Diesel generator for electricity - assumed 38% efficient. No heat captured.	Diesel generator and electricity - Assumed 38% efficient
Orientation	Front door facing south (can vary depending on cluster orientation)	Building aligned north-east south-west to catch prevailing wind
Door	Wooden door assumption of U-Value of 3W/m2/K	Assumption of U-Value of 3W/m2/K
Walls	Brick 22cm, no insulation U-value of 2.12 W/m2K	Steel frame and concrete - no insulation
Roof	Aluminium/Steel Layer of insulation materials (Fibre glass rolls) will be inserted over the gypsum board panels, thus increasing the insulation capacities of the ceiling (50mm insulation). U-value of 0.57W/m2K	Steel frame and concrete - no insulation
Floor	Assumed concrete slab - no additional insulation U-value of 0.37 W/m2K	Steel frame and concrete - no insulation
Windows	No information - assumed metal frame, no solar shade, single glazed U-value of 5.32W/m2K (G-value: 0.86) (G value defines coefficient of the permeability of total solar radiation energy. The closed to zero the better performance to reduce solar radiation)	Designs in some plans of 1.4 x 1.4m, Assume single glazing, no solar film
Cooling	AC Unit assumed 18000 BTU split with emitter in living room and kitchen Efficiency of air conditioners assumed at 2.8 COP. Thermostat assumed to be set at 25^{0}C	28 air conditioning units (splits), 18000 BTU kW cooling COP 2.8 , local units placed above windows (not through the window design)
Ventilation	Fan in AC unit to bring in air - energy consumption unknown Ceiling void created by curved roof is vented with air holes/air bricks Windows will be open able	Through fans in air conditioning units – 5 ACH AC Temperature set point 25 degrees C
Air permeability	30 m3/h/m2 - This collarets to similar levels of air infiltration in the UK to 1995 Building Regulations	Same
Shading	Overhang from curved roof	Assumed no shading devices, and no trees etc
Internal Lighting	Assumed 5 x 18W - no controls (two in the living room, two in the bedroom and one in the bathroom)	Total 15 W/m2 (Office are 18W lights and toilets tungsten bulbs)
External Lighting	Assumed 2 X 36 W -manual controls	n/a
Hot water	Assumed 30 litre store (100 litres per day from 20-60degeeC) from diesel generators	Assumed 7kWh/m2 for hand washing only
Additional Small power	2.7kW in living room (60% diversity of 4.8 kW) occupied hours Small power load has been calculated based on the UNDPKO Draft Specification for Prefabricated buildings and an additional diversity factor has been added to account for mainly night time use.	Computers, printers, phones, modems faxes etc - 15 W/m2 Small power loads are calculated based on benchmark figures for a typical open plan office.
(De)humidification	Assumed none	Assumed none
Metering	No Metering	No metering

Water assumptions

As with energy there are two main water consumption profiles within the camp – residential units and offices units. While together they give an indication of the anticipated total output their individual consumption profiles differ reflecting their operational differences.

Residential

In line with the occupancy profile water consumption will equate to 21125 litres per day (lpd) will originate from residences within the camp by the end of 2011, 33800 lpd by the end of 2013 and 84500 lpd by the end of 2015.

These figures relate to water consumption from three main sources including: showers, toilets and personal ablutions. Allowances have been made for communal activities such as kitchen washing, dishwashing, food preparation, laundry and external use. Personal consumption of 4.5 litres per day remains the same.

Offices

The consumption profile for offices relates principally to the use of water for sanitary purposes including hand washing. For a single office block of 120 people occupancy this equates to 2580 lpd per office block.

Currently it is understood that water will be abstracted from the local aquifer through three boreholes already installed on site. It is assumed that an appropriate assessment will be made of the sustainability for any natural water feature to support abstraction without causing long-term environmental impacts. All water will be treated prior to consumption by potable treatment units each with a 5000 litres per hour or 120,000 litres per day maximum capacity.

At present rainwater harvesting is believed to be practiced but on an ad hoc basis and no information is available regarding the efficiency of such systems, as such this system has been excluded from more detailed assessment within this study. Rainwater harvesting is an efficient process that provides an alternative source of water for camp use and is used in a variety of environmental and social settings, however engineering considerations such as volume capacity and storage and retention time (to avoid degradation of the quality of the water and subsequent health risks) are important factors.

Liquid Waste

Liquid waste was assumed to be the combination of potable water (4.5 litres) and non-potable water (80 litres) provision for a total of 84.5 litres per day per person for the residential component and 2580 litres per day arising from each office block – this latter equating the consumption profile arising from use of toilets and washbasins The DPKO/DFS Environmental Policy for UN Field Missions states that there will be no discharge of wastewaters directly into streams, rivers or other bodies of water without prior treatment. Sewage will be treated on-site. Wastewater requiring treatment will be held in a septic tank and, following a sufficient residency time, transferred to the wastewater treatment unit. Following treatment, it is understood that the wastewaters are dealt with in numerous ways. It is assumed that all wastewaters are tested to ensure compliance with wastewater discharge consent criteria. The following three disposal pathways are assumed:

Grey water (water that is not contaminated with human wastes) is discharged to the natural environment. It is acknowledged that provision exists within current documentation that some aspect of re-use be considered to the extent possible in non-sensitive areas such as irrigation or toilet flushing, after which it becomes black water requiring treatment prior to discharge. Any excess will be discharged to an evaporation pond, currently being constructed.

2.2. Step 2. Evaluation of resource efficiency measures

Following the development of the baseline parameters, a review of resource efficiency measures for reducing energy, water and waste was undertaken. Acknowledgement is required of the work completed for the UNSOA/AMISOM study. South Sudan has a climate and operating environment similar to that in Mogadishu and therefore many, of the options assessed as being applicable in Somalia are applicable here. Of course, there are intrinsic differences in the constituent components of camp operation and expectation and these have been taken into account – for instance the use of photovoltaic cells can be considered applicable in the context of Juba whereas these were discounted in the context of Mogadishu due to practicality of operation in a high security context.

As with UNSOA/AMISOM, three main criterion were considered: practicality (ease of use), technical robustness and financial implications. A 'traffic light' categorisation system was adopted to rank technologies. Within the grading system, initiatives ranked as 'green' are those considered to be applicable in the immediate-term and are detailed further within chapter 4 of this report. Initiatives categorised as 'yellow' require further assessment and may be applicable under different operating environments. Finally those classified as 'red' are deemed as not applicable. All of the technology options and best practices considered are listed in appendices 2, 3 and 4. Where it was not possible to assess options, best practice was included within the narrative text.

Figure 1. Explanation of traffic light categories used in the assessment

	Green: Initiatives categorized as "green" are considered to be viable and are deemed to withstand the rigours of a peacekeeping operation. This includes cost (initial outlay and operational expenditure), robustness and ease of use. These are recommended for immediate consideration by UNMIS and are to be included within the design plans for the two sites and for deployment in existing camps.
	Yellow: Initiatives categorized as "yellow" require further consideration as one or more characteristics (costs, technical robustness or ease of use) were deemed to be unsuitable for the site. However they should be re-assessed and selected measures should be adopted on a pilot basis.
	Red: Initiatives categorized as "red" are presently unsuitable in that they do not achieve the three criteria – ease of use, technical robustness and financially acceptable. This does not preclude that they may fulfil the criteria at a later date.

2.3. Step 3. Calculation of potential reductions

Based on the traffic light system, step 3 involved calculating the potential energy, water and waste reductions that could be achieved from the adoption of the green ranked resource efficiency measures. A comparison of the baseline parameters with the revised parameters was conducted.

3 Baseline analysis

3.1. Overview

Using information provided in the DFS camp provisions and specifications spreadsheet, the consumption levels for energy and water as well as the production levels for liquid waste were estimated.

Furthermore consumption profiles have been split on the basis of residential occupation and office occupation using office ‘types’ as advised by UNMIS.

3.2. Energy

Residential Baseline Energy and Carbon Emissions

The annual energy demand profile for the residential units has been determined through thermal modelling computer software. The energy consumption figures and related carbon emissions are provided in the tables below. It is important to note that energy is provided as primary energy supply, which takes account of the efficiency of the diesel generator. Actual energy demand would therefore be 62 percent lower than these figures. Carbon emissions are calculated on the carbon emission factor of diesel (0.25kg CO_2/kWh).

Visual charts show the carbon emissions by end uses for the single residential and office units. Regardless of scaling the proportions remain the same.

Table 3 – Annual Energy Consumption for Residential Unit (1 unit- 3 rooms)

End Use	Size (kW)	Hours run	Diesel Energy (kWh)	CO_2 (t)	Notes
Lighting Internal External	 0.09 0.07	Manual control 14 hours daily	2,178	0.54	None
Cooling	As required	Operation determined by model	11,397	2.85	Assumed a 18 000 BTUunit, however size is based on demand during occupied hours to meet 25°C temperature in dynamic model
Hot Water	Sized for 30 l store		5,173	1.29	None
-Small Power	4.8 kW with 60% diversity.		9,078	2.27	The model being run during night time assumes stand by or sleep mode – 75% reduction over full operational mode
Ventilation (fans)	Within AC units.		4,331	1.08	None
Total			**32,157**	**8.04**	

From this baseline modelling, cooling and small power have the highest energy demand. Information relating to equipment energy consumption has to be added as a set value into thermal modelling software. As a result the output consumption is more dependent on the input data rather than the energy demand requirements and will not vary with the annual weather profile. As small power generates heat, the level size and operation of these power loads within an accommodation unit also has a bearing on the chillers and fan loads.

Chillers and fan loads are based on achieving an internal temperature of 25°C. With occupancy pattern set at 6pm to 8am these loads will be relatively small compared to the day time office requirements.

Using the calculated reduced energy consumption for one residential unit, simple multiplication (by a factor of 358 which represents the number of single units on the masterplan) provides the overall energy consumption and carbon emissions from these units.

Table 4 – Annual Energy Consumption for Residential Units (358 units)

End Use	Diesel Energy (kWh)	CO_2 (t)
Cooling	4,080,069	1,020
Fans	1,550,423	388
Lighting	779,875	195
Small Power	3,249,792	812
Hot Water	1,851,898	463
Total	**11,512,057**	2,878

Offices Baseline Energy and Carbon Emissions

As with the residential units, annual energy demand for a typical office on the site has been calculated using thermal modelling software based on the assumptions and the standard weather profile for Juba. Demand figures and related carbon emissions are based on primary energy from the diesel generators.

Table 5 – Annual Energy Consumption for Office (1 Office)

End Use	Size (kW)	Primary Energy (kWh)	CO_2 (t)	Notes
Cooling	Variable depending on outside and inside temperature	211,511	53	Based on 28 units of 18000 BTU
Ventilation (fans)	-	80,374	20	-
Small Power (accommodation)	-	65,185	16	-
Lighting (internal)	-	88,741	22	-
Hot Water	-	6,755	1.69	-
Total		**452,566**	**113.14**	**-**

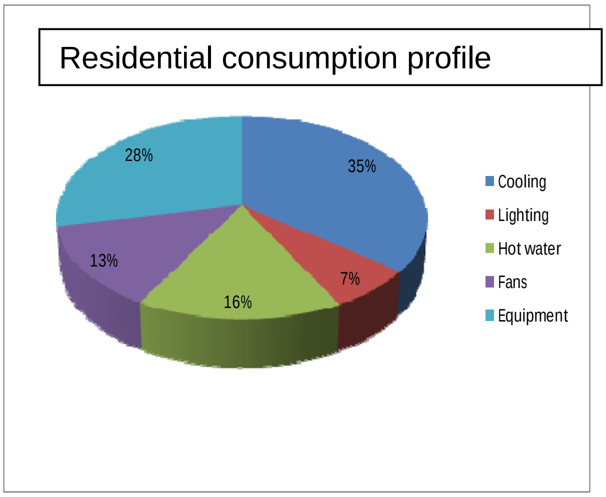
The largest energy demand in the base design of the office building is for cooling requirements:- this is followed by lighting, fans for ventilation and small power requirements (computers, printers etc). Domestic hot water demand for the office is small as it is just required for hand washing. It is assumed that no catering facilities are provided within the offices and that staff use the restaurants and cafeterias on the site.

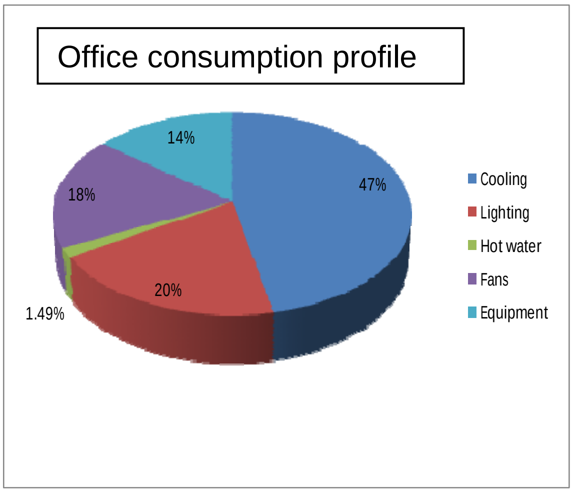
Energy reduction measures for the offices should therefore be targeted at the cooling, lighting and fans equipment to make the most savings.

Table 6 – Annual Energy Consumption for new offices (6 offices)

End Use	Diesel Energy (kWh)	CO_2 (t)
Cooling	1,269,063	317
Fans	482,244	121
Lighting	532,448	133
Small Power	391,108	98
Hot Water	40,530	10
Total	**2,715,393**	679

Figure 2. Energy and carbon footprints – residential and office units





3.3. Water

The baseline estimates for water consumption based on an assessment of the consumption profile is presented in Tables 7 and 8. The associated water footprint is presented in Figure 3. The table takes into account principal water demand usages and utilizes standard volumes of water consumption based on UK reference values[1].

While the profile focuses on the 'residential' aspect of camp occupation and incorporates issues such as washing, food preparation, laundry etc, the profile relating specifically to the use of offices has also been assessed (reflecting the ability to influence consumption at design stage).

Table 7 –Total Water Consumption – residential units per year

Use	Litres	Units	Litres per person per day	Usage per year - occupation 1000
Shower	37.5	1	37.5	13687500
Toilets	7	4	28	10220000
Handwashing	2	4	8	2920000
Personal consumption	1	4.5	4.5	1642500
Fixed usage communal				
Kitchen washing	200	4	1.00	365000
Food preparation	280	6	2.10	766500
Dishwashing	140	5	0.90	328500
Laundry	240	5	2.00	730000
External use	200	2	0.50	182500
Total (litres consumed)			**84.5**	**30842500**

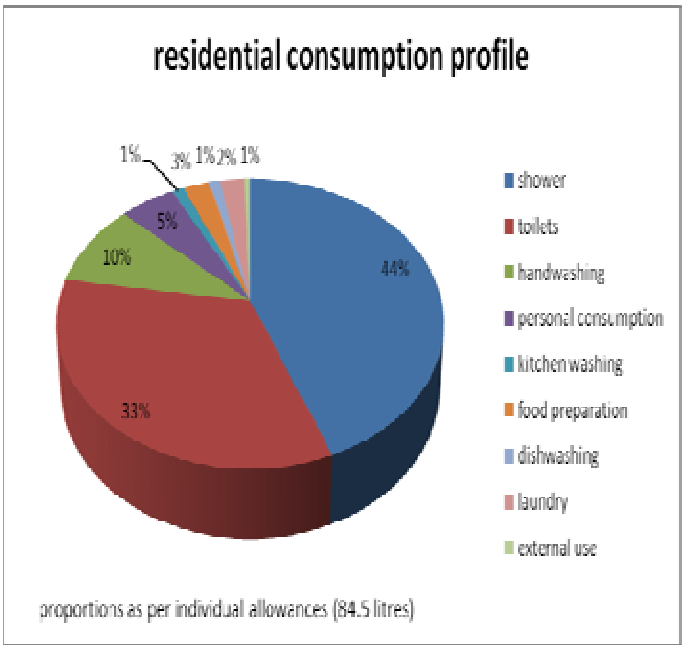
Note: the third column (units) represents the number of times per day the usage of either that activity or process listed in column 1 – this is based on the following reference material -l UK Environment Agency - Conserving Water in Buildings, 2007. http://www.environment-agency.gov.uk/static/documents/Leisure/geho1107bnjree_1934318.pdf

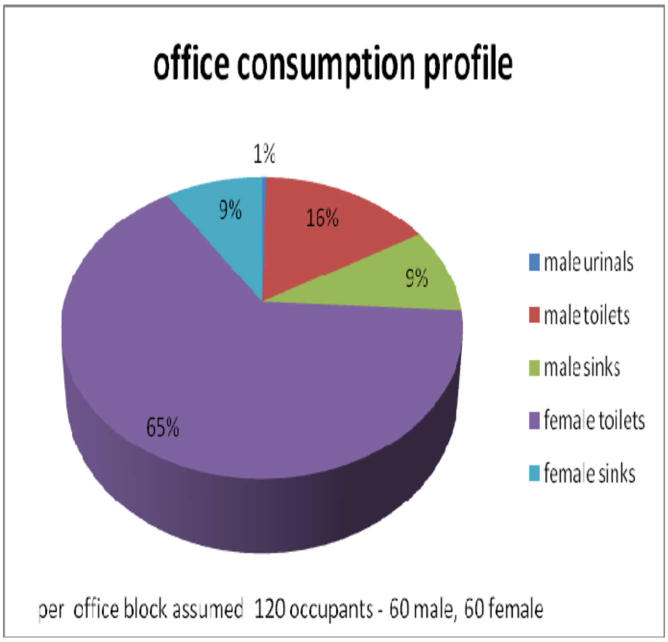
1

Table 8 – Total water consumption – single office block per year

Use	Consumption	Unit	Consumption per person per day	Usage per year for a single office block (occupancy 120 people)
Male urinals	720	constant	12.00	262800
Male toilets	7 litres per bowl	1	420.00	6552000
Male sinks	2 litres per wash	2	240.00	3744000
Female toilets	7 litres per bowl	4	1680.00	26208000
Female sinks	2 litres per wash	2	240.00	3744000
Total litres consumed			**2580**	**40510800**

Figure 3. Water footprints – residential and office components

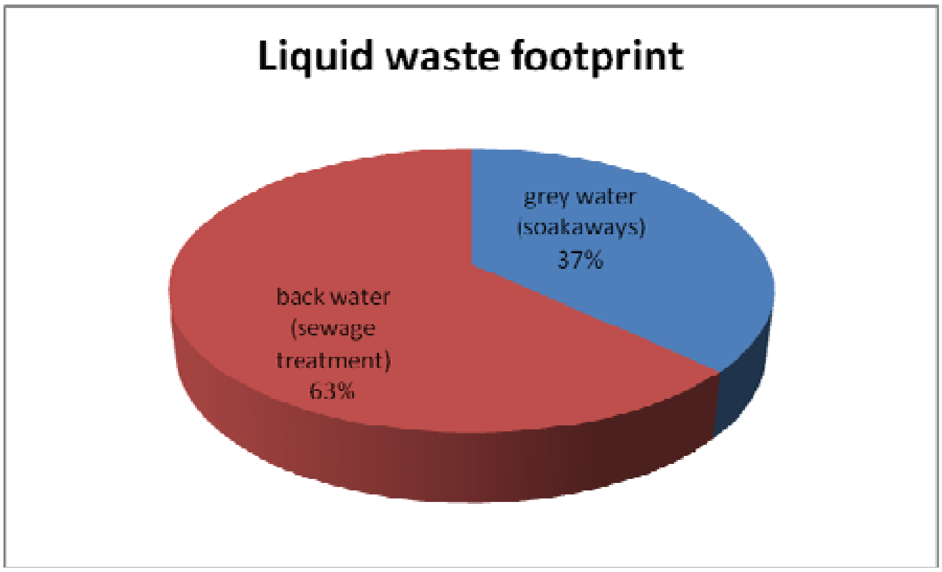




3.4. Liquid Waste

The volume of liquid waste requiring treatment before exiting the camp has been calculated at 84 litres of wastewater per person per day. Figure 4 presents the proportion of liquid waste disposed as black water (37 percent) and as grey water (63 percent).

Figure 4. Estimated liquid waste footprint



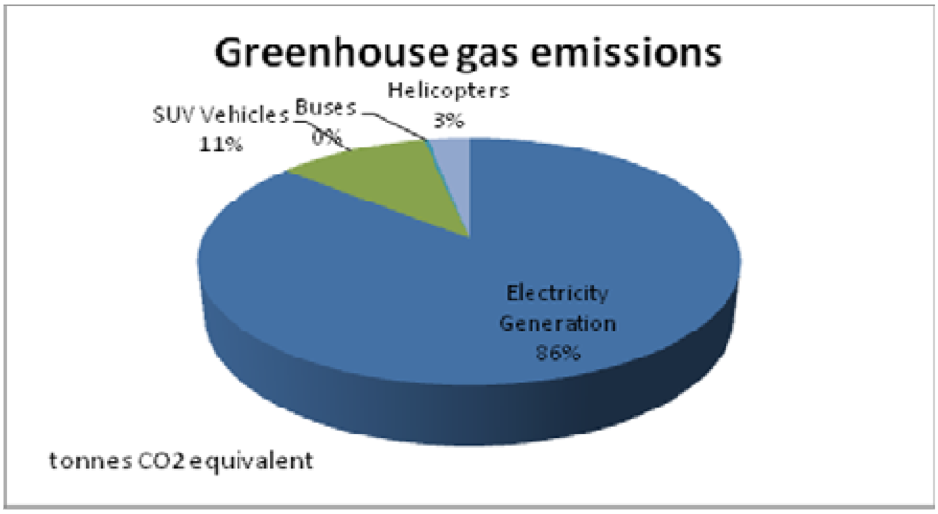
3.5. Greenhouse Gas Emissions

The total estimated emissions for UN House in Juba once operating at full capacity is 19521 tonnes of carbon dioxide equivalent (CO2 e) per annum. Table 9 shows these emissions by source and type of GHG gas. Figure 5 shows the breakdown of these emission sources on a percentage basis, this provides a better feel for the share of emissions per activity and can assist in identifying areas where emission reductions can be made in the future.

Table 9 – Sources of Greenhouse Gas Emissions

Source/ Activity	Nitrous Oxide N_2O (Tonnes)	Carbon Dioxide CO_2 (Tonnes)	Methane CH_4 (Tonnes)	CFCs/ HFCs / HCFCs (Tonnes)	Total CO_2 e (Tonnes)
Electricity Generation	0.357 (106.4 tCO_2 e)	16,553	2.22 (55.5 tCO_2e)	-	16,695
SUV Vehicles	0.042 (12.5 tCO_2 e)	1,970.5	0.264 (6.6 tCO_2e)	0.072 of R-134a (103 tCO_2e)	2,093
Buses	0.001 (0.3 tCO_2e)	60.0	0.008 (0.2 tCO_2e)	0.002 of R-134a (2.86 tCO_2e)	63
Helicopters	0.013 (3.9 tCO_2e)	564.4	0.079 (2.0 tCO_2e)	-	570
Fugitive Emissions of Refrigerants	-	-	-	0.0624 R-134a (81.1 tCO_2e)	81
Sewage Treatment	-	-	0.74 (18.5 tCO_2e)	-	19
TOTAL EMISSIONS	**0.413 (123 tCO_2e)**	**19,148**	**3.311 (83 tCO_2e)**	**0.136 (177 tCO_2e)**	**19,521**

Figure 5 – Greenhouse Gas emissions (as percentages)



4 Resource efficiency measures

4.1. Overview

A total of 97 potential resource efficiency measures for energy and water reduction were identified and reviewed for possible application in UN Camp at Juba. A 'traffic light' categorisation system was adopted to rank technologies based on three equally weighted criteria: practicality (ease of use), technical robustness and financial implications. Measures ranked as 'green' are those considered to be applicable in the immediate-term and are detailed further within the following sections of this chapter.

Table 10 - Number of resource efficiency measures considered and breakdown of ranking

Resource	Location	Number of Resource Efficiency Options Assessed	Green Ranked	Yellow Ranked	Red Ranked
Energy	Residential	33	17	12	4
	Office	49	34	13	2
Water	Site wide	15	10	5	

4.2. Energy

A total of thirty-three energy efficiency measures were identified for the residential units with seventeen ranked as green, twelve as yellow, and four as red. For the offices, forty-nine energy efficiency measures were identified with thirty-four ranked as green, thirteen as yellow, and two as red. These are a range of measures to reduce cooling demand, lighting energy consumption, to reduce hot water demand and energy, to generate energy from low carbon technologies, to improve controls, and to provide metering to reduce the energy consumption of the building.

Where feasible energy demand ideas have been assessed individually using thermal modelling computer software against the baseline office or accommodation units to determine the relative impact on annual energy consumption.

From this additional modelling, the most effective energy reduction measures have been selected and an assessment made of their collective – positive – impact (i.e. the level of impact that could be expected if all the measures were included into the building design). Due to the interaction of services within a building, when modelled collectively, energy reduction measures will not necessarily have the same impact as when modelling individually against the baseline building. For example, improving insulation can reduce the overall cooling demand in a building.

In addition to the modelled efficiencies of buildings, a brief assessment has been made of three potentially important site-wide energy production measures. These options require further study and it is recommended that this should be undertaken in the context of the procurement currently underway.

- **Combined heat and power (CHP) with Absorption Cooling:** Diesel generators produce electricity and heat. With this existing design only the electricity is captured and the heat is wasted. The process to produce electricity is only 35-40 percent efficient. Significant energy savings at the site will be realised if the diesel generators can be made to be more efficient.

Combined heat and power units (CHP) are like generators but enable the heat to be utilised as well as the electricity, increasing the overall efficiency of the unit. The waste heat can be used to generate cooling within an absorption (or adsorption) chillers. This can either be from centralised chillers (from one or two CHP units) or packaged absorption chillers available for each building. This option would require more detailed investigation to assess the costs and cooling capacity (due to the high external temperatures and minimal water available to dissipate internal heat);

- **Biodiesel generators:** Fuels using part or all biofuel can reduce emissions and be a cost-effective method for electricity production. However, issues including over supply, sustainability of production, cost and carbon content need to be addressed at each site before the technology could be adopted.
- **Wind Turbines:** Wind energy could be transformed into electricity from either roof-mounted or stand alone wind turbines. However, there is a need to ensure compatibility with the current electrical design of each site. Also, as the turbines provide intermittent power, they will require back-up supplies. This technology can be used at off-peak hours or to generate hydrogen for a fuel cell. The threshold depends on wind speed, suitable location for siting turbine, security risk (height of turbine), and skills for installation. There is a need to consider the use of wind to make hydrogen in off-peak hours for a fuel cell.

<u>Thermal modelling</u>

Thermal modelling has been used to evaluate energy demand from various aspects of the operation (residential and office) that consume energy. From the modelling results the most effective energy reduction measures have been selected to determine their collective impact; – this represents a real life scenario in which the composite benefits are realised.

Energy demand ideas are separated for the residential and office designs in the sections below.

<u>Residential Energy Reduction Measures</u>

Tables 11 details the energy reduction measures considered that are applicable to residential units. Relative efficiency savings, or gains, have been modelled on the majority of these measures. Those for which it was impractical to model have been assessed from a qualitative basis. Individual assessments have been modelled together to develop a composite model to indicate the overall energy savings, as detailed in Table 12.

Table 11 – Potential resource efficiency measures assessed using thermal modelling for residential units

Model Description	Energy Reduction (kWh)	Percentage Saving
Front door facing West	-196	0.6%
Front door facing North	-194	0.6%
Front door facing East	-92	0.3%
Wall - add 150mm Rockwool insulation (or suitable other)	-1545	4.8%
Roof - increase to 200mm of insulation on under roof	109	-0.3%
Roof - Reflective coating on roof (SRI) above or = 78	-202	0.6%
Floor - Add 150 mm of insulation to floor	71	-0.2%
Elevated floor	-353	1.1%
Window - Double glazing. U Value of 1.8W/m2k?	137	-0.4%
Window - Solar tinted glass - Max SHGC of 0.3 (G value of 0.4?)	-237	0.7%
Internal Lighting - LED lights. Reduce to 7 W each for internal lights	-882	2.7%
Internal Lighting - Last man out switch	-882	2.7%
External Lighting - Occupancy Sensors	-812	2.5%
External Lighting - daylight sensors	-152	0.5%
Hot water - Solar thermal 3 m2	-1689	5.3%
Air conditioning - increase efficiency to 3.5 COP	-3082	9.6%
Ventilation - add extract fans to ceiling during occupied hours	111	-0.3%
Metering - add for property for main services	-1233	3.8%
Air infiltration to 10 m3/m2/hr at 50 Pa	115	-0.4%

Table 12 – Composite model of savings for those measures modelled as having a significantly positive impact- and that are therefore recommended

Model Description	Energy Reduction (kWh)	Percentage Saving
Front door facing North & West	-196	0.6%
Wall - add 150mm Rockwool insulation (or suitable other)	-1545	4.8%
Roof - Reflective coating on roof (SRI) above or = 78	-202	0.6%
Window - Solar tinted glass - Max SHGC	-237	0.7%
Internal Lighting - LED lights. Reduce to 7 W each for internal lights	-882	2.7%
Internal Lighting - Last man out switch	-882	2.7%
External Lighting - Occupancy Sensors	-812	2.5%
External Lighting - daylight sensors	-152	0.5%
Hot water - Solar thermal 3 m2	-1689	5.3%
Air conditioning - increase efficiency to 3.5 COP	-3082	9.6%
Metering - add for property for main services	-1233	3.8%
Overall Saving	**-9417**	**29.3%**

The modelling provided some interesting results and identified some key energy saving areas:

- Improved efficiency of **air-conditioning**: Specifying air conditioning with seasonal efficiency of at least 3.5COP will have a significant impact on energy consumption;
- **Solar thermal**: Has a strong impact on energy consumption;
- **Orientation**: With a prevailing North-Westerly wind and highest solar gains at the south elevation the most energy efficient orientation was found with the front door facing north and west
- **Insulation**: Wall insulation appears to have a significant impact on the energy performance of the unit. Improved roof thermal performance only has a minimal impact on the energy efficiency of the unit – this could be due to the high heat levels at the top of the unit are being held in by higher levels of insulation. As with roof insulation, additional floor insulation seems little impact on the energy consumption of the unit.
- **Internal and external lighting**: With occupancy and light detection externally and controls and low energy lights internally, these measures can reduce energy consumption.
- **Metering**: Thermal modelling programme assumes that metering can save energy based on the education and change of behaviour through the information.
- **Improved glazing U-value (thermal performance)**: Interestingly, this measure did not have an impact on the energy performance of the unit. This is possibly due to low air tightness of building. It is likely that double glazing should be installed anyway as will assist with noise control and protect against harsh weather conditions that are not able to be modelled.
- **Addition of solar glazing**: Reduces solar gain - reduces energy consumption and is likely to be cost effective
- **Reflective coating on roof**: Reduces energy consumption and is likely to be cost effective;
- **Elevated Floor**: This measure does reduce energy consumption; however from this modelling it does not have a significant effect. This measure has not been included in the group of energy measures as it may have a large impact on cost. However if the buildings need to be raised for other reasons – such as flood defence, it would be an additional argument to elevate the building;
- **Fan ventilation in roof**: This measure was added to assist in removing heat gains from the building. However this measure appears to increase energy consumption as additional energy for fans outweighs benefits from the reduced cooling demand.

A number of other measures that cannot be modelled are considered viable for the residential unit. In the table below the overall list of green measures from the assessment is provided

Table 13 – Green ranked technologies for energy efficiency for the Residential Units

	Suggested improvements	Comments
Lighting – External		
Occupancy sensors	Lights controlled by occupancy. Can be through Passive Infra-Red (PIR) (movement) sensors, timers, occupancy settings (only work if door closed or key installed).	With lights for front door and veranda - as small area will be served by occupancy control
Lighting – Internal		
LED (reduced wattage) for bedroom and bathroom areas	LED lights are higher efficiency than fluorescent tubes. Lights may dim with high current. Electrical design needs to take account of this.	Further details to follow on progress with LED technology and application with camp lighting
Last man out switch	For lighting and can also be used for other small power. All internal lights should be linked to one switch.	Easy to install and as simple control to switch off lights
Deflectors	Light deflectors can increase lighting levels whilst allow wattage to decrease	Requires design to ensure it works effectively. As so few lights in room assumed will be undertaken - but no modelled reduction
Reducing cooling demand		
Orientation	Modelling units with the front door facing north and west have best impact on energy consumption.	Orientation has a small impact on energy consumption - it is therefore a design decision to include the most energy efficiency orientation into the design.
Wall Insulation	Add 150mm rockwool insulation (or suitable other).	Improving insulation to the building will reduce heat gain. It is most effective with good air tightness and control over ventilation.
Improved Glazing	Double glazing. U Value of 1.8W/m2k.	Modelled impact is fairly low, possibly due to low air tightness of building.
Elevate Floor	Elevated house floor can improve reduce cooling demand for a home in hot conditions.	Elevating the floor above the ground is considered a green item if there is an additional reason, such as floor defence, for elevating the property. Otherwise it is likely that this would not be feasible.
Solar Tinted glass (Glazing Solar Heat Gain Coefficient) (SHGC)	Use coated glass that allows sunlight but reflects heat from the building. Max SHGC of 0.3.	Likely to be cost-effective measure to reduce energy consumption.
Shading	Trees shrubbery to assist with shading.	Should be considered for properties where feasible. Will also improve amenity of area.
Roof - reflective coating	Reflective coating on roof will reduce heat build up and cooling load - Coating with Solar Reflectance Index (SRI) above or = 78.	Likely to be cost-effective measure to reduce energy consumption.

Air tightness	Minimise loss of treated air (and ingress of outside air) through good air tightness in the construction and airtight openings such as doors and windows.	With high levels of air tightness good controls are required and necessary levels of ventilation to ensure comfort conditions. May be difficult to achieve for modular units.
Increase seasonal efficiency of up to 3.5 COP	Ensure that air conditioning units are suited to the location and of high efficiency.	With good specification improved products can be purchased.
Ventilation		
Fans	Fans to have a maximum fan power of 2.2. W/l/s	Should be considered the within overall air conditioning package
Domestic hot water		
Solar thermal	Use solar thermal panels to produce hot water	Potential change to current design
Reduced water consumption	Low flow toilets, taps, showers	Worth ensuring all fittings enable low water consumption
Equipment (Small Power)		
A+ rated appliances	Appliances are highest efficiency	Should use most efficient equipment
Last man out switch/Key card control	Instead of card key - last man out switch for non-essential power could be used	
Timers on small power/light and recreation equipment	Timers: Add timers to link with occupancy	Reduce energy consumption
Energy Generation		
CHP - with heating for hot water or cooling through absorption chillers	A diesel CHP could generate electricity with the waste heat utilised within an absorption chillers.	CHP provides heat and power from one unit increasing the efficiency. In this situation where generator is being used it may be economic to ensure heat is captured - this could be used for cooling. Need to make sure this does not compete for energy demand
Photovoltaic cells (also see solar cooling). Within draft specification	Photovoltaic's (PV) systems convert energy from the sun into electricity through semi-conductors cells, most commonly made of silicon. To be used in conjunction with battery back-up. Thin film incorporated into roof. Could be integrated into roof at manufacture.	PV cells produce electricity. Need to ensure they can link with current electrical design
Metering		
Meters on main plant and across main areas of site	Measuring energy consumption helps to monitor consumption, benchmark against similar sites and develop targets for reduction	Metering is essential to energy management

Office Energy Reduction Measures

A number of energy reduction measures have been considered for the offices. The majority of these measures have been assessed through the thermal modelling software.

As with the residential units individual energy efficiency measures have been modelled in Table 14 and then those considered to represent the most effective modelled together and savings calculated, as shown in table 15.

Table 14 – Measures Assessed Using Thermal Modelling for Offices

Model Description	Diesel Energy Reduction (kWh)	Percentage Saving
Baseline model using above assumptions	-	
Orientation - Entrance facing West	12,972	-2.9%
Orientation - Entrance facing North	1,962	-0.4%
Orientation - Entrance facing East	13,177	-2.9%
Wall - 150mm Rockwool insulation (or suitable other) U: 0.15W/m2k	-10,712	2.4%
Roof - 200mm of insulation on under roof U: 0.18 W/m2k	-7,099	1.6%
Roof - Reflective coating on roof (SRI) above or = 78	-6,783	1.5%
Floor - Add 150 mm of insulation to floor U: 0.11W/m2k	-1,507	0.3%
Window - Double glazing. U Value of 1.8W/m2k	-5,942	1.3%
Window - Solar tinted glass - Max SHGC of 0.3 (G value of 0.4)	-10,035	2.2%
Improve air tightness to 10 m3/h/m2	-83,878	18.5%
Solar shading - Assumed 0.8m (horizontal) x 0.6m (vertical) external shading device, internal blinds	-15,833	3.5%
Internal Lighting - LED lights.	-60,746	13.4%
Internal Lighting - Occupancy detection to corridor lights, timers and controls for office lighting	-11,838	2.6%
Internal Lighting - Sun pipes.	-18,796	4.2%
Central Chillers (VRF) COP 3.2 – **Centralised cooling**	-58,379	12.9%
Centralise Ventilation with SFP of 2.5W/l/s	54,027	-11.9%
Centralise Ventilation with SFP of 2.5W/l/s & air permeability of 10 m3/h/m2	-37,669	8.3%
BMS control	-28,257	6.2%
Fan coil system – Assessed with COP 2.8	12,342	-2.7%
Metering and monitoring	-14,596	3.2%
Solar PV - Assume 50m2 on roof	-22,655	5.0%

Table 15 – Composite model of savings for those measures modelled for offices as having a significantly positive impact

Model Description	Diesel Energy Reduction (kWh)	Percentage Saving
Wall - 150mm Rockwool insulation (or suitable other) U: 0.15W/m2k	-10,712	2.4%
Roof - 200mm of insulation on under roof U: 0.18 W/m2k	-7,099	1.6%
Roof - Reflective coating on roof (SRI) above or = 78	-6,783	1.5%
Floor - Add 150 mm of insulation to floor U: 0.11W/m2k	-1,507	0.3%
Window - Double glazing. U Value of 1.8W/m2k	-5,942	1.3%
Window - Solar tinted glass - Max SHGC of 0.3 (G value of 0.4)	-10,035	2.2%
Improve air tightness to 10 m3/h/m2	-83,878	18.5%
Solar shading - Assumed 0.8m (horizontal) x 0.6m (vertical) external shading device, internal blinds	-15,833	3.5%
Internal Lighting - LED lights.	-60,746	13.4%
Internal Lighting - Occupancy detection to corridor lights, timers and controls for office lighting	-11,838	2.6%
Centralise Ventilation with SFP of 2.5W/l/s & air permeability of 10 m3/h/m2	-37,669	8.3%
BMS control	-28,257	6.2%
Metering and monitoring	-14,596	3.2%
Solar PV - Assume 50m2 on roof	- 22,655	5.0%
Total	**- 161,796**	**36%**

The modelling demonstrates a high saving (36 percent) from the measures identified. Below is a discussion of the key savings with a discussion on the feasibility to include into existing designs.

- **Ventilation and air tightness:** Results from the thermal modelling show that the largest reduction on energy demand for the building is to improve the air tightness. A key assumption in the development of the model is that the office buildings are 'leaky' to outside air. If a building is leaky to air, through seals and joints in walls, windows or roof etc. it will require a higher cooling load than an air tight building (imagine a refrigerator – its effectiveness increases as a consequence of its air tightness; the same can be applied to the cooling of buildings). However the more air tight a building the more controlled mechanical ventilation needs to be provided (either local or central) to allow for sufficient fresh air for the occupants.

  In the thermal model it is assumed that ventilation is currently achieved through the passive introduction of air into the building augmented by circulation fans within the local air conditioning units. The model does not include sufficient fan power and energy to deliver five air changes an hour of fresh air for the offices – which would have much higher fan energy consumption. If the full fresh air requirement for ventilation is provided through central air handling units (or locally), there would be a significant increase in fan power. In Run 17 in the table above which assesses the full fresh air load from a centralised air handling plant, there is a significant increase in energy from fan power against the base model. Air can either be provided locally or centrally. Central provision of fresh air would require distribution for the air, - usually through designed ductwork - and distributed through a terminal box or fan coil unit requires additional design, but allows for tighter control. **Local or mechanical ventilation is not proposed unless linked to a significant improvement in the air tightness of the building.**

- **Centralised cooling:** Table 14 shows the modelling results for cooling provided with a Variable Refrigerant Volume (VRF) system which requires internal refrigerant pipework within the ceiling void as well as internal emitters to distribute locally to the office areas. This system has an improved efficiency (as it balances the loads throughout the building with returning refrigerant temperatures), and control over local units, which needs to be balanced against the increased complexity of distribution from local units. The model assumes that ventilation is provided locally in through air ingress augmented by the circulation fans in the local distribution units. For this option external plant would be required for the central chillers unit (s).

  A separate assumption modelled is that a centralised chiller distributes chilled water through chilled water pipework within the building ceiling voids with local fan coil units. For demonstration purposes we have not raised the efficiency against the base line case to demonstrate the additional pump energy required for this option; however it is likely that this central plant would be of similar efficiency as a VRF system. A significant benefit of using chilled water over refrigerated water is that the costly use of a refrigerant specialist and installer is removed. However from the perspective of overall sustainability the main benefit of introducing a chilled water system is that it could be more compatible with low carbon technologies – such as CHP with absorption cooling.

- **Building Management Systems** improved controls, such a centralised Building Management System can limit significant energy waste within the buildings (which can be in excess of 10 percent efficiency savings) – this is detailed further in Appendix 5.
- **Orientation:** The modelling results suggest that a south facing front door is the most energy efficiency design.
- **Insulation**: As with the residential unit, adding insulation to the wall has higher impact than the floor or roof.
- **Improved glazing:** If improved glazing is specified, the impact on reduced cooling loads does not seem to be significant. However additional benefits for comfort may drive the introduction of this option.
- **Addition of solar glazing:** Reduces solar gain - reduces energy consumption and is likely to be cost effective.
- **Shading:** We have demonstrated that shading on the outside of the building is good measure to reduce energy demand.
- **Reflective coating on roof:** Reduces energy consumption and is likely to be cost effective.
- **Internal lighting:** With occupancy and light detection externally and controls and low energy lights internally, these measures can reduce energy consumption. The introduction of sun pipes was also assessed, however shallow layout of the office not considered viable for the building.
- **Renewables:** A notional area of 50m^2 of PV array was modelled for the building, with a good energy reduction. PV can be expensive and cost benefit assessment should be undertaken. Solar thermal has not been modelled although an energy reduction would be realised.
- **Metering:** Thermal modelling programme assumes that metering can save energy based on the education and change of behaviour through information and by adapting buildings' energy-management.

In summary, measures considered to be viable with the most impact on energy efficiency for an office have been collectively modelled and obtain a reduction in energy consumption by 36 percent. These included improved air tightness with local or central mechanical ventilation, improved insulation, improved lighting efficiency and controls, and centralised cooling using chilled water distribution (to allow for future connection with absorption cooling) and metering.

A number of other measures that cannot be modelled are considered viable for the office unit. The table below provides a list of all the recommended (green) measures from the assessment – both modelled and not modelled. Some of these measures would only be viable with a centralised cooling and/or ventilation system.

Table 17 – Green ranked technologies for energy efficiency for the offices

	Suggested improvements	Comments
Lighting – Internal		
LED (reduced wattage)	LED lights are higher efficiency than fluorescent tubes. Lights may dim with high current. Electrical design needs to take account of this.	Further details to follow on progress with LED technology and application with camp lighting
Occupancy sensors	Lights controlled by occupancy. Can be through Passive Infra-Red (PIR) (movement) sensors	With parts of the camp used at different times, occupancy control can save energy. Only modelled for the offices.
Ambient light sensors	Photo receptors respond to levels of light. Would be suitable for ground floor	Potential application on ground perimeter lights. Some areas would not be suitable
Reducing Cooling Demand		
Orientation	Orientate building so that high occupancy areas are in North of building (south in South Hemisphere).	Best orientation needs to be determined. Energy balance on which areas would benefit from sun shading. Also impact of east/west glare can be included in design
Solar Tinted glass (Glazing Solar heat Gain Coefficient) (SHGC)	Use coated glass that allows sunlight but reflects heat from the building. Max SHGC of 0.3	Likely to be cost-effective measure to reduce energy consumption
Roof - reflective coating	Reflective coating on roof will reduce heat build up and cooling load - Coating with Solar Reflectance Index (SRI) above or = 78	Likely to be cost-effective measure to reduce energy consumption
Building shading	Solar shading - Assumed 0.8m (horizontal) x 0.6m (vertical) external shading device, internal blinds	Shading device outlined in specification. Models demonstrate good energy reduction measure
Tree shading	Trees shrubbery to assist with shading	Should be considered for buildings where feasible. Will also improve amenity of area.
Air tightness	Minimise loss of treated air (and ingress of outside air) through good air tightness in the construction and airtight openings such as doors and windows	With high levels of air tightness good controls are required and necessary levels of ventilation to ensure comfort conditions.
Roof insulation	Roof - increase to 200mm of insulation on under roof U: 0.18 W/m2k	Adding additional roof insulation appears to have a minimal impact on the energy reduction over the year.
Wall insulation	Wall - add 150mm rockwool insulation (or suitable other) U: 0.155W/m2k	Improving insulation to the building will reduce heat gain. Is most effective with good air tightness and control over ventilation.
Improved glazing	Window - Double glazing. U Value of 1.8W/m2k	Modelled impact is fairly low, possibly due to low air tightness of building

Centralised system	Centralised system allows for increased control and greater efficiency. Design and Build contract being pursued	Depending if ventilation is included will require significant design changes. Possible to find half way house with local or no air supply and centralised Variable Refrigerant Volume chillers (VRF). Carbon savings based on improved efficiency and controls. - Further design consideration required.
Night cooling	Alongside use of appropriate materials, night ventilation (cooling) to reuse thermal mass in next day	Higher savings if linked to building materials with high thermal mass
Free cooling	(Enthalpy Cooling) To reduce energy consumption, sensors detect cooling capacity of external air. Draws in more than basic fresh air requirement, which reduces mechanical cooling.	Only possible with centralised ventilation. Requires control sensors to monitor inside and outside temperatures. May only be viable with centralised plant.
Air recirculation	Use recirculated and fresh air for 'free cooling' where possible before mechanical cooling. Greater feasibility with centralised system	Only viable with centralised ventilation plant that would benefit from reduced cooling load.
Refrigerants	Carbon emissions associated with leakage of refrigerants	Refrigerant leakage contains GHG emissions. Ensuring good maintenance and choice of refrigerant will lower any climate impact.
Ventilation		
Low energy fans	All fans should be specified to be below 2.2 W/l/s for central plant	If central ventilation is provided, fans should be low energy
VSD on large fans if centralised ventilation plant	Large fans and pumps should all be fitted with variable drives to reduce energy consumption	Variable speed drives match power demand with load
Domestic hot water		
Solar thermal	Use solar thermal panels to produce hot water	Requires water store. Potential to increase energy demand and cost due to water store and distribution system. Requires further investigation.
Insulated thermal and chilled immersions	Ensure all hot water /chilled water stores and pipework have sufficient insulation	Probably already included - but worth checking if any pipework insulation specification can be improved
Reduced water consumption	Low flow taps, catering with pull taps, dishwashers	Worth ensuring all fittings enable low water consumption
Server rooms		
Temp control and layout	Use free-cooling where possible and do not overcool. Server rooms are often cooled too much and arranged to block cooling pathways. Clear design and guidance on temperature settings will reduce energy consumption	
Small power		
A+ rated appliances	Appliances are highest efficiency	Should use most efficient equipment

Timers on printers/photocopiers and recreation equipment	Add timers to link with occupancy	Reduce energy consumption
Small PV charges for mobiles and non-essential IT equipment	Use small renewables to save on energy demand	Reduce energy consumption
Controls		
Centralise control. Building Management Systems.	Centralised control of cooling, lighting, ventilation. Centralise control (simple management system). Ensure local controls have sufficient occupancy and temperature controls	May only be suitable with more centralised control
Local control	Ensure local controls have sufficient occupancy and temperature controls	If no central plant, local controls should be under regular review to ensure suitable set-up.
Any large fans or pumps should have a Variable Speed Drives	Large fans and pumps should all be fitted with variable drives to reduce energy consumption	Variable speed drives match power demand with load.
Meters on main plant and across main areas of site	Measuring energy consumption helps to monitor consumption, benchmark against similar sites and develop targets for reduction	Metering is essential to energy management
Energy Generation		
CHP - with heating for hot water or cooling through absorption chillers	A diesel CHP could generate electricity with the waste heat utilised within an absorption chillers. Will require all camp (or all residential units) to be served from central chillers with distribution of chilled water.	CHP provides heat and power from one unit increasing the efficiency. In this situation where generator is being used it may be economic to ensure heat is captured - this could be used for cooling. Would require chilled water distribution from a centralised generation plant.
Photovoltaic cells. Modelled with 50m2 on roof	Photovoltaic's (PV) systems convert energy from the sun into electricity through semi-conductors cells, most commonly made of silicon. To be used in conjunction with battery back-up. Thin film incorporated into roof. Could be integrated into roof at manufacture.	PV cells produce electricity. Need to ensure can link with current electrical design

4.3. Water

A total of fifteen water saving features have been assessed and ranked for use. Ten were ranked as green and five as yellow. The measures which were ranked by the traffic light system as green are presented in Table eighteen. These measures should be accompanied by awareness-raising efforts to reduce water consumption. The complete traffic light analysis is available in Appendix 3.

The most significant potential savings come from the adoption of the following three resource efficiency measures:

- **Single flush or waterless urinals:** Constant flow urinals consume a significant amount of water and should be replaced with either single flush or waterless urinals to reduce water consumption. Waterless urinals utilize a trap insert filled with a sealant liquid instead of water. The lighter-than-water sealant floats on top of the urine collected in the U-bend, preventing odours from being released into the air. Although the cartridge and sealant must be periodically replaced, the system saves anywhere between 55,000 and 170,000 litres of water per urinal per year.

This is particularly relevant in the context of saving water in the setting of an office – occupancy profiles are confined generally to a maximum use of ten hours per day, five days per week. The use of non efficient urinals would result in water discharge into the urinals over a twenty-four hour period, seven days a week.

- **High-efficiency toilets:** Install water saving devices in the toilet cistern to reduce the amount of water used per flush. A high-efficiency toilet uses less than 6 litres per flush, which is 60 percent less water than conventional toilets, which use approximately 13 litres. Composting toilets, which are waterless and rely on natural bacteria to break down the organic waste, were not green ranked as they require daily attention as well as behavioural training and have not been widely tested in a peacekeeping context. However, they could be used on a trial basis to determine future suitability.
- **Aerated shower heads:** Aerated shower heads maintain a strong stream of water by mixing in air with the water. The resulting flow feels just as invigorating as it would from a normal shower head but uses 30 to 60 percent less water.

Two potentially important resource efficiency measures could be used for on-site water production. However, they require further study before they can be adopted in a peacekeeping context. These include:

- **Rainwater harvesting**: At present, rainwater harvesting is believed to be practiced but on an ad hoc basis and no information is available regarding the efficiency of such systems. As a result, this option has been excluded from more detailed assessment within this study. Rainwater harvesting is an efficient process that provides an alternative source of water for camp use and is used in a variety of environmental and social settings. However, engineering considerations such as volume capacity, storage and retention time (to avoid degradation of the quality of the water and subsequent health risks), are important factors to be further considered.

- **Grey water recycling:** Grey water recycling reuses non-sensitive water, including water that is uncontaminated by faecal or organic matter. Grey water is typically water derived from hand washing, showers, bathing etc, which can be reused for flushing toilets and for the purposes of gardening. There is a capital outlay relating to infrastructure enhancement but these costs are repaid through reduced water consumption and output for treatment.

Table 18 – Green ranked technologies for water efficiency

Use	Suggested improvements	Comments
Showers	Use of aerated shower heads	Ensure provision of aerated shower heads within camp design and fit out
	Install mixer valves to better control temperature regulation	As above – it is essential at provision stage (fit out) that the correct equipment is installed – retrofitting at a later date will prove cost inefficient and could result in less water savings.
Toilets	Reduce cistern capacity	Install water saving devices in toilet cistern to offset volume or procure dual flush cisterns
Urinals	Single flush urinals	As above – these are common place and simple to procure
	Waterless urinals	Odours are eliminated with 'odour blocks.' – thought should be given to cultural issues relating to the use of waterless urinals however this could easily be overcome through an appropriate level of education or targeted information.
Hand washing	Install flow regulators	The use of spray taps or inserts (tap magic).
Kitchen washing	Install flow regulators	The use of spray taps or inserts (tap magic).
Dish washing	Install A-rated machines	These can be easily obtained and should not prove difficult.
Food preparation	Install flow regulators	Spray taps or inserts (tap magic).
Air conditioning	Review use of Coolerado™	
Laundry	Install A-rated machines	These can be easily obtained.
Metering	Meters on locations within the complex where water use is prevalent: ablution blocks, kitchen, toilets	Measuring water consumption helps to monitor consumption, benchmark against similar sites, and develop targets for reduction.

4.4. Liquid Waste

Only two resource efficiency measures are considered to address liquid waste production and disposal. These include recycling systems for grey water and anaerobic digestion systems for blackwater.

- **Recycled grey water (toilet flushing and outdoor use):** Alternative disposal routes can be developed to effectively re-use the grey water for non-sensitive uses within the operation of the camp, such as toilet and urinal flushing and for outdoor uses such as gardening, vehicle wash down, etc. Such re-use would require some capital cost outlay in the form of tanks, pipework and pumps, and some operational costs to maintain the infrastructure. However, the payback period of this investment should fall well within the lifetime of the camps. This could be accentuated with the use of photovoltaic panels to power the pumps, creating a sustainable closed loop system.
- **Black water (anaerobic digestion):** A study is being progressed on the efficiencies related to the use of black water for energy production as well as conversion of biomass into useful products such as soil conditioners. This study will be completed in the near future. Initial assessments indicate that the camp is unlikely to be producing sufficient volumes of organic waste to enable efficient production of electricity however gas (for use in cooking) could be produced in volumes that make its use effective.

5 Potential Reductions and Savings

5.1. Overview

A summary of the potential reductions that could be achieved from the application of "green" rank resource efficiency measures are presented in Table 11. The following sections provide more detailed calculations and graphs comparing the baseline and revised figures.

5.2. Energy

A comparison of the energy footprint for the baseline designs and for the revised design incorporating the green ranked resource efficiency measures for the residential units and office designs is provided in Tables 19 and 20 and Figures 6 and 7. The analysis from thermal modelling found that energy consumption could be reduced by 26 percent in the residential units and by 36 percent in the offices. The energy figures for both the baseline energy and the revised reduction figure only include 'green' energy consumption and measures modelled within the thermal modelling software. It is likely that additional savings could be realised with the 'green' measures identified that could not be modelled within the software.

Table 19 – Potential Annual Energy and Carbon Reductions for Residential Units (358 units)

End Use	Baseline Energy (kWh)	Baseline CO_2 (t)	Revised Energy (kWh)	Revised CO_2 (t)	Saving (%)
Cooling	4,080,069	1,020	2,364,402	591	
Fans	1,550,423	388	1,325,825	331	
Lighting	779,875	195	382,721	116	
Small Power	3,249,792	812	3,249,792	812	
Hot Water	1,851,898	463	1,007,161	252	
Total	**11,512,057**	**2,878**	**8,410,319**	**2,103**	**27%**

Table 20 – Potential Annual Energy and Carbon Reductions for Offices (6 Type A Units)

End Use	Baseline Energy (kWh)	Baseline CO_2 (t)	Revised Energy (kWh)	Revised CO_2 (t)	Saving (%)
Cooling	1,269,063	317	540,802	135	
Fans	482,244	121	536,637	134	
Lighting	532,448	133	235,541	59	
Small Power	391,108	98	391,108	98	
Hot Water	40,530	10.	40,530	10	
Total	**2,715,393**	**679**	**1,744,618**	**436**	**36%**

Note: The energy figures for both the baseline energy figure and the revised/reduced energy figure only include energy consumption and measures modelled within the thermal modelling software. It is likely that additional savings could be realised with the measures identified that could not be modelled. This is especially true for equipment (small power) in the residential units.

Figure 6. Potential Annual Energy and Carbon Reductions from Energy Efficiency Measures – from residential units

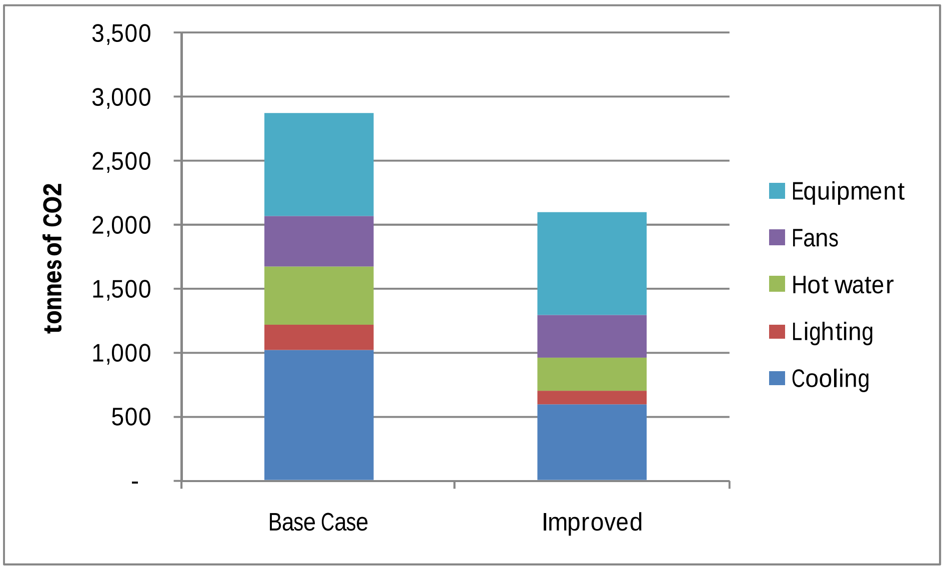
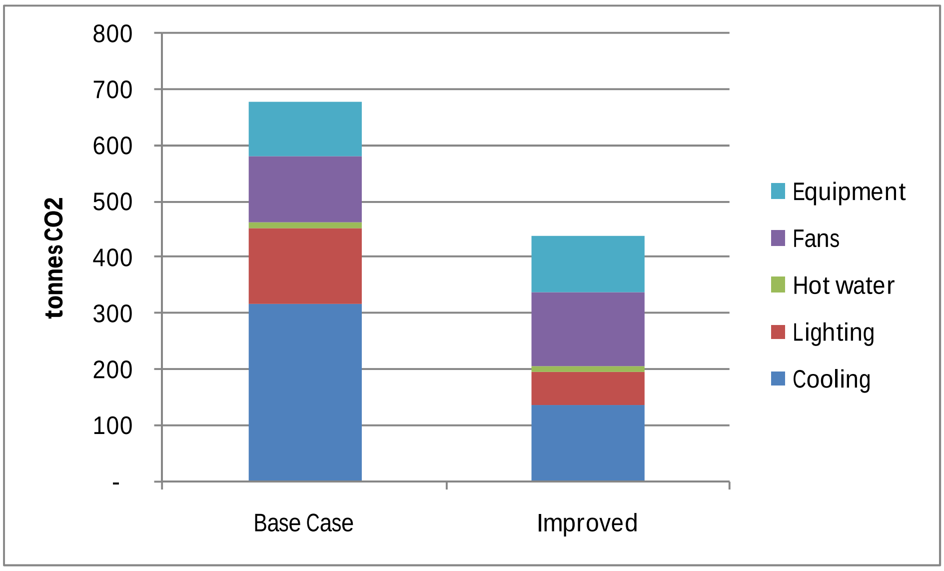


Figure 7. Potential Annual Energy and Carbon Reductions from Energy Efficiency Measures from six Type A offices



5.3. Water

A comparison of the water footprint for the baseline designs and for the revised design incorporating the green ranked resource efficiency measures is provided in Table 21 and 22 and Figure 8. The analysis found that water consumption could be reduced by 46 percent in the offices and 37 percent for the residential.

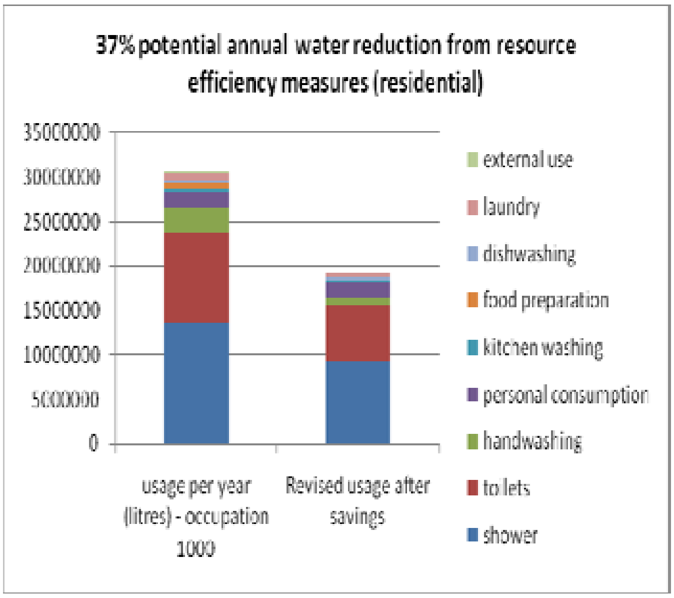
Table 21 – Potential Annual Water Reductions for Residential units

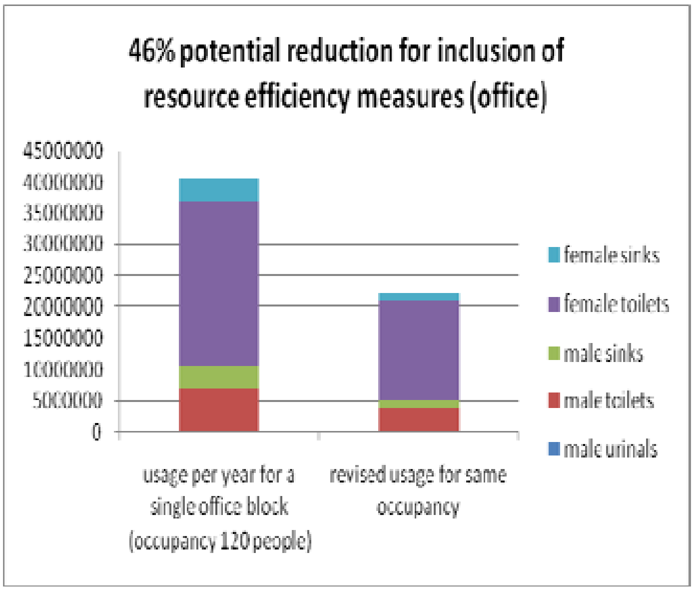
Usage	Usage per year (litres) - occupation 1000	Revised usage after savings
shower	13505000	9453500
toilets	10220000	6132000
Hand washing	2920000	876000
personal consumption	1642500	1642500
kitchen washing	365000	73000
food preparation	766500	229950
dishwashing	328500	262800
laundry	730000	584000
external use	182500	0
Total (litres consumed)	30660000	19253750
	Saving (%)	37

Table 22 – Potential Annual Water Reductions for offices

Usage	Usage per year for a single office block (occupancy 120 people)	Revised usage for same occupancy
male urinals	262800	78840
male toilets	6552000	3931200
male sinks	3744000	1123200
female toilets	26208000	15724800
female sinks	3744000	1123200
Total litres consumed	**40510800**	**21981240**
Saving		46%

Figure 8. Potential Annual Water Reductions from Resource Efficiency Measures





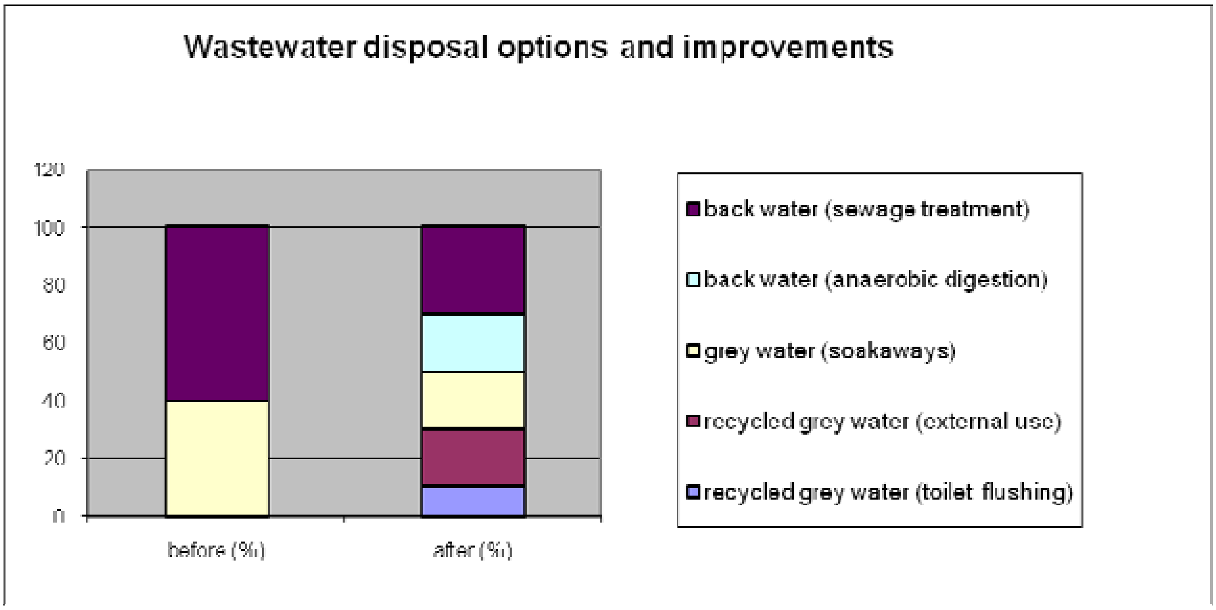
5.4. Liquid Waste

A comparison of the liquid waste footprint for the baseline design and for the revised design incorporating the green ranked reduction measures is provided in Table 23 and Figure 9. The analysis found grey water to soakaways could be reduced by 63 percent through recycling.

Table 23 – Liquid Waste Reduction Measures and Alternative Disposal Routes

Liquid Waste Management Measure	Percentage of Total		
	baseline	Revised	Difference
recycled grey water (toilet flushing)	0	10	10
recycled grey water (external use)	0	20	20
grey water (soakaways)	40	20	-20
black water (anaerobic digestion)	0	20	20
black water (sewage treatment)	60	30	-30
TOTALS	**100**	**100**	0

Figure 9. Potential liquid waste reduction options



6 Summary of Findings and Recommendations

6.1 Findings

This assessment has considered a total of forty eight different resource efficiency measures to achieve reductions in energy and water at the proposed UN camp. Significant resource reduction measures were identified through the use of green ranked technologies which could be implemented prior to finalisation of the camp design and construction.

In order for UNMIS to act on the four recommendations contained in this report, the following sections are divided into immediate actions for the design phase, medium-term recommendations for camp operations, and long-term recommendations for further camp design.

6.2 Immediate recommendations for the design phase

The recommendations offered below relate to the contractor negotiations and incorporation into the final design and are intended to be implemented within the next three months, prior to the construction of the remainder of the camp infrastructure.

Recommendation	Reasoning	Responsibility
1. Review 'green' ranked measures, select items for immediate application and develop specifications for procurement.	For maximum effectiveness to be realised it will be necessary to have more detailed discussions on the practical applicability of some of the 'green' ranked measures.	**UNMIS engineers and UNEP experts**
2. Incorporate recommendations arising from the closed loop energy assessments.	This is currently being completed	**UNEP experts**
3. Incorporate recommendations arising from the environmental impact assessment (EIA) into the overall camp design and operation.	It is understood that this is currently being commissioned	**DFS/Mission – environmental engineer with assistance from FOI**

6.3 Medium-term recommendations for camp operation

The recommendations offered below relate to the operational phase of the UN House and are intended to be implemented within the next three to six months in parallel with the construction of the compound.

Recommendation	Reasoning	Responsibility
6. Develop and implement an environmental management plan (EMP)	Based on the outcomes of an EIA, the EMP should address all aspects of resource use and reduction, as well as waste management. It should be developed in the early stages of the camp operation and identify specific operational targets for resource efficiency. It should be treated as a working document which can be updated as needed based on the outcomes of on-going data collection.	**DFS/Mission – environmental officer**

Appendix 1 - Power demand profiles

Conversion Factors		
Diesel	0.25	kg CO_2/kWh
Diesel	2.63	kg CO_2/l
Litres to kWh	10.9	litres to kWh
Diesel	38%	% efficient
Gallons to litre	5	G
COP = EER / 3.412	3.412	Refrigerant effectiveness

BTU to kW		
	0.000293	
BTU	kW	
12000	3.516	
18000	5.274	
24000	7.032	
1 ton cooling	12000	BTU

Air conditioning units

Units	**BTU**	**Cooling**
19	12000	3.516
57	18000	5.274
114	24000	7.032
190	**54000**	

Appendix 2 – Ranked energy reduction measures

Residential

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
Lighting - External	**Lighting - External**	**Lighting - External**									
	Assumed 2 X 36 W - manual controls	Occupancy sensors	Lights controlled by occupancy. Can be through Passive Infra-Red (PIR) (movement) sensors, timers, occupancy settings (only work if door closed or key installed)	Lights will turn off if area not occupied	Possible some reduce user comfort	With lights for front door and veranda - as small area will be served by occupancy control	Yes	0.5%	High	Design needs to include occupancy sensors	Low
Lighting - Internal	**Lighting - Internal**	**Lighting - Internal**									

	Assumed 2 x fluorescent tubes per room and 1 in bathroom to achieve 300 lux in each room	LED (reduced wattage) for bedroom and bathroom areas	LED lights are higher efficiency than fluorescent tubes. Lights may dim with high current. Electrical design needs to take account of this.	Low energy	May require dedicated fittings and modified electrical design	Further details to follow on progress with LED technology and application with camp lighting	Yes	2.7%	High	Further research on light quality and potential impact of changes in current	Low/ medium
		Use of natural lighting	Add roof lights to module units	Increased lighting. Will increase heat gain.	Could increase heat and therefore cooling requirements	Link with occupancy and light sensors	No	Low	Low	Due to impact on heat gain - not considered viable	Low
		Last man out switch	For lighting and can also be used for other small power. All internal lights linked to one switch	Lights can all be switched off at one switch	Wring of room will need to incorporate design	Easy to install and as simple control to switch off lights	Yes	3%	Yes		Low
		Deflectors	Light deflectors can increase lighting levels whilst allow wattage to decrease	Increased light levels with lower wattage	Can cause glare	Requires design to ensure works effectively. As so few lights in room assumed will be undertaken - but no modelled reduction	No	Low	High	No size threshold	Low
Reducing Cooling Demand	**Reducing Cooling Demand**	**Cooling**									
	AC Unit assumed 7.03kW split with emitter in living room and kitchen Efficiency of air con assumed at 2.8 COP	Orientation	From the modelling units with the front door facing north and west have best impact on energy consumption	No cost energy saving solution	Needs to be integrated at beginning of design process. Means that all units would need to be orientated in north/north-west or west manner - not preferred design	Orientation has a small impact on energy consumption - it is therefore a design decision to include the most energy efficiency orientation into the design	Yes	0.6%	High	A clear benefit exists in north to west facing orientation, but has a small impact on energy consumption.	Low

		Roof Insulation	Add to existing assumed 50mm of fibre glass roll to 200 mm of insulation. U Value 0.18 W/m2k	Reduces heat gain to the building	Additional expense for roof insulation and needs to be installed well. Impact is reduced with building that is not air tight.	Adding additional roof insulation appears to have a minimal impact on the energy reduction over the year.	Yes	-0.3%	Medium	Will require additional insulation in the roof	Low
		Wall Insulation	Wall - add 150mm rockwool insulation (or suitable other). U Value 0.15W/m2k	Reduces heat gain to the building	Additional expense for wall insulation and needs to be installed well. Impact is reduced with building that is not air tight.	Improving insulation to the building will reduce heat gain. Is most effective with good air tightness and control over ventilation.	Yes	4.8%	High	Will require additional insulation in the wall	Low/ medium
		Floor Insulation	Floor - Add 150 mm of insulation to floor. U Value 0.11	Reduces heat gain to the building	Additional expense for floor insulation and needs to be installed well. Impact is reduced with building that is not air tight.	Adding additional floor insulation appears to have a minimal impact on the energy reduction over the year.	Yes	-0.2%	Medium	Likely that double glazing should be installed anyway as will assist with noise control and harsh weather condition not able to be modelled	Low/ medium
		Improved Glazing	Double glazing. U Value of 1.8W/m2k	Reduces heat gain to the building	Expensive and does not lead to particularly large carbon savings.	Modelled impact is fairly low, possibly due to low air tightness of building	Yes	-0.4%	Medium	Likely that double glazing should be installed anyway as will assist with noise control and harsh weather condition not able to be modelled	Low

		Elevate Floor	Elevated house floor can improve reduce cooling demand for a home in hot conditions	Some energy reduction	Expensive and small energy savings	If this measure had little impact on construction (may be required for other reasons such as flood defence anyway) then should be undertaken, but not otherwise	Yes	1.1%	High		High
		Solar Tinted glass (Glazing Solar heat Gain Coefficient) (SHGC)	Use coated glass that allows sunlight but reflects heat from the building. Max SHGC of 0.3	Low cost energy saving solution	May affect window design and has additional expense. Need to balance with light requirements	Likely to be cost-effective measure to reduce energy consumption	Yes	0.7%	High	Already in draft specification. Use as appropriate	Low
		Shading	Trees shrubbery to assist with shading	Reduces energy demand	Space availability and water may not be sufficient for all properties. Will take time to develop	Should be considered for properties where feasible. Will also improve amenity of area.	No	Low	High	Depends of space and will take time to develop	Mediu m
		Roof - reflective coating	Reflective coating on roof will reduce heat build up and cooling load - Coating with Solar Reflectance Index (SRI) above or = 78	Reduce cooling loads	Will increase costs slightly for coating	Likely to be cost-effective measure to reduce energy consumption	Yes	0.6%	High		

		Air tightness	Minimise loss of treated air (and ingress of outside air) through good air tightness in the construction and airtight openings such as doors and windows	Should save energy from reduced cooling loss and enables greater temp control	Requires good ventilation and cooling control. If too airtight will heat too quickly. Therefore balance is required	With high levels of air tightness good controls are required and necessary levels of ventilation to ensure comfort conditions.	Yes	-0.4%	Low	No threshold	Low/ medium
		Ventilation fans in roof	Additional fans in roof should remove hot air and reduce cooling demand	Reduce cooling loads	Increase in fan power and could draw in additional hot air from leaky building	Appears to increase energy consumption as additional energy for fans outweighs benefits from the reduced cooling demand	Yes	-0.3%	Medium		
		Phase Change materials	Phase change used in combination with conventional air con or wind catcher to reduce cooling loads	Reduces energy consumption as energy is stored during day and released at night with phase change	Could be expensive and would not work if phase change material requires sufficient night time cooling	Phase change materials can be placed in walls or within ventilation/AC entry, Requires night temperature to drop below phase change material freezing temperature to work	No	Low/ medium	Medium	Experimental design - would need to have test case and measure impact and thermal comfort provided	Low/ medium
		Wind Catchers	Natural ventilation added by ventilation system on roof	Low energy solution	May not provide sufficient cooling requirements	Worth experimenting with design for future phases	No	Medium	Medium	Will need to be carefully designed and tested to ensure sufficient cooling load	Medium

		Increase seasonal efficiency of to 3.5 COP	Ensure that air con units are suited to the location and of high efficiency	Minimal cost for energy improvements	None	With good specification improved products can be purchased	Yes	9.6%	High	No impact on design.	
Ventilation		**Ventilation**									
	Assumed no additional ventilation aside from air drawn in from leaky building and air-con circulation fan. Delivers 5 Air Changes per Hour	Fans	Fans to have a maximum fan power of 2.2. W/l/s	Would reduce fan energy consumption	Difficult to specify if within air con unit	Worth considering within overall air-con package	No	Low/ medium	High	Could be dealt with within air-con specification	Low
Domestic hot water		**Domestic hot water**									
	Point of use heaters - spec to be confirmed	Solar thermal	Use solar thermal panels to produce hot water	Low energy solution	Capital outlay. Will require store of hot water and therefore change to current design	Potential change to current design	Yes	5.3%	High	Requires water store. Therefore a number of separate systems or one large system (which could be more efficient with diversity) is required	Medium

		Reduced water consumption	Low flow toilets,, taps, showers	Minimise loss of energy	May be more difficult to user	Worth ensuring all fittings enable low water consumption	No	Low	High	Measures outlined with draft specification	Low
		Control	Only allow hot water to be used at certain times of day - put hot water units on timers	Minimise loss of energy	Need to be careful that disease control is still taken account of. Users may complain	Control when water can be used centrally to minimise losses	No	Low	Medium	Link with use	Low/ medium
Equipment (Small Power)		**Equipment (Small Power)**									
		A+ rated appliances	Appliances are highest efficiency	Low energy	Potential increase in capital cost	Should use most efficient equipment	No	Low	High	On all appliances	Low
		Thermal isolation	Ensure fridges and freezers are thermally isolated from ovens	Reduces energy demand of kitchen equipment	Space unlikely to be available in residential units	Fridges and freezers have to work use more energy in hotter environments - therefore is more efficient to isolate	No	Low	Low	Where feasible. If necessary consider new modal design	Low/ medium
		Last man out switch/Key card control	Instead of card key - last man out switch for non-essential power could be used	Reduces energy wastage when unit is unoccupied	some additional cost and additional wiring complexity		No	Medium	High	Modification to wiring of electricity in room May require essential and non-essential rings	Low

		Air con key/occupancy isolators	Air con is occupancy controlled - like in hotels where air con only works with keys	Ensures power only consumed when room is occupied	Requires additional electrical design. May not be suitable for room where some power is required. Comfort conditions may take time to achieve when occupied.	Could break in hot environment and not have suitable technical expertise to fix or maintain	No		Medium	Would not provide steady state environmental conditions. Threshold depends on some thermal isolation of units and acceptance of time to cool. Cooling should be designed to keep room at minimal temp and work harder with detected occupancy. Assumed part of centralised control	
		Timers on small power/light and recreation equipment	Timers: Add timers to link with occupancy	Reduce energy consumption	None	Reduce energy consumption	No	Low	High	On all appliances	Low
Energy Generation		**Energy Generation**									
		CHP - with heating for hot water or cooling through absorption chillers	A diesel CHP could generate electricity with the waste heat utilised within an absorption chillers. Will require all camp (or all residential units) to be served from central chillers with distribution of chilled water.	Provides heat and power- improves efficiency on current design where heat is wasted from generators	Need continual outlet for heat otherwise may not be economic in design. Hot water load will also compete with solar thermal technology if installed. Large plant may be difficult to deliver to site. Absorption chillers are also large plant. Will require energy centre and distribution network of chilled water to be viable.	CHP provides heat and power from one unit increasing the efficiency. In this situation where generator is being used it may be economic to ensure heat is captured - this could be used for cooling. Would require chilled water distribution from a centralised generation plant.	No	High	High	Requires centralised system and absorption chillers to make use of waste heat (if hot water demand is not sufficient). Need to undertake detailed energy modelling to determine viability. Need to consider size and transport feasibility of CHP and absorption chillers. CHP could be specified with heat store to make more efficient. Assumed for now that cooling load not high enough for absorption chillers and solar thermal more suitable for hot water. Threshold for absorption cooling to be determined	Low/ medium

		Photovoltaic cells. Within draft specification	Photovoltaic's (PV) systems convert energy from the sun into electricity through semi-conductors cells, most commonly made of silicon. To be used in conjunction with battery back-up. Thin film incorporated into roof. Could be integrated into roof at manufacture.	Reduced energy demand	Capital cost is high. Large area may be required to deliver noticeable savings	PV cells produce electricity. Need to ensure can link with current electrical design	No	Low/ medium	High		Low
		Evaporative Cooling - Diabatic cooling	Mechanical process of lowering outside air temperature from process of evaporating stored water.	Cheaper to install, easier to maintain, consumes less energy, can provide humidification, increase air change rate	Works in climates where air is hot and humidity is low. Less suitable for locations with high humidity. Requires a constant supply of water.	Cooling output may not be sufficient for building loads. Potential to combine with mechanical chillers and use in evaporative mode to gain best efficiencies	No	Medium/high	Medium	Access to water required (specific quantity to be determined from size of cooling requirement). Therefore not suggested as viable at present.	Medium
		Solar air conditioning	Utilises thermal energy (from solar collectors) to drive an absorption chillers.	Could provide low cost cooling	Effectiveness depends of amount of heat available. Could require large solar thermal system to deliver energy. Plant can be expensive	New technology. Cost effectiveness will depend on requirements for heat and power and whether solar thermal can provide sufficient heat for cooling. Back-up generator would be required	No	Medium/high	Medium	Further investigation required on the array size and appropriateness of application.	Medium/high

		Use ground source heat pump	Using open (aquifer) or closed (boreholes/building piles) efficiency of cooling can be improved	Energy savings	Cost/ Requires drilling many boreholes or availability of aquifer water	Significant construction required for either option that probably would not be possible unless permanent camp. Would require centralised system.	No	Medium	Low	Only suitable if borehole or suitable water body is available	High
		Wind turbines	Either roof mounted or stand alone to provide electricity	Reduces energy demand	Rood mounted turbines provide limited energy. Stand alone will require careful siting and foundation. Will also need to link in with electricity generation from site	Wind turbines can provide free electricity. Need to link with current electrical design. Intermittent power - will require back up supplies. Can be used at off peak hours or generate hydrogen for fuel cell	No	Low/ medium/high - depending on size	Medium	Threshold depends on wind speed, suitable location for siting turbine, security risk (height of turbine), and skills for installation. Need to consider use of wind to make hydrogen in off-peak for fuel cell	Low/ medium
		Fuel Cells - with heating for hot water or cooling through absorption chillers	Like CHP fuel cells produce heat and power. Can run on fossil fuels, hydrogen	Provides heat and power in higher ratio of electricity: heat than CHP therefore potentially more suitable. If using hydrogen from wind, high savings	Expensive- still considered not commercially viable	An important technology to demonstrate. However expensive	No	Medium/high	Medium	Further research into suitable type and fuel source required. Requires centralised system and absorption chillers to make use of waste heat (if hot water demand is not sufficient). Need to undertake detailed energy modelling to determine viability	Low/ medium

		Biodiesel Generators, CHP and transport fuels	Fuels using part or all bio fuel can reduce emissions	Reduced emissions	Security and cost of fuel supply and use of engine may be compromised unless expert is available	Bio fuels can realise significant carbon savings. But issues over supply, sustainability of production, cost and carbon content need to be resolved	No	High	Medium	Threshold depends on access to fuel and suitable technology and skilled maintenance staff	Low/ medium
Metering											
	Assumed diesel is monitored for consumption but further sub-metering	Meters on main plant and across main areas of site	Measuring energy consumption helps to monitor consumption, benchmark against similar sites and develop targets for reduction	Allows plans to be formalised to reduce energy consumption	Can be expensive to install meters and needs user interface and someone who knows how to use it	Metering is essential to energy management	No	zero direct savings but useful tool to drive savings	High	Metering should be provided for main plant. Threshold size of camp and load would apply.	low

Offices

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
Lighting - External	**Lighting - External**										
	Assumed camp perimeter and external lighting will be sourced from solar lamp stands - these have been purchased and are ready to be installed. Therefore not included in this analysis.										
Lighting - Internal	**Lighting - Internal**										
	Assumptions made based on built admin buildings. Average of 15 W/m2 in office areas and 18 W/m2 in toilets.	LED (reduced wattage)	LED lights are higher efficiency than fluorescent tubes. Lights may dim with high current. Electrical design needs to take account of this.	Low energy	May require dedicated fittings and modified electrical design	Further details to follow on progress with LED technology and application with camp lighting	Yes	13%	High	Further research on light quality and potential impact of changes in current	Low/ medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Occupancy sensors	Lights controlled by occupancy. Can be through Passive Infra-Red (PIR) (movement) sensors	Lights will turn off if area not occupied	Expensive technology. Some areas not feasible for health and safety concerns.	With parts of the camp used at different times, occupancy control can save energy. Only modelled for the offices.	Yes	3%	High	Some areas of office (possibly on corridors and toilets) should be fitted with occupancy sensors	Low
		Ambient light sensors	Photo receptors respond to levels of light. Would be suitable for ground floor	Lights reduce in brightness in response to external lighting	Could be expensive	Potential application on ground perimeter lights. Some areas would not be suitable	No	Low	High	Would only be suitable to lights with perimeter widows	Low/ medium
		Sun pipes	Allows sunlight into deep plan office areas and rooms without natural light	Reduces lighting load if employed with suitable controls and awareness	Need to be controlled with light sensor otherwise occupants will use usual lights without benefits of sun pipe	Corridor areas are not exposed to natural light. Could be an option in these areas. Offices are shallow plan and would not need additional natural light	No	Low	Medium	Only suitable in corridor areas - maybe prohibitively expensive	Medium
		Use of natural lighting	Add roof lights office block	Increased lighting. May increase expense for additional windows	Could increase heat and therefore cooling requirements. May not be technically feasible with double skin roof and vent stacks	Link with occupancy and light sensors	No	Low	Low	Overall likely to increase the cooling demand more than decrease the lighting load.	Medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Deflectors/Diffusers	Light deflectors can increase lighting levels whilst allow wattage to decrease	Increased light levels with lower wattage	Can cause glare	Requires design to ensure works effectively	No	Low	High	No size threshold	Low
Reducing Cooling Demand	**Reducing Cooling Demand**										
	28 air con units (splits), 18000 BTU cooling COP 2.8, localalised units placed above windows (not through the window design)	Orientation	Orientate building so that high occupancy areas are in North of building (south in South Hemisphere).	No cost energy saving solution	Needs to be integrated at beginning of design process	Best orientation needs to be determined. Energy balance on which areas would benefit from sun shading. Also impactions of east/west glare can be included in design	Yes	n/a	High	Buildings should be orientated to benefit from prevailing wind and minimise solar gain	Low
		Solar Tinted glass (Glazing Solar heat Gain Coefficient) (SHGC)	Use coated glass that allows sunlight but reflects heat from the building. Max SHGC of 0.3	Low cost energy saving solution	May affect window design and has additional expense. Need to balance with light requirements	Likely to be cost-effective measure to reduce energy consumption	Yes		High	No threshold limit - however must ensure design is balanced with sufficient light.	Low

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Roof - reflective coating	Reflective coating on roof will reduce heat build up and cooling load - Coating with Solar Reflectance Index (SRI) above or = 78	Reduce cooling loads	Will increase costs slightly for coating	Likely to be cost-effective measure to reduce energy consumption	Yes	1.5%	High	No threshold	
		Building Shading	Solar shading - Assumed 0.8m (horizontal) x 0.6m (vertical) external shading device, internal blinds	Reduced solar gain and reduced cooling loads.	Needs to balance with sufficient light into the building	Shading device outlined in specification. Models demonstrate good energy reduction measure	Yes	3.5%	High	No threshold	Low
		Tree Shading	Trees shrubbery to assist with shading	Reduces energy demand	Space availability and water may not be sufficient for al buildings. Will take time to develop	Should be considered for buildings where feasible. Will also improve amenity of area.	No	Low	High	Depends of space and will take time to develop	Medium
		Air tightness	Minimise loss of treated air (and ingress of outside air) through good air tightness in the construction and airtight openings such as doors and windows	Saves energy from reduced cooling loss and enables greater temp control	Requires good ventilation and cooling control. If too airtight will heat too quickly. Therefore balance is required	With high levels of air tightness good controls are required and necessary levels of ventilation to ensure comfort conditions.	Yes	19%	High	Requires specification of building to include air tightness requirements - difficulty in assessing compliance	Low/ medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Roof Insulation	Roof - increase to 200mm of insulation on under roof U: 0.18 W/m2k	Reduces heat gain to the building	Additional expense for roof insulation and needs to be installed well. Impact is reduced with building that is not air tight.	Adding additional roof insulation appears to have a minimal impact on the energy reduction over the year.	Yes	1.6%	High	Will require additional insulation in the roof	Low
		Wall Insulation	Wall - add 150mm rockwool insulation (or suitable other) U: 0.155W/m2k	Reduces heat gain to the building	Additional expense for wall insulation and needs to be installed well. Impact is reduced with building that is not air tight.	Improving insulation to the building will reduce heat gain. Is most effective with good air tightness and control over ventilation.	Yes	2.4%	High	Will require additional insulation in the wall	Low/ medium
		Floor Insulation	Floor - Add 150 mm of insulation to floor U: 0.11W/m2k	Reduces heat gain to the building	Additional expense for floor insulation and needs to be installed well. Impact is reduced with building that is not air tight.	Adding additional floor insulation appears to have a minimal impact on the energy reduction over the year.	Yes	0.3%	Medium	Likely that double glazing should be installed anyway as will assist with noise control and harsh weather condition not able to be modelled	Low/ medium
		Improved Glazing	Window - Double glazing. U Value of 1.8W/m2k	Reduces heat gain to the building	Expensive and does not lead to particularly large carbon savings.	Modelled impact is fairly low, possibly due to low air tightness of building	Yes	1.3%	High	Likely that double glazing should be installed anyway as will assist with noise control and harsh weather condition not able to be modelled	Low

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Insulation on internal partitions	Minimises cooling loads between separate units	Enables tighter zonal control	Areas cannot share services as shut off from each other	Need balance for thermal insulation between spaces at difference temperatures and benefit of sharing services and temperature zones	No	Low	Low	No threshold	Low/ medium
		Centralised system	Centralised system allows for increased control and greater efficiency. Design and Build contract being pursued	Allows wider choice of technologies, greater efficiency and controls. With correct technology will allow for connection of technologies such as CHP and absorption cooling.	If ventilation also provided will require ductwork for air. Depending on the cooling distribution will require Fan Coil Units and if chilled water, pumps and chilled water distribution. Will require additional plant secure area. Requires higher levels and cost of maintenance	Depending if ventilation is included will require significant design changes. Possible to find half way house with local or no air supply and centralised Variable Refrigerant Volume chillers (VRF) or chilled water supply. Carbon savings based on improved efficiency and controls. - Further design consideration required.	Yes	13%	High	The larger the building the more relevant to centralise cooling.	High

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Materials	Use materials with high thermal mass. Assist with night ventilation (cooling) to reuse thermal mass in next day	Energy savings/ more comfortable living and working environment	Usually more expensive materials.	Materials such as concrete with high thermal mass can be used to increase the thermal mass and provide a method to assist with reducing daytime temperatures and cooling requirement. Already using concrete. Need to make sure design allows for exposed there	No	Low/ medium	Medium	Materials mainly decided- appear mostly heavyweight with higher thermal mass	n/a
		Cool recovery	Similar to heat recovery, air that is cooler than external air is recirculated or exchanged with incoming air to reduce cooling requirements.	Saves energy as reduces cooling load	Only viable if combined with central ventilation plant. Needs sufficient controls to ensure only used at suitable times of day	Can save energy if application can be found	No	Medium	High	Will need to have centralised system with recirculation and/or cool recovery on air handling units	Medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Night cooling	Alongside use of appropriate materials, night ventilation (cooling) to reuse thermal mass in next day	Lowers cooling demand of the building	Needs integrated control with cooling and ventilation strategies. Need to balance energy used against cooling saved	Higher savings if linked to building materials with high thermal mass	No	Low/ medium	High	In draft specification. Would be essential with phase change materials	Low
		Free cooling	(Enthalpy Cooling) To reduce energy consumption, sensors detect cooling capacity of external air. Draws in more than basic fresh air requirement which reduced mechanical cooling	Energy savings	Will require centralised ventilation system to enable free cooling.	Only possible with centralised ventilation. Requires controls to monitor inside and outside temperatures and facility to increase ventilation without cooling May only be viable with centralised plant	No	Medium	High	Threshold requires control over air and cooling - more likely to be central control.	Low/ medium
		Phase Change materials	Phase change used in combination with conventional air con or wind catcher to reduce cooling loads	Reduces energy consumption as energy is stored during day and released at night with phase change	Could be expensive and would not work if phase change material requires sufficient night time cooling	Phase change materials can be placed in walls or within ventilation/AC entry, Requires night temperature to drop below phase change material freezing temperature to work	No	Low/ medium	Medium	Experimental design - would need to have test case and measure impact and thermal comfort provided	Low/ medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Air recirculation	Use recalculated and fresh air for 'free cooling' where possible before mechanical cooling. Greater feasibility with centralised system	Greater control over the volume and temperature of the supply air	Only viable if combined with central ventilation plant. Needs sufficient controls to ensure only used at suitable times of day	Only viable with centralised ventilation plant that would benefit from reduced cooling load.	No	Low/ medium	High		Low/ medium
		Air ducts/earth tubes	Deliver air through a series of tunnels or ducts underneath the building. Lowers air temperature before use of chillers	Reduce cooling load	Requires specific building design to include earth tubes. Expensive. Depth needs to be sufficient to benefit from cooler temperatures. Surface area needs to be sufficient to provide cooling	Would require further design to determine depth and size of earth tubes and to calculate carbon savings. Would require a centralised ventilation system (air handling system)	No	High	Medium	Threshold depends on including central air conditioning	High
		Refrigerants	Carbon emissions associated with leakage of refrigerants	Part of good practice maintenance regime	If replacing refrigerant need to ensure it can perform to required standard	Refrigerant leakage contains GHG emissions. Ensuring good maintenance and choice of refrigerant will lower any climate impact	No	Low	High	Draft specification outlined use of zero ozone depleting substances in all air con units	Low

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Wind Catchers	Natural ventilation added by ventilation system on roof	Low energy solution	May not provide sufficient cooling requirements	Worth experimenting with design for future phases	No	Medium	Medium	Will need to be carefully designed and tested to ensure sufficient cooling load	Medium
		Solar desiccant technology	Uses solar thermal energy to dry a desiccant and air to lower humidity of air (making it feel cooler). Will require new ventilation design with desiccation material	Will lower cooling requirements	Would require centralised ventilation. Will add cost and complexity to design	More detailed assessment of design impactions and potential energy savings required	No	Low/ medium	Medium	Further research required to determine cooling benefits and appropriateness to climate	Medium/high
Ventilation	**Ventilation**	**Ventilation**									

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
	Assumed no additional ventilation aside from air drawn in from leaky building and air-con circulation fan. Delivers 5 Air Changes per Hour	Low energy fans	All fans should be specified to be below 2.2 W/l/s for central plant	Reduces energy consumption	None at this size of building	If central ventilation is provided, fans should be low energy	No	Medium	High		Low
		VSD on large fans if centralised ventilation plant	Large fans and pumps should all be fitted with variable drives to reduce energy consumption	Reduced energy demand	May not be suitable for small fans and pumps. Most suitable for centralised system or larger air handling units/distribution systems.	Variable speed drives match power demand with load	No	Low/ medium	High	should be used on all large centralised pumps and fans	Low
Domestic hot water	**Domestic hot water**	**Domestic hot water**									
	Assumed point of use heaters - spec to be confirmed	Solar thermal	Use solar thermal panels to produce hot water	Low energy solution. Toilets all in one area. May not require additional hot water supply.	Capital outlay. Will require store of hot water and therefore change to current design. Losses from store may outweigh gains from solar thermal/.	Requires water store. Potential to increase energy demand and cost due to water store and distribution system. Requires further investigation.	No	Low	High	Would require large store and distribution system Level of water demand.	Medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Insulated thermal and chilled immersions	Ensure all hot water /chilled water stores and pipework have sufficient insulation	Minimise loss of energy	Size of pipework increase	Probably already included - but worth checking if any pipework insulation specification can be improved	No	Low	High	For all cooling and heating distribution systems	Low
		Reduced water consumption	Low flow taps, catering with pull taps, dishwashers	Minimise loss of energy	May be more difficult to user	Worth ensuring all fittings enable low water consumption	No	Low	High	Measures outlined with draft specification	Low
Server rooms	**Server rooms**	**Server rooms**									
	Server room design	Temp control and layout	Use free-cooling where possible and do not overcool. Server rooms are often cooled too much and arranged to block cooling pathways. Clear design and guidance on temperature settings will reduce energy consumption	Minimise loss of energy	Need to ensure that server functions are not affected		No	Low	High	Design of all server rooms should consider temperature requirement and guidance on placement of servers	Low/ medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
Small power	**Small power**	**Small power**									
	Assumed standard PC/laptop with docking port. Assumed no switching off	A+ rated appliances	Appliances are highest efficiency	Low energy	Potential increase in capital cost	Should use most efficient equipment	No	Low	High	On all appliances	Low
	Timers	Timers on printers/photocopiers and recreation equipment	Add timers to link with occupancy	Reduce energy consumption	None	Reduce energy consumption	No	Low	High	On all appliances	Low
	Micro PV and battery	Small PV charges for mobiles and non-essential IT equipment	Use small renewables to save on energy demand	Reduce energy consumption	Capital cost	Reduce energy consumption	No	Low	High	Where feasible and does not affect use	Low

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
Controls	**Controls**	**Controls**									
	Assumed all manual control of air con units, lights and equipment	Centralise control. Building Management Systems.	Centralised control of cooling, lighting, ventilation. Centralise control (simple management system). Ensure local controls have sufficient occupancy and temperature controls	Allows timing to be set (relate to occupancy), centrally set room condition (and can limit occupancy changes) can measure consumption, allow so for zoning. Can provide metering function.	Expensive, will require dedicated staff to run, expertise required if malfunctions	May only be suitable with more centralised control	Yes	6%	High	Will require BMS designs to be integrated with building design and construction	Medium
		Local Control	Ensure local controls have sufficient occupancy and temperature controls	Reduced energy consumption. Simpler to control than central BMS	Local controls can easily be overridden with energy savings reduced	If no central plant, local controls should be under regular review to ensure suitable set-up.	No	Low/ Medium	High	Ensure controls are specified with building equipment and training provided to staff	Low

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
Pumps and fans											
		Any large fans or pumps should have a Variable Speed Drives	Large fans and pumps should all be fitted with variable drives to reduce energy consumption	Reduced energy demand	May not be suitable for small fans and pumps	Variable speed drives match power demand with load.	No	Low/ medium	High	Threshold of large fans	Low
Metering	Assumed diesel is monitored for consumption but further sub-metering	Meters on main plant and across main areas of site	Measuring energy consumption helps to monitor consumption, benchmark against similar sites and develop targets for reduction	Allows plans to be formalised to reduce energy consumption	Can be expensive to install meters and needs user interface and someone who knows how to use it	Metering is essential to energy management	Yes	3%	High	Metering should be provided for main plant. Threshold size of camp and load would apply.	low

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
Energy Generation	**Energy Generation**	**Energy Generation**									
		CHP - with heating for hot water or cooling through absorption chillers	A diesel CHP could generate electricity with the waste heat utilised within an absorption chillers. Will require all camp (or all residential units) to be served from central chillers with distribution of chilled water.	Provides heat and power- improves efficiency on current design where heat is wasted from generators	Need continual outlet for heat otherwise may not be economic in design. Hot water load will also compete with solar thermal technology if installed. Large plant may be difficult to deliver to site. Absorption chillers are also large plant. Will require energy centre and distribution network of chilled water to be viable.	CHP provides heat and power from one unit increasing the efficiency. In this situation where generator is being used it may be economic to ensure heat is captured - this could be used for cooling. Would require chilled water distribution from a centralised generation plant.	No	High	High	Requires centralised system and absorption chillers to make use of waste heat (if hot water demand is not sufficient). Need to undertake detailed energy modelling to determine viability. Need to consider size and transport feasibility of CHP and absorption chillers. CHP could be specified with heat store to make more efficient. Assumed for now that cooling load not high enough for absorption chillers and solar thermal more suitable for hot water. Threshold for absorption cooling to be determined	Low/ medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Photovoltaic cells. Modelled with 50m2 on roof	Photovoltaic's (PV) systems convert energy from the sun into electricity through semi-conductors cells, most commonly made of silicon. To be used in conjunction with battery back-up. Thin film incorporated into roof. Could be integrated into roof at manufacture.	Reduced energy demand	Capital cost is high. Large area may be required to deliver noticeable savings	PV cells produce electricity. Need to ensure can link with current electrical design	Yes	5.0%	High		Low
		Evaporative Cooling - Diabetic cooling	Mechanical process of lowering outside air temperature from process of evaporating stored water.	Cheaper to install, easier to maintain, consumes less energy, can provide humidification, increase air change rate	Works in climates where air is hot and humidity is low. Less suitable for locations with high humidity. Requires a constant supply of water.	Cooling output may not be sufficient for building loads. Potential to combine with mechanical chillers and use in evaporative mode to gain best efficiencies	No	Medium/high	medium	Access to water required (specific quantity to be determined from size of cooling requirement). Therefore not suggested as viable at present.	Medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Solar air conditioning	Utilises thermal energy (from solar collectors) to drive an absorption chillers.	Could provide low cost cooling	Effectiveness depends of amount of heat available. Could require large solar thermal system to deliver energy. Plant can be expensive	New technology. Cost effectiveness will depend on requirements for heat and power and whether solar thermal can provide sufficient heat for cooling. Back-up generator would be required	No	Medium/high	Medium	Further investigation required on the array size and appropriateness of application.	Medium/high
		Use ground source heat pump	Using open (aquifer) or closed (boreholes/building piles) efficiency of cooling can be improved	Energy savings	Cost/ Requires drilling many boreholes or availability of aquifer water	Significant construction required for either option that probably would not be possible unless permanent camp. Would require centralised system.	No	Medium	Medium	Only suitable if borehole or suitable water body is available	High
		Wind turbines	Either roof mounted or stand alone to provide electricity	Reduces energy demand	Rood mounted turbines provide limited energy. Stand alone will require careful siting and foundation. Will also need to link in with electricity generation from site	Wind turbines can provide free electricity. Need to link with current electrical design. Intermittent power - will require back up supplies. Can be used at off peak hours or generate hydrogen for fuel cell	No	Low/ medium/high - depending on size	Medium	Threshold depends on wind speed, suitable location for siting turbine, security risk (height of turbine), and skills for installation. Need to consider use of wind to make hydrogen in off-peak for fuel cell	Low/ medium

	Current design	Potential re-design	Brief specification and design implications	pro's	con's	commentary	Modelled	Energy/Carbon saving	ranking	Modifications/threshold required to make viable	Difficulty of installation
		Fuel Cells - with heating for hot water or cooling through absorption chillers	Like CHP fuel cells produce heat and power. Can run on fossil fuels, hydrogen	Provides heat and power in higher ratio of electricity : heat than CHP therefore potentially more suitable. If using hydrogen from wind, high savings	Expensive- still considered not commercially viable	An important technology to demonstrate. However expensive	No	Medium/high	Medium	Further research into suitable type and fuel source required. Requires centralised system and absorption chillers to make use of waste heat (if hot water demand is not sufficient). Need to undertake detailed energy modelling to determine viability	Low/ medium
		Biodiesel Generators, CHP and transport fuels	Fuels using part or all biofuel can reduce emissions	Reduced emissions	Security and cost of fuel supply and use of engine may be compromised unless expert is available	Bio fuels can realise significant carbon savings. But issues over supply, sustainability of production, cost and carbon content need to be resolved	No	High	Medium	Threshold depends on access to fuel and suitable technology and skilled maintenance staff	Low/ medium

Appendix 3 – Ranked water reduction measures

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
Showers	non-regulated conventional showers running from hot water tank at 30 litres per shower (average at 6 minutes per shower)	30	use of aerated shower heads				requires minimum of 1 bar to operate effectively	30%	retrofitting for existing shower installation - alterations to the procurement specification will ensure roll out across DPKO. Pumping may be required to reach 1 bar	
			install mixer valves to better control temperature regulation		use of mixer valves reduces water demand by reducing water lag time (i.e. residence time of water in pipes)				retrofitting could be achieved although would require more operational resource	

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
Toilets	single cistern siphon flush	10	dual flush toilets		this would involve installation of new cisterns or retrofit of existing single siphon flush		Users require education to use the correct function. Prone to leakage and breaking	40%		
			reduce cistern capacity	install water saving devices in toilet cistern (offsets volume)		low cost		20%	simple devices require minimum installation requirements	
			variable flush	use of a knob rotated around the flush mechanism		effective at variable volumes of water saving	user requires education - not suitable for those lacking incentive	40%		
			compost toilets	compost toilets are waterless relying on natural bacteria to break down the organic waste - waste can be used as compost	this achieves high water savings but requires daily attention	Saves 100% water. Organic waste can be used as compost once broken down.	Needs daily attention to ensure bacteria remain active.	100%	compost toilets will require the development of a new specification - it is felt that they are generally impractical to the requirements of a peacekeeping mission but could be used as a trial	

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
Urinals	urinal continuous flushing system i.e. no controls	180 (litres per urinal per day)	install flush controllers	controllers often are dependent on the presence of people therefore requiring motion or light sensors		the same electrical circuit can be used as for the lighting controls	A complex system compared to the two below with more risks of leaks and/or failures.	50%	installation of infra-red or motion sensors - either specified at procurement stage or extensive retro-fitting	
			single flush urinals	each user activates a flush mechanism	if the flush mechanism is not activated more water will be saved	This can save significant water volumes.		70%	these are already common-place and any supplier of toilet ware would be able to supply these	
			waterless urinals	no water is used - odours are eliminated with 'odour blocks'		total water savings, avoids flooding and potential mis-use	Does not deal with blockages as effectively as water - requires use of traps. Requires regular sluicing (weekly). Possible hygiene perception problems	100%	procurement specifications will require revision	

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
Hand washing	use of conventional (non-efficient taps)	5	install flow regulators	spray taps or inserts (tapmagic)		reduces water flow with the illusion of higher flow rates	prone to blocking as a response of calcium build up	80%		
				sensor taps or timed push on - off		prevent flooding and improves hygiene		80%		
Kitchen washing	use of conventional (non-efficient taps)	5	install flow regulators	spray taps or inserts (tapmagic) or cartridges installed into single lever taps	flow regulators work by reducing the volume of flow used in handwashing, teeth brushing etc. available at a variety of settings including 8, 6 and 5 litres	reduces water flow with the illusion of higher flow rates	increases the time taken to fill a sink as compared to conventional taps	80%	use of spray taps would require retrofitting or changes to the procurement specification - simple retrofitting can achieve immediate results	
				sensor taps or timed push on - off	removes the flow automatically	prevent flooding and improves hygiene		80%		
Dishwashing	use of conventional dishwasher	35 (per machine per operation)	use of A rated machines	these can be easily obtained and should not prove difficult			slightly higher capital expenditure	20%		

Use	Current design	Water consumption (litres - per person/day)	Potential re-design options	Brief specification and design implications	Comments	Strengths	Weaknesses	Water savings	Difficulty of installation	Ranking
Food preparation	use of conventional (non-efficient taps)	5	install flow regulators	spray taps or inserts (tapmagic)		reduces water flow with the illusion of higher flow rates		80%		
				sensor taps or timed push on - off		prevent flooding and improves hygiene		80%		
Air conditioning units	air conditioning is proposed to be 57 x 18000BTU (115volts/60 hz, window type units and 19 x 12000BTU and 114 x 24000, assumed COP of 3.2	3200 per day - all AC units	use of centralised system	further research is required on the relative savings of water against energy for closed or open loop centralised systems						
Laundry	use of conventional washing machine	35 (per machine per operation)	use of A rated machines	these can be easily obtained and should not prove difficult			slightly higher capital expenditure	20		

Appendix 4 – Ranked liquid waste reduction measures

Type of waste	Source	Current design	Potential re-design options	Brief specification and design implications	Strengths	Weaknesses	Ranking
Black water	urinals	sewerage system	anaerobic digestion system (AD) - biosolids to agriculture	AD system uses bacterial activity to reduce organic wastes to methane and carbon dioxide - methane can be used to generate energy	AD systems can utilise solid as well as liquid waste and reduce greenhouse gas emissions with a potential for positive energy impact, reduces disposal of organic waste to landfill - positive impact on vector (vermin) and nuisance problems	it is assumed that Mombasa is a lower security risk than Mogadishu and therefore AD is more applicable	
	toilets	sewerage system					
Grey water	showers	soakaway/evaporation	recycling system and remainder to soakaway or evaporation	the provision for grey water recycling will require the installation of tanks, pipework and pumps	obvious benefits in water reduction, increased perceptions of sustainability - use of photovoltaic's can make the system closed loop for energy intensity	Potential 'cultural' conflict for water re-uses. Initial capital outlay for tanks and pipework and pumps. Ongoing operational requirement	
	Handwashing	soakaway/evaporation					
	kitchen washing	soakaway/evaporation					
	food preparation	soakaway/evaporation					
	dishwashing	soakaway/evaporation					
	laundry	soakaway/evaporation					

Appendix 5 – Building Management System and Metering

UN House Juba - Building Management System and Metering

Introduction

The recently released report *Assessment of Energy and Water Reduction Options for the proposed UN House Juba, South Sudan* detailed that significant savings on building energy consumption could be saved through the use of a centralised management system.

This paper serves to introduce the concept of centralised or building management systems to enable UNMIS to undertake further evaluations with suppliers should such a system be installed and used.

Subsequently it is recommended that the following paper be read in conjunction with the above referenced report.

It has been assessed that improving the control of building services in all buildings on the UN House site in Juba, will significantly reduce energy consumption and therefore also reduce carbon emissions. At present limited controls have been specified for the main services such as cooling and lighting, small power and hot water consumption- which could lead to energy waste as equipment such as air conditioning (AC) units are left on during unoccupied times.

Centralised controls can also be used to monitor and optimise building services, raise alarms when plant is not working properly, act as a fire alarm system and be linked to site security.

Monitoring and reporting on energy consumption linked with awareness and reduction programmes can further enhance any savings. The capability to monitor energy consumption from the site level down to different end users within a single residential unit can provide a powerful tool to identify energy wastage and reduce consumption.

A number of products are available to provide improved control, monitoring and metering of services within a building and across the site. These range from a comprehensive building/site BMS system to installation of building /site metering.

Furthermore a number of strategies are available to ensure information is provided to building technicians and users to embed energy reduction opportunities in their office Standard Operating Procedures (SOPs) and individual behavioural practices.

This paper considers the benefits and disadvantages of these systems and identifies some of the key issues to be delivered to any Contractor within a performance specification.

Building Management System

The purpose of a Building Management System (BMS) is to automate and take control of building services in the most efficient way possible within the constraints of the installed plant. It can control, monitor and optimise building services, such as lighting; cooling; ventilation, humidity (if any) security, CCTV and alarm systems; access control. In some circumstance a BMS can be used for time and attendance control and reporting (notably staff movement and availability). BMS systems can also be linked to water meters to measure consumption and pressure sensors to raise the alarm of potential water leaks in the pipe work.

As a core function most BMS systems control cooling and manage the systems that distribute air throughout the building (for example by operating fans or opening/closing dampers), and then locally controls the mixture of heating and cooling to achieve the desired room temperature.

The BMS is a stand-alone computer system that can calculate the pre-set requirements of the building and control the connected plant to meet those needs. Its inputs, such as temperature sensors, and outputs, such as on/off signals are connected into outstations around the building (s). Programmes within these outstations use this information to decide the necessary level of applied control. The outstations are linked together and information can be passed from one to another. In addition a modem is also connected to the system to allow remote access.

The level of control via the BMS is dependent upon the information received from its sensors and the way in which its programmes tell it to respond to that information. As well as offering a precise degree of control to its environment, it can be made to warn if these are outside of specification and on individual items of plant failure.

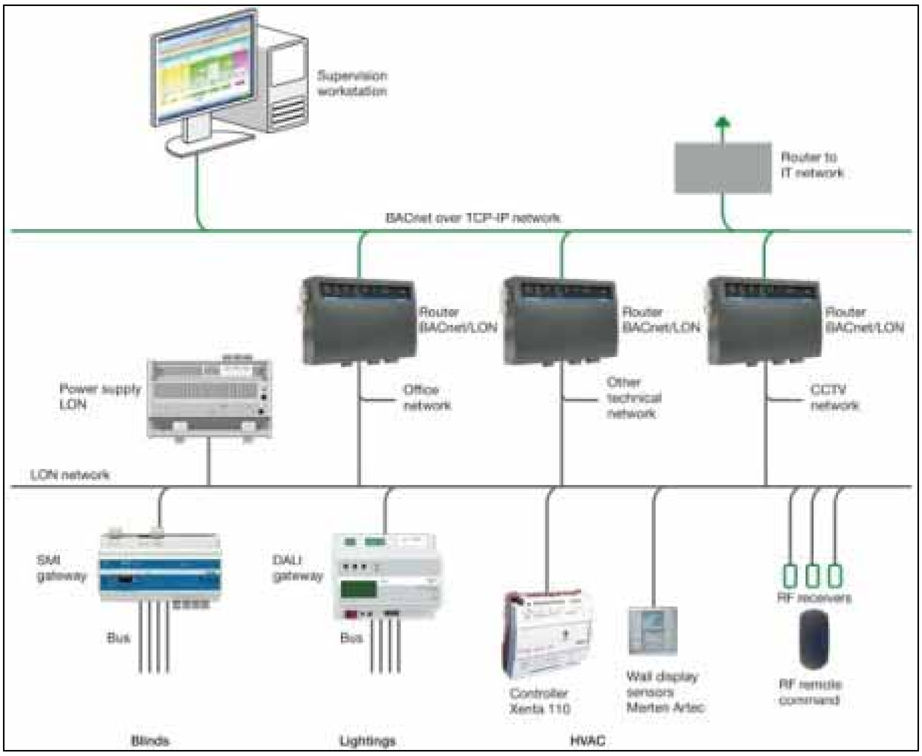
Occupancy times for different areas/buildings are programmed into the Building Management System such that the plant is brought on and off to meet the occupier requirements. These times are often under optimum start control. This means that the cooling plant is enabled, at a varying predetermined time, to ensure that the cooled space is at the set desired temperature for the start of the day.

A BMS is made up of three key elements. The first is the monitoring devices or sensors used to measure properties such as room temperature. The second is the controlled devices or actuators, such as valves, which can be opened to increase the volume of hot water running through a heating system and, in turn, warming a room. These two elements are connected or networked to the third element, the controller – the BMS – which is, in effect, a computer system with specialist software. The BMS receives data from the sensor and, if the values are not within the acceptable thresholds, the BMS tells the controlled devices to adjust to achieve the desired conditions. BMS software can be relatively simple or very sophisticated, allowing remote operation.

Figure 1 below provides an illustration from Schneider Electric[2] of a BMS system which is labelled to show the BMS control computer, sensors and connections to the different systems. The figure shows that the system can be connected across the internet networks within an office building and other communication systems.

[2] http://www.schneider-electric.com/sites/corporate/en/customers/contractors/energy-efficiency-solution-for-buildings/combine-various-control-systems.page

Figure 1: Illustrative BMS system



BMS Systems – Benefits

- Provide complete control, optimisation and monitoring of the building services within a building
- Monitor and adjust plant to provide required internal comfort conditions in most efficient manner
- Provide warnings and alarms for services outside of normal working parameters
- Utility data monitoring and targeting
- Central and remote control for building services
- Reduced energy consumption
- Improved plant reliability and life
- Effective response to heating/ventilation and air conditioning HVAC-related complaints
- Save staff time and money during the maintenance by being able to focus on those areas of sub-optimal performance highlighted by the BMS
- Computerized maintenance scheduling
- Early detection of problems and diagnostics

BMS system – Potential Disadvantages

- Requires on-site knowledge and handling capacity
- Risk of access to BMS support – absence of local service companies
- Capital cost against potential energy savings
- Limited access to BMS engineers and software upgrades

Key Considerations for BMS

The key considerations in determining the level of sophistication required from a BMS are:

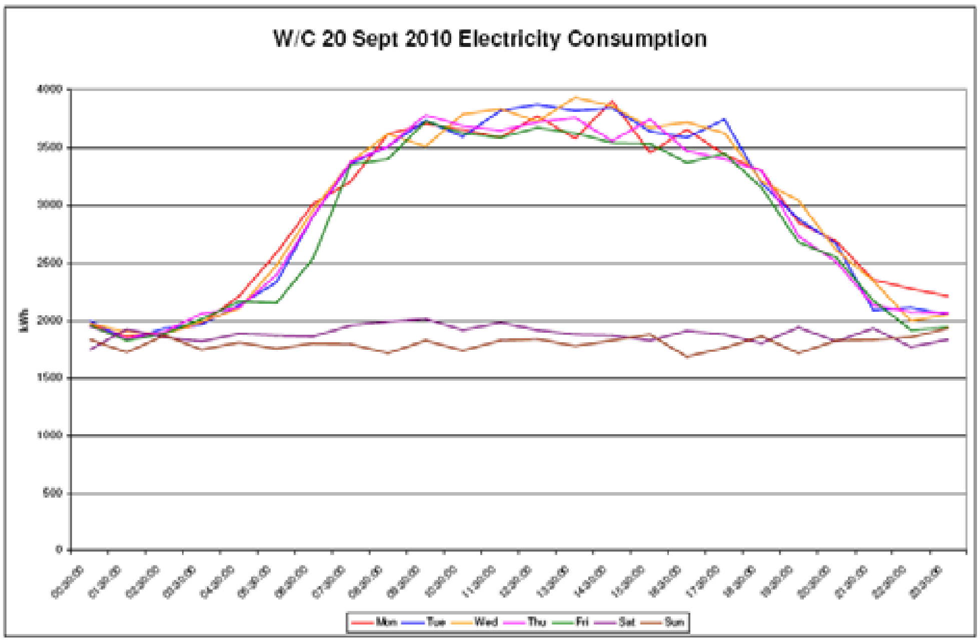
- What level of control/BMS sophistication is required?
- Which buildings should be included?
- How will the BMS be networked?
- What other functions are needed – optimisation, alarms, metering?
- How will information be recorded and disseminated?
- Who will use and manage the BMS?
- How will the BMS software and hardware be maintained?
- What are the capital cost and annual costs of the system versus expected resource gains?

Metering

A number of suppliers provide metering services which can be connected back to the BMS, recorded onto a stand-alone PC, or remotely to a website for online assessment and reporting.

Installing metering - or sub-metering if describing meters on a site not used directly for energy billing purposes – does not reduce energy consumption in itself. However making use of the information for consumption in different areas, services and times will provide important insights to where energy management can be improved. The example below shows the baseload electrical demand for a building, whilst also providing building managers with evidence that most other services are turned off when not required at the weekends.

Figure 2: Example of weekly electrical consumption for an office building



Metering is usually connected to some form of monitoring and targeting software to facilitate the analysis and reporting of data. A range of software exists that perform similar functions.

As with a BMS system, metering can be through a range of communication techniques, from sim card data loggers to Ethernet connections. Metering companies will determine the most suitable communication/recording strategies for a site based on the communication and security requirements of the customer.

Metering forms the basis for good energy (and carbon) management. With a clearly defined baseload of energy consumption for a site/building/activity, the impact of energy management decisions and investments can be tracked over time.

Metering can also be used to monitor consumption of cold water. This is especially important in a climate and location where fresh water is a valuable and scare commodity. As with energy metering a balance needs to be struck between the number of meters installed against the benefit of the information provided. It is recommended that water meters are specified for main incoming water meters to each office buildings and cafeteria and for groups of residential units.

It is recommended that the main energy and cold water uses in the offices, cafeterias and accommodation units are metered. These include:

Offices

- Cooling
- Ventilation fans (if any)
- Lighting
- Small power
- Hot water
- Cold water meter

Accommodation units

- Cooling
- Lighting
- Small power
- Hot water
- Cold water meter for groups of units

Cafeterias

- Hot water
- Main cooking appliances
- Ventilation
- Cooling??
- Lighting
- Cold water consumption

Metering should also be provided for the diesel consumption and electricity production from diesel generators.

With metering a balance needs to be struck between the number of sub-meters and the amount of useful information that can be acted upon.

Key Considerations for metering

- Specialist installation and commissioning expertise required
- Suitable recording system for site and building data collection
- On-site knowledge and use of monitoring and targeting software
- Capital cost, annual software and data management costs of the system

Summary and Recommendations

Significant benefits, including reduced energy consumption, can be realised with a central energy monitoring system.

BMS systems are most suited for large buildings with a range of building services which need careful control, monitoring and optimisation to provide set internal conditions and occupancy patterns.

The planned office buildings at the UN House in Juba will have relatively simple services and it may not be appropriate for the installation of a comprehensive and potentially complex Building Management System with full optimisation, alarm and monitoring controls.

It is recommended however that central building control options are investigated with BMS suppliers and installers to develop suitable system for the location and complexity of the buildings at the UN House site in Juba. From initial discussions with BMS suppliers, bespoke resilient systems are available to provide adequate control of internal environmental conditions, reduce maintenance imperatives and realise energy savings.

Some products (such as the Plug Wise product in the suppliers section below) are available on the market that provide simple on/off controls for electrical equipment whilst also linking with energy reporting software. These products mainly developed for the domestic market can be fitted to plug switched or lighting circuits and be programmed to occupancy patterns. These are simple products which if fail can be relatively easily removed and equipment can be used manually. This type of control is recommended for individual accommodation units – but may also be suitable for central control of the offices.

Metering should be installed across the site for all different buildings and key energy and cold water services within these buildings. Detailed design of the metering approach will take into account the number of meters required against the benefit of the information provided. Metering should be installed to provide half hourly energy consumption data.

Monitoring and targeting software should be specified to develop reports on a frequent basis that are then reviewed and acted upon to improve energy management across the site. This should be the same software for the whole site for ease of use and comparison purposes and linked into any BMS where possible.

Specification of Requirements

Outlined below are some of the key criteria required for BMS/metering control for the office and accommodation units

BMS Design requirements

Office and Cafeterias

- To be central point for all suitable non-residential buildings on the site
- Central control of main services linked to occupancy and internal environment
- Optimisation of building services to provide energy efficient services
- Alarms for plant outside normal operating parameters
- PC interface to be used by on-site maintenance staff
- Online remote support
- Appropriate fall-back measures if the system fails to control the building services
- Utility and data monitoring and targeting software
- Computerized maintenance scheduling
- Flexibility to take on future changes to the site

Accommodations requirements

- Metering should be provided for key energy uses –hot water, cooling, lighting small power
- Key services should be linked to a system that switches electrical equipment on/off against occupancy schedules
- Energy consumption should be captured within energy monitoring and targeting software

Operating Environment

- BMS controls, sensors, and communication devices need to be appropriate for weather conditions in South Sudan
- Communication needs to be appropriate to link to the information technology software at the site and be compatible with any security restrictions

Installation

- Detailed specification of the design, cost, communication approach, timescale and installers should be provided against the specification requirements for a simple resilient BMS system.
- Provision of regular trainings for the on-site BMS managers and maintenance staff.

Maintenance

- Suppliers would need to provide details of maintenance requirements; software and system update procedures and online and on-site support services they would facilitate.

Lifetime issues

- Suppliers would need to provide information on lifetime of the system, details of replacement procedure, costs and timescale for delivery of spare parts and details of length and coverage of warranty

Suppliers

BMS Suppliers

Name	Website	Email	Tel	Coverage
Cisco	www.cisco.com			
Johnson Controls	http://www.johnsoncontrols.com		44 (0) 1252 346300	Global
Schneider Controls	www.schneider-electric.com		0870 608 8 608	Global
Trend/Honeywell	https://www.trendcontrols.com/en-GB/bmssystem/Pages/default.aspx	www.trendcontrols.com	44 (0)1403 226 931	Global

Energy Management and Wireless Appliance Control

Name	Website	Email	Tel	Coverage
Plugwise	http://www.plugwise.com/idplugtype-g/about-plugwise	info@plugwise.com	+44(0)12 23 96 86 13	Global

Metering Suppliers

Name	Website	Email	Tel	Coverage
Envido	http://www.envido.co.uk/	info@envido.co.uk	020 7199 0090	TBC
Stark	http://www.stark.co.uk/contact.htm	office@stark.co.uk	+44 (0) 1293 776 747	TBC
Schneider Controls	www.schneider-electric.com		0870 608 8 608	Global

More technical information available at:
http://www.unep.org/disastersandconflicts/
or: postconflict@unep.org

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