Cheetham Hill Extension

Energy Efficiency & Sustainable Development Report

Issue 2 – 24th January 2024

A Submission by

DOCUMENT ISSUE STATUS

Issue No	Issue Date	Description	Written By	Approved By
1	18-01-24	DRAFT Planning Issue	J. Clarke	D.J. Sorbie
2	24-01-24	Updated to include design team comments	J. Clarke	D.J. Sorbie
3				

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Executive Summary

In adopting the approach set out in this document Safestore aim to demonstrate their continued commitment to Sustainable Development into each and every construction project they undertake.
This document details commitment to both $C0_2$ and environmental impact reduction at the proposed extension of the existing Safestore at Cheetham Hill Road, Manchester.

The report demonstrates how the proposed scheme far exceeds the current requirements of the energy and sustainability policies of Manchester City Council, by achieving a predicted reduction in regulated CO_2 emissions in excess of 100% against the **new Part L Building Regulations 2022** Target Emission Rate compliant baseline through the use of energy efficiency measures and renewable energy roof mounted PV array.

The extension will be carbon negative as it will generate more carbon savings than the extension will consume.

Energy Efficiency

Safestore are very low energy users, the main extension storage space is 'untreated' (not heated or cooled) so the only energy load within the main space is lighting which is high efficiency LED controlled on occupancy detectors.

The proposed development has achieved a highly rated 'A+' EPC – Net Zero
The proposed development will incorporate the following:

- Photovoltaic Array to achieve net zero
- Internal & external high efficiency LED Lighting linked to presence detectors
- 100% improvement of the new Part L Building Regulations 2022 Target Emission Rate
- Air sealing building improvement over Part L
- Carbon Neutral development

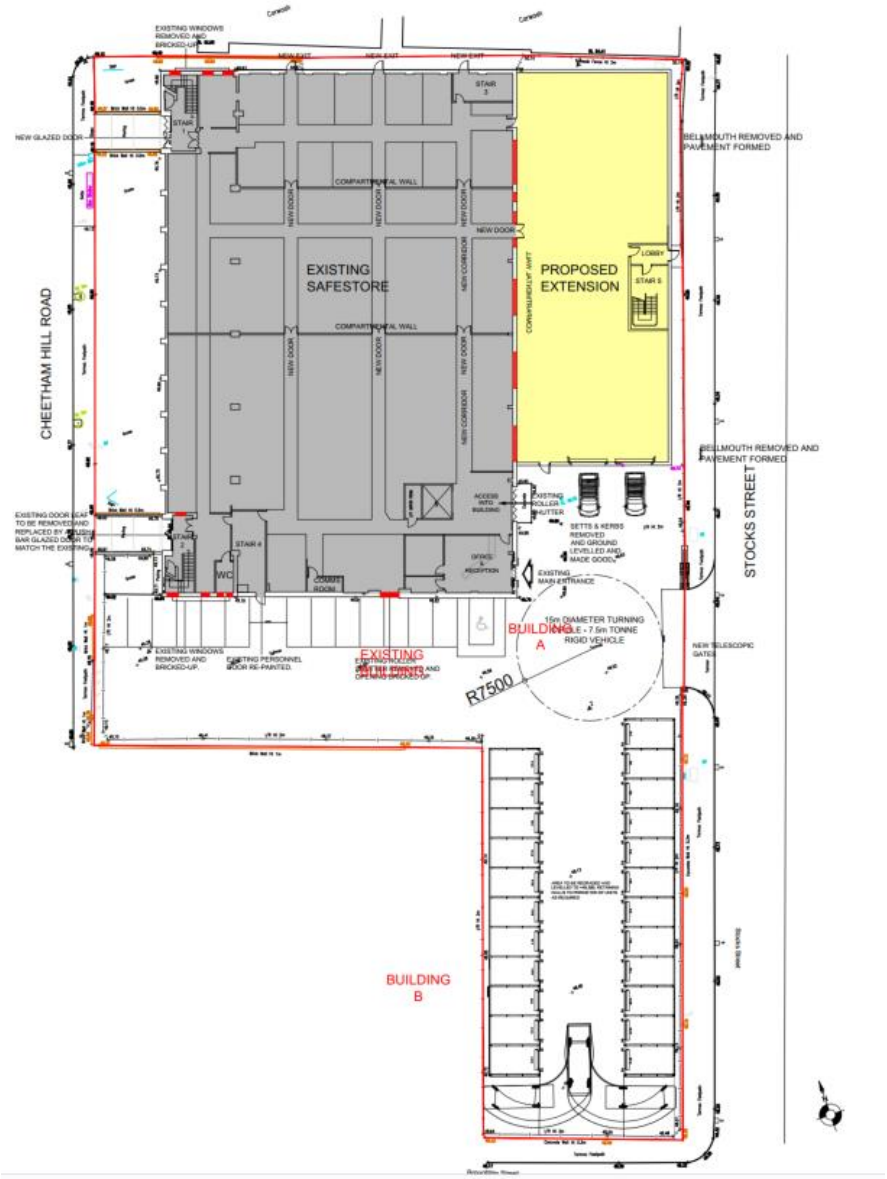
On Site Renewable Energy

Given the zero heat demand for the building renewable energy in the form of electricity is the best suited technology, therefore a roof mounted photovoltaic array will be incorporated.
The array will be sized during the detailed design stage of the project and as a minimum will achieve net zero EPC.

1.0 Brief Description of Proposed Development

The description of the development is as follows:

Erection of an extension to the existing self-storage warehouse



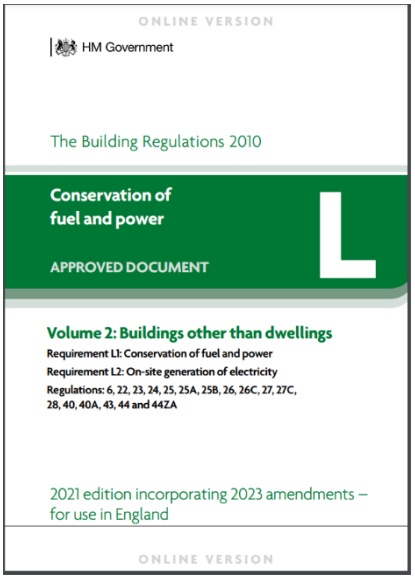
*Proposed Site Plan

**Please refer to Architects details for latest drawing information*

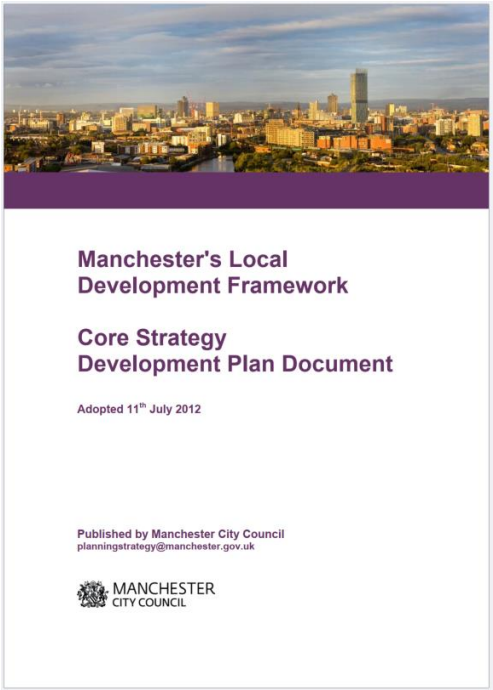
2.0 Relevant Legislation & Documentation

Building Regulations

As required by current legislation the Development as a minimum will be carried out in accordance with current Building Regulations including Part L2A 'Conservation of Fuel & Power'



Relevant Planning Policy



Local Authority Policy

3.0 Key Planning Policy

Manchester Local Development Framework
Core Strategy

Development Plan Document – 11th July 2012

Policy EN 4

Reducing CO_2 Emissions by Enabling Low and Zero Carbon Development

The Council will seek to reduce fuel poverty and decouple growth in the economy, growth in CO_2 emissions, and rising fossil fuel prices, through the following actions:

- All development must follow the principle of the Energy Hierarchy, being designed:
  - to reduce the need for energy through design features that provide passive heating, natural lighting and cooling
  - to reduce the need for energy through energy efficient features such as improved insulation and glazing
  - to meet residual energy requirements through the use of low or zero carbon energy generating technologies
- Wherever possible new development and retrofit projects, including energy generation plant, must be located and designed in a manner that allows advantage to be taken of opportunities for low and zero carbon energy supplies.
- Where possible new development and retrofit projects will be used as a mechanism to help improve energy efficiency and provide low and zero carbon energy supplies to existing buildings.
- Where appropriate new development and retrofit projects will be required to connect to and/or make contributions to low or zero carbon energy schemes and/or to incorporate provision to enable future connection to any existing / potential decentralised energy schemes.
- The use of building materials with low embodied carbon in new development and refurbishment schemes.

Policy EN 6

Target Framework for CO_2 reductions from low or zero carbon energy supplies

Applications for residential development of 10 or more units and all other development over 1,000 sq m will be expected as a minimum to meet the target shown in Tables 12.1 or 12.2, unless this can be shown not to be viable. This should be demonstrated through an energy statement, submitted as part of the Design and Access Statement. Such a statement will be expected to set out the projected regulated energy demand and associated CO_2 emissions for all phases of the development.

Developments smaller than the above threshold, but involving the erection of a building or substantial improvement to an existing building will also be expected to meet the minimum target, where viable, but will not be expected to submit an energy statement.

The target framework relates to three broad development locations and their potential for low and zero carbon, decentralised energy. The areas are defined as follows

- Target 1 Network development areas: Locations where the proximity of new and existing buildings, the mix of uses and density of development provide the right conditions to support district heating (and cooling).
- Target 2 Electricity intense areas: Locations where the predominant building type has an all electric fit-out such as retail units and leisure complexes.
- Target 3 Micro-generation areas: Locations where lower densities and a fragmented mix of uses tend to mean that only building scale solutions are practical.

Domestic CO_2 emissions reduction targets

Table 12.1

Target	% Minimum requirement
Target 1: Network development area	CHP/district heating anchor or connection or where not feasible a 15% increase on Part L 2010
Target 2: Electricity intense buildings	+15% increase on Part L 2010
Target 3: Micro generation area	+15%increase on Part L 2010

Non-domestic CO_2 emissions reduction targets

Table 12.2

Target	% Minimum requirement
Target 1: Network development area	CHP/district heating anchor or connection or where not feasible, a 15% increase on Part L 2010
Target 2: Electricity intense buildings (Applies to commercial uses with a high proportion of emissions from electricity use (>45 kg CO2/m2))	+10%increase on Part L 2010
Target 3: Micro generation area	+15% increase on Part L 2010

Where the CO_2 emissions reduction required under any future revision to Part L of the building regulations becomes greater than the '% Minimum requirement', the reduction required under building regulations would apply.

Where the Council identifies an 'allowable solution', for example within an energy proposals plan, that would produce higher carbon reductions at no extra cost than that of achieving the '% Minimum requirement' (or required under building regulations if greater) the higher percentage reduction will be required. The cost comparison is based on the cost of incorporating the 'allowable solution' at design stage.

The energy statement will be required to be submitted at the outset of any proposed development (outline application or before). Developers will be permitted to use green infrastructure elements such as green roofs, green walls, street trees and waterways to contribute to compliance with CO_2 mitigation, subject to the energy statement incorporating evidence such as modelling to demonstrate compliance.

Guidance on what the energy statement should contain and how to decide which target applies to a development proposal is given in Appendix A.

4.0 Report Authors

This report has been produced by Synergy Building Services Solutions Ltd. Synergy are independent Building Services Consultants and have been providing energy & sustainability expertise for over 24 years.

Synergy are;

- Low Carbon Energy Assessors
- Low Carbon Consultants
- Renewable Energy Consultants
- ESOS Assessors
- BREEAM Assessors
- Thermal Modellers
- Building Services Consultants

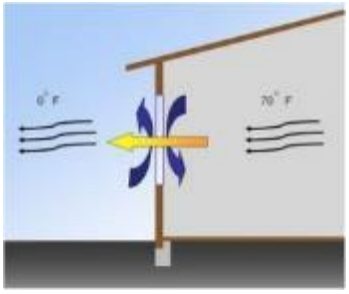
The chief author of this report is David Sorbie who has more than 40 years' experience of efficient building services design

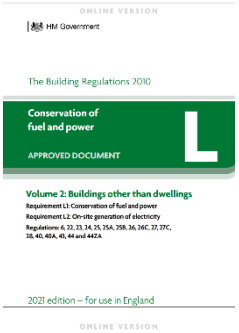
5.0 Be Lean Energy Efficiency

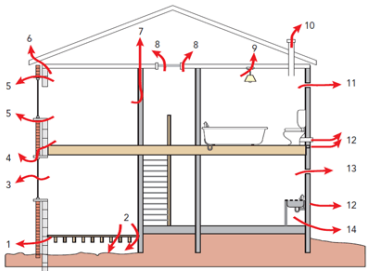
To comply with Part L Building Regulations an BRUKL/EPC has been produced at this early design stage of the project to inform the construction detail, material selections, energy efficiency measure required and on-site renewable energy generation. (Output Included in later section).

Fabric Improvements

To comply with current Building Regulations the new building the new building will be constructed to comply with L2A Conservation of Fuel & Power 2021 – came into force June 15th 2022







The majority of the proposed Safestore building is unoccupied and therefore 'Untreated' as defined by Part L Building Regulations. This is taken into account during the SBEM modelling of the building.

Synergy utilise TAS UK Government approved thermal modelling and Part L compliance software.

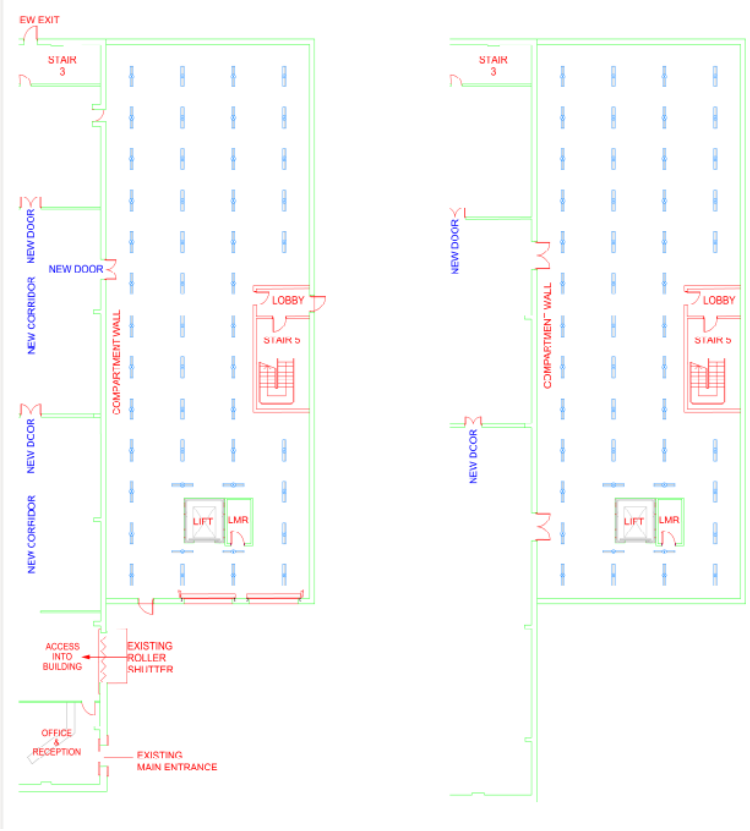
Plant & Equipment Energy Efficiency

To minimise the onsite energy demand of the construction 100% LED lighting will be utilised. This will not only reduce the energy consumption, but also future maintenance and lamp replacement. The lighting will also be connected to presence detection control to ensure that the luminaires are only ON whilst the area is occupied.

5.0 Energy Use Calculations

The proposed extension area will not be heated or cooled, the only energy consumed within the space will be lighting. Lighting will be provided by high efficiency LED linear battens.
We have produced a simple draft layout to indicate a possible fit out arrangement, likely the quantity will reduce from the numbers shown below.
The lighting is controlled on PIR occupancy sensors to maximise efficiency

Safestore's are efficient buildings and consume very little energy.



Extension Area Predicted Energy Use Table				
Description	Size/Quantity	kW Rating	Connected Load	kWHrs PA With Diversity
Gas Boiler	0	NA		
Air Source Heat Pump/s	0	NA		
Roller Shutter Doors	2	1.0	2.0	17.52
Lighting	96No 1500mm	0.03	2.88	87.6
Total kWhs per year				**210.24**
Predicted energy generated from per year				**21,055.00**

6.0 Renewable & Low Carbon Energy

See Appendix A & B for detailed review of all renewable technologies.

The renewable energy will be provided by a roof mounted Photovoltaic Array which will reduce the on-site electrical energy demand that is drawn from mains electricity.

Photovoltaic Cells

When certain materials are subjected to sun light, they develop an electric potential that can be used to generate electricity. These photovoltaic (or PV) systems can be used for large scale centralised power generation, for de-centralised grid-connected power supply and as a remote power source when there is no grid-supplied electricity available.

Positive Considerations

- *Photovoltaics have a proven track record*
- *One of the first UK installations from 50 years ago, is still operating today.*
- *Photovoltaics require very little on-going maintenance*
- *Failure of operation will not affect site operation*
- *Photovoltaics can be incorporated as part of the building fabric or in part installed in a highly visual location to make a public statement as is required*
- *Photovoltaics do not emit noise or vibration*
- *Photovoltaics are not dependent on-site fuel delivery*
- *The cost of the fuel source will not increase*

Negative Considerations

- *Comparatively high capital cost to energy production ratio*
- *Government reduction on Feed in Tariffs*
- *May add weight to structure – increased steel*
- *May produce negative visual aspects*
- *Not all sites will be suitable for location of PV cells*

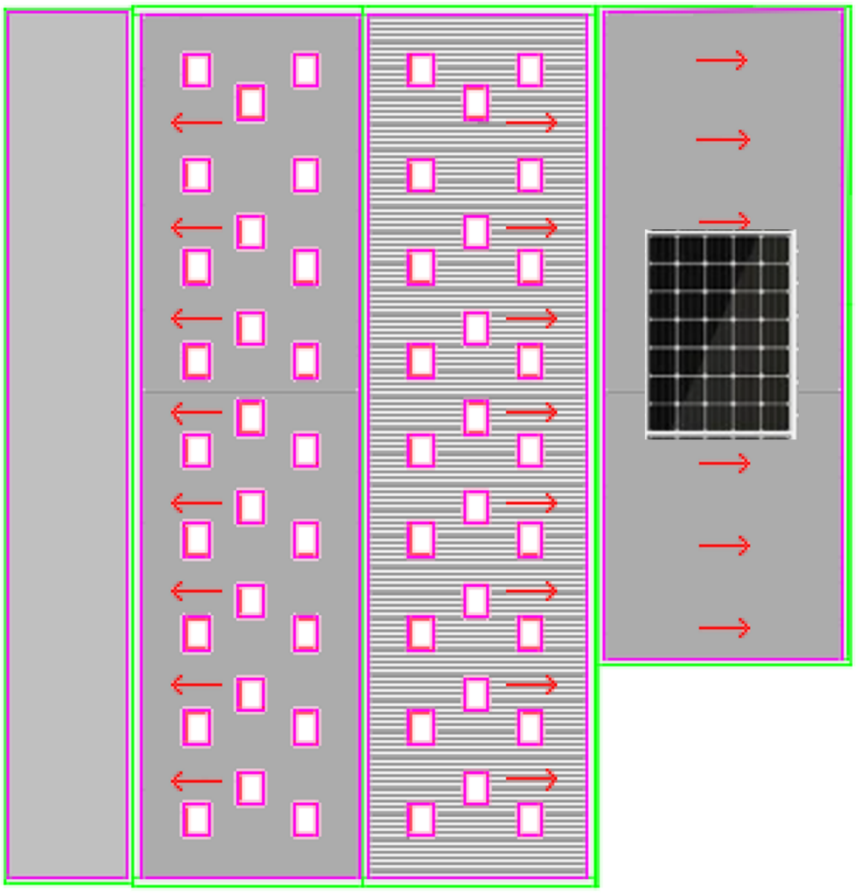
Technical Review

There is no noise issue associated with the use of this technology and roof mounted solution(s) would minimise any visual impact on the site. That said, there are structural steel considerations and access issues to some areas of the roof which may limit the extent of arrays.

Photovoltaic panels will suit the proposed development's energy profile, and will be utilised to target the requirements set out within the Planning Policy

PV Array Integration

To maximise the energy production the PV array shall be roof mounted, ideally south facing and elevated 20-30 degrees. It is important that the location of the array considers maximum efficiency, safe access and working with the structure of the building, increasing the structural steel to cope with an increased roof loading should be avoided.



Roof Plan Showing Approx Location for PV Array

The array will be sized to achieve net zero and a s minimum which far exceeds the requirements of both Building Regulations and Planning Policy.

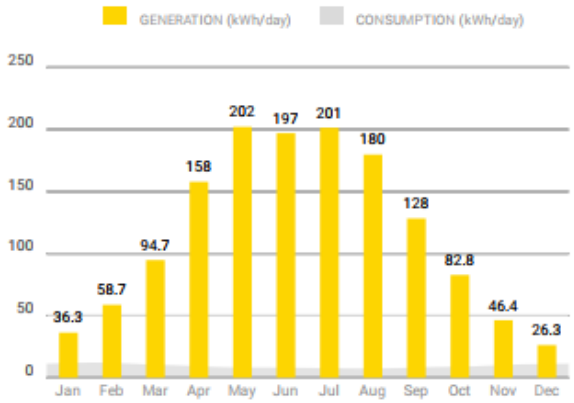
PV Specialist Proposal

Information provided based upon similar Safestore project
Manchester specific calculations will be carried out at detailed design stage

V-TAC
Meaningful Innovation.

System Performance

1230%
Energy From Solar



System Performance Assumptions: System Total losses: 15.2%, Inverter losses: 1.6%, Optimizer losses: 0%, Shading losses: 0%, Performance Adjustment: 0%, Output Calculator: System Advisor Model 2020.02.29.r2. Panel Orientations: 48 panels with Azimuth 180 and Slope 20, 44 panels with Azimuth 90 and Slope 20.

The MCS output (MIS 3002) and self-consumption (MGD 003) calculation methodology was not used in calculating the numbers in the table below. An alternative calculator System Advisor Model 2020.02.29.r2 was used.

A. Installation data		
Installed capacity of PV system - kWp (stc)	50.14	kWp
Orientation of the PV system - degrees from South	Group 1: 48 panels with Orientation: 0 ° Group 2: 44 panels with Orientation: 90 °	•
Inclination of system - degrees from horizontal	Group 1: 48 panels with Tilt: 20° Group 2: 44 panels with Tilt: 20°	•
Postcode region	12	
B. Performance calculations		
kWh/kWp (Kk)	858.7	kWh/kWp
Shade Factor (SF)	1.00	
Estimated annual output (kWp x Kk x SF)	43,055	kWh
C. Estimated PV self-consumption - PV Only		

Assumed occupancy archetype	In Half Day	
Assumed annual electricity consumption, kWh	3,500.00	kWh
Assumed annual electricity generation from solar PV system, kWh	43,055	kWh
Expected solar PV self-consumption (PV Only)	1,568.71	kWh
Grid electricity independence / Self-sufficiency (PV Only)	44.82	%

Environmental Benefits

Solar has no emissions. It just silently generates pure, clean energy.

Each Year

1230%	11 tons
Of CO_2, SO_x & NO_x	Avoided CO_2 per year

Over System Lifetime

320,163	2,058	229
Car km avoided	Trees planted	Long haul flights avoided

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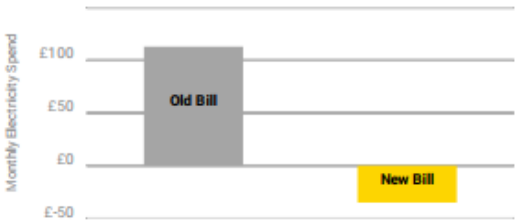
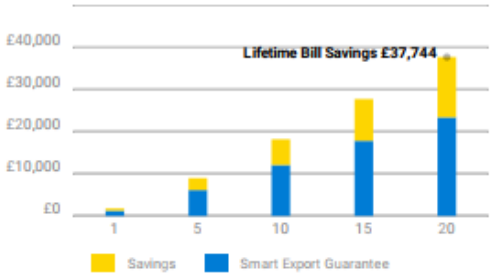
Electricity Bill Savings

First Year Monthly Bill Savings



Lifetime Bill Savings



Month	Solar Generation (kWh)	Electricity Consumption before solar (kWh)	Electricity Imported after solar (kWh)	Electricity Exported after solar (kWh)	Export Credit (£)	Utility Bill before solar (£)	Utility Bill after solar (£)	Estimated Savings (£)
Jan	1,126	350	241	1,018	31	133	65	67
Feb	1,644	341	218	1,521	46	130	42	88
Mar	2,937	339	188	2,786	84	129	-6	135
Apr	4,735	289	135	4,581	137	112	-78	190
May	6,266	257	102	6,110	183	101	-135	236
Jun	5,911	244	84	5,751	173	97	-130	227
Jul	6,242	236	85	6,090	183	94	-140	234
Aug	5,573	232	100	5,441	163	93	-115	208
Sep	3,849	255	132	3,727	112	100	-53	153
Oct	2,566	284	171	2,453	74	110	-2	112
Nov	1,391	324	219	1,286	39	124	50	74
Dec	815	349	257	722	22	133	79	53

Rate not specified specified, using Electricity based on location.

Your projected energy cost is calculated by considering a 3.0% increase in energy cost each year, due to trends in the raising cost of energy. This estimate is based on your selected preferences, current energy costs and the position and orientation of your roof to calculate the efficiency of the system. Projections are based on estimated usage of 3500 kWh per year, assuming Electricity Electricity Tariff.

Your electricity tariff rates may change as a result of installing the system. You should contact your electricity retailer for further information.

Proposed Tariff Details - E.ON Electricity (England)	
Energy Charges	
Usage Charge *All Day*	**£0.45 / kWh**
Feed-in Tariff	

Latest UK Government Carbon Factors

UK Government GHG Conversion Factors 2022	
Fuel	kg CO_2e / kWhr
Natural gas	0.201
Grid supplied electricity	0.193
Grid displaced electricity	0.233

Department for Business, Energy & Industrial Strategy

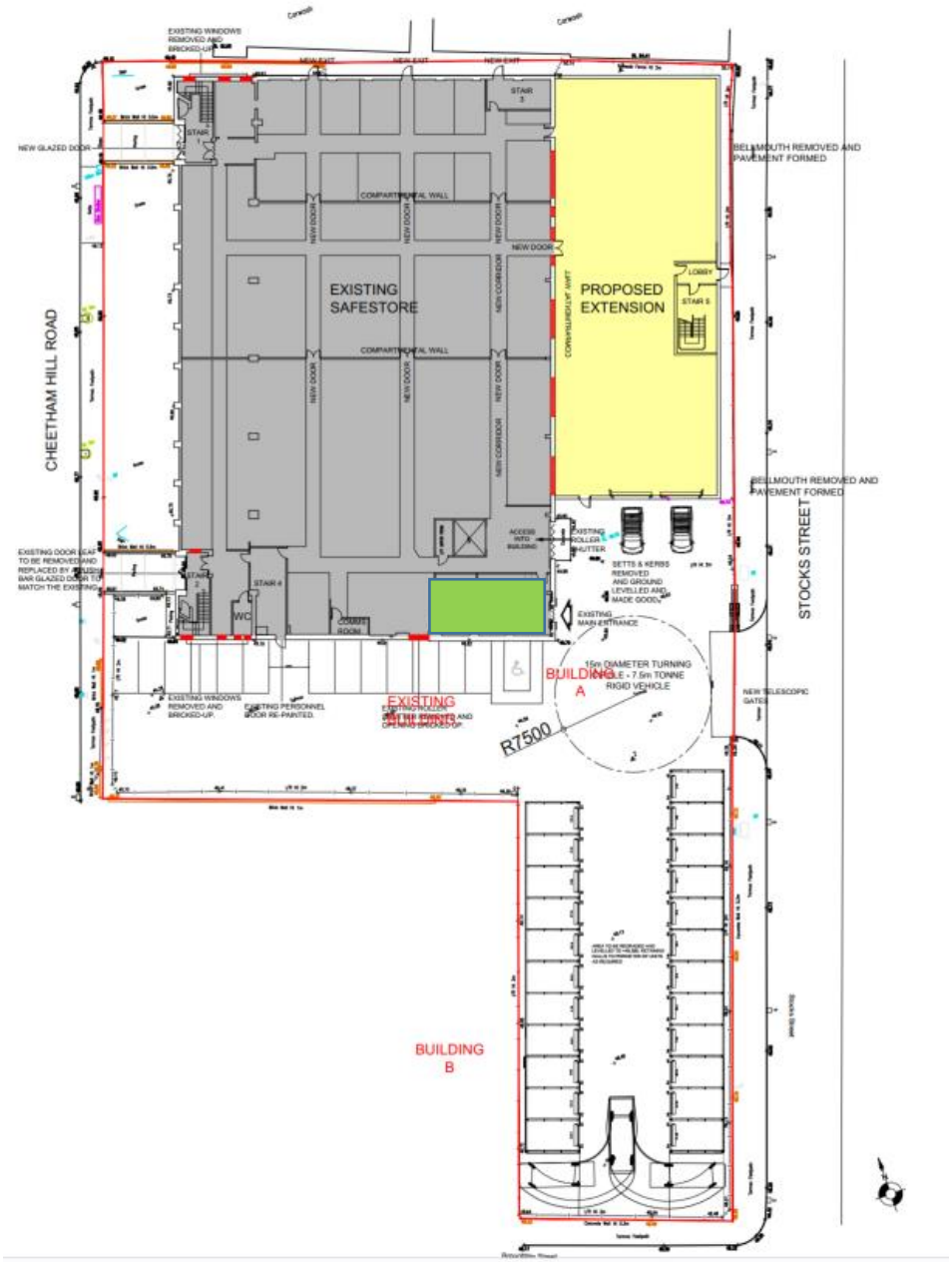
Department for Environment Food & Rural Affairs

7.0 Treated – Untreated Areas

The proposed Safestore extension is similar in layout and proportions to many existing units that make up the Safestore estate. The Occupied –'Treated' areas make up around 1% of the complete development.

The extension area is not heated or cooled it is classified as 'untreated'

The plans below show the 'Treated Green to Untreated Area Proportions' hence energy use is very low in terms of kg./CO^2M^2.



8.0 EPC/BRUKLs

Much like the multi-coloured sticker on new appliances, EPCs tell you how energy efficient a building is and give it a rating from A (very efficient) to G (inefficient). They let the person who will use the building know how costly it will be to heat and light, and what its carbon dioxide emissions are likely to be.

BE-GREEN EPC DOCUMENT (WITH PV) AS PROPOSED FOR DEVELOPMENT

Energy Performance Certificate

HM Government

Non-Domestic Building

202-208 Cheetham Hill Rd
MANCHESTER
M8 8LW

Certificate Reference Number:
1729-6997-7032-8562-4556

This certificate shows the energy rating of this building. It indicates the energy efficiency of the building fabric and the heating, ventilation, cooling and lighting systems. The rating is compared to two benchmarks for this type of building: one appropriate for new buildings and one appropriate for existing buildings. There is more advice on how to interpret this information in the guidance document *Energy Performance Certificates for the construction, sale and let of non-dwellings* available on the Government's website at www.gov.uk/government/collections/energy-performance-certificates.

Energy Performance Asset Rating

More energy efficient

A+

-23 **This is how energy efficient the building is.**

Net zero CO_2 emissions

A 0-25
B 26-50
C 51-75
D 76-100
E 101-125
F 126-150
G Over 150

Less energy efficient

Technical information

Main heating fuel:	Other
Building environment:	Unconditioned
Total useful floor area (m^2):	1826
Building complexity:	Level 5
Building emission rate ($kgCO_2/m^2$ per year):	-2.01
Primary energy use (kWh_{PE}/m^2 per year):	-23.36

Benchmarks

Buildings similar to this one could have ratings as follows:

16 If newly built

65 If typical of the existing stock

ONLY FOR ILLUSTRATION

Administrative information

This is an Energy Performance Certificate as defined in the Energy Performance of Buildings Regulations 2012 as amended.

Assessment Software:	TAS v9.5.6 using calculation engine TAS v9.5.6
Property Reference:	UPRN-123456789012
Assessor Name:	Paul Cownley
Assessor Number:	LCEA141452
Accreditation Scheme:	CIBSE Certification Limited
Assessor Qualifications:	NOS5
Employer/Trading Name:	Synergy Building Services Solutions Ltd
Employer/Trading Address:	Synergy Building Services Solutions, Ground Floor, Kings Ride Court, Kings Ride, Ascot, SL5 7JR
Issue Date:	18 Jan 2024
Valid Until:	17 Jan 2034 (unless superseded by a later certificate)
Related Party Disclosure:	Not related to the owner

Recommendations for improving the energy performance of the building are contained in the associated Recommendation Report: 7046-1233-7945-7949-7455

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by CIBSE Certification Limited. You can obtain contact details of the Accreditation Scheme at www.cibsecertification.com.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.ndepcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. For further information about how data about the property are used, please visit www.ndepcregister.com. To opt out of having information about your building made publicly available, please visit www.ndepcregister.com/optout.

There is more information in the guidance document *Energy Performance Certificates for the construction, sale and let of non-dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document and advises on how to identify the authenticity of a certificate and how to make a complaint.

Opportunity to benefit from a Green Deal on this property

The Green Deal can help you cut your energy bills by making energy efficiency improvements at no upfront costs. Use the Green Deal to find trusted advisors who will come to your property, recommend measures that are right for you and help you access a range of accredited installers. Responsibility for repayments stays with the property - whoever pays the energy bills benefits so they are responsible for the payments.

To find out how you could use Green Deal finance to improve your property please call 0300 123 1234.

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BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

Manchester Central Safestore

As designed

Date: Thu Jan 18 16:16:35 2024

Administrative information

Building Details

Address: 202-208 Cheetham Hill Rd, MANCHESTER, M8 8LW

Certifier details

Name: Paul Cownley

Telephone number: 01344874446

Address: Synergy Building Services Solutions, Ground Floor Kings Ride Court, Kings Ride, Ascot, SL5 7JR

Certification tool

Calculation engine: TAS

Calculation engine version: "v9.5.6"

Interface to calculation engine: TAS

Interface to calculation engine version: v9.5.6

BRUKL compliance module version: v6.1.e.0

Foundation area [m^2]: 1.92

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	1.4	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	-2.01	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	15.17	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	-23.36	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.23	0.23	External Wall
Floors	0.18	0.25	0.25	Ground Floor
Pitched roofs	0.16	0.25	0.25	Roof
Flat roofs	0.18	-	-	No flat roofs in project
Windows** and roof windows	1.6	-	-	No windows or roof windows in project
Rooflights***	2.2	-	-	No rooflights in project
Personnel doors^	1.6	2.19	2.19	PD
Vehicle access & similar large doors	1.3	1.49	1.49	Roller Shutters
High usage entrance doors	3	-	-	No high usage entrance doors in project

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$] $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check. *** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m^2K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	5

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	NO
Whole building electric power factor achieved by power factor correction	<0.9

1- Lift- LMR 1

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0	-	-	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

1- POU

	Water heating efficiency	**Storage loss factor [kWh/litre per day]**
This building	1	0
Standard value	1	N/A

"No zones in project where local mechanical ventilation, exhaust, or terminal unit is applicable"

General lighting and display lighting	**General luminaire**	**Display light source**	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
Circ - 1	130	-	-
Circ - 2	130	-	-
Circ - 3	130	-	-
Circ - 4	130	-	-
Circ - 5	130	-	-
Circ - 6	130	-	-
Store - 1	130	-	-
Store - 2	130	-	-
Store - 3	130	-	-
Lift- LMR 1	130	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	**Solar gain limit exceeded? (%)**	**Internal blinds used?**
Store - 1	N/A	N/A
Store - 2	N/A	N/A
Store - 3	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	1826	1826
External area [m²]	2193	2193
Weather	MAN	MAN
Infiltration [m³/hm²@ 50Pa]	5	5
Average conductance [W/K]	558	719
Average U-value [W/m²K]	0.25	0.33
Alpha value* [%]	21.36	6.36

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
100	**Storage or Distribution**
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	0	0
Cooling	0	0
Auxiliary	0	0
Lighting	6.54	6.54
Hot water	3.79	3.79
Equipment*	29.41	29.41
TOTAL**	**10.33**	**10.33**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	26.36	0.06
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*26.36*	*0.06*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	0	0
Primary energy [kWh_{PE}/m^2]	-23.36	15.17
Total emissions [kg/m²]	-2.01	1.4

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Other local room heater - unfanned, [HS] Direct or storage electric heater, [HFT] Electricity, [CFT] Electricity										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

9.0 Sustainable Development

Considerate Constructors Scheme

The appointed Main Contractor will be registered under the Considerate Constructors scheme. This development will achieve a level of performance that significantly exceeds 'compliance' with the criteria of the scheme. The Main Contractor will aim for a score of at least 35 (with a minimum of 7 in each section).

Materials and construction waste

Waste will be kept to a minimum throughout the construction phase by the use of economical design and construction processes combined with good management practice. A Site Waste Management Plan will be put in place at pre-construction stage, which will be continually maintained. Waste minimisation techniques to be employed and referenced in the SWMP will include, but not be limited to:

- eliminate waste at source wherever possible
- reduce waste on site by employing good management systems
- re-cycle waste on site wherever possible.

This hierarchy will be further managed in a number of ways:

- economical design
- ensure correct management procedures are employed when measuring and procuring materials to ensure correct quantity and specification
- clean, tidy and safe storage of materials on site
- timely delivery of materials
- manage client expectations to minimise design changes
- control of quality to minimise defective work
- re-use of materials on site wherever possible
- where space allows the segregation of waste for recycling, or the use of external licensed waste contractors who will collect mixed waste skips, then segregate and recycle from their own premises.

The existing site construction elements will be recycled where possible

Appendix A

Renewable Energy Generation Technologies Overview

Renewable Energy Generation Technologies Overview							
Technology	Characteristics	Functionality	Cost Effectiveness	Reliability	Maintenance Requirement	CO_2 Saving Potential	Suitability for this project
Absorption Cooling	Requires no mechanical vapour compression. Activated by external heat source	High. Waste heat from CHP source used to provide cooling source for air conditioning	Medium. More expensive than conventional chillers but uses waste heat	High. Few moving parts	Low	Medium - High	Low
Biomass	Uses plant-derived organic material (relatively carbon neutral). Can produce heat or biogas depending on the type of technology	Uses plant-derived organic material (relatively carbon neutral). Can produce heat or biogas depending on the type of technology	Medium. More expensive than conventional boilers	High for direct combustion systems. Anaerobic digestion and gasification systems can be problematic	Medium/high Direct combustion systems are partially self cleaning	High	Low
CHP	Generates both electricity and heat using fossil or renewable fuels	High. Requires predictable and relatively constant loads for best performance	Medium. Requires full utilisation of waste heat	Medium. Proven technology	Medium. Requires regular planned maintenance	Medium. Can be improved if biomass fuel is used	Low
Fuel Cells	Medium. Can be improved if biomass fuel is used	High, same as CHP	Low. Limited range of commercially available fuel cells, and expensive	Low. Limited range of commercially available fuel cells, and expensive	Medium. Few moving parts. Fuel cell stack has finite life	Low	Low

Renewable Energy Generation Technologies Overview							
Technology	Characteristics	Functionality	Cost Effectiveness	Reliability	Maintenance Requirement	CO_2 Saving Potential	Suitability for this project
Grey Water Recovery	Reuses waste water (bathing, washing, laundry) for toilet flushing, irrigation, and other non-potable uses	Medium. Requires match between waste water source and use	Low. Installation and on-going costs may not justify savings	Medium. Pumps, filters, and sensors can present problems	Medium. Requires planned maintenance regime to cover health risks	Low	Low
Ground source systems – air	Uses heat from the ground to pre-condition the supply air to a building	High. Can pre-cool air in summer and pre-heat it in winter	Medium. Depends on cost of drilling or excavation to install pipes	High, no moving parts	Low. Providing steps are taken to pre-filter air and avoid water ingress	Medium	Low
Ground source systems – water	Makes use of water from aquifers (either directly or indirectly) to provide cooling in summer	High. Can be combined with heat pump technology. Heat source can pre-heat ventilation air	Medium. Depends on cost of boreholes.	High. However, open-loop systems are susceptible to blockages and biological fouling	Low for closed-loop systems	Medium	Low
Ground source heat pumps	Takes up heat from ground and releases it at higher temperatures. Heat can be used for space heating and domestic hot water	High. Systems can be run in cooling mode	Medium	High. Relatively few moving parts. Proven technology	Low	Medium. High COPs are dependent on relatively low supply temperatures in heating mode	Low

Renewable Energy Generation Technologies Overview							
Technology	Characteristics	Functionality	Cost Effectiveness	Reliability	Maintenance Requirement	CO_2 Saving Potential	Suitability for this project
Photovoltaics	Converts sunlight directly to DC electrical power. Requires inverter to convert to AC	Medium. Requires careful positioning for optimum performance. Wide range of installation options	Low. However, costs are predicted to improve	Medium. Associated inverters can cause problems	Low, but specialist	Low. Relative to high cost	High
Rainwater recovery	Collects and stores rainwater from roofs and other catchment areas for toilet flushing	Medium. Requires a balance between collected water and its use. Large storage tanks may be required	Low. Installation and on-going costs may not justify savings	Medium. Pumps, filters, and sensors can present problems	Medium. Requires inclusion in a planned maintenance regime	Low	Low
Solar air heating	Collects solar energy to heat supply air. Can also heat re-circulated air	Medium. Relatively large number of techniques. Can also pre-heat domestic hot water	Medium. Solar collectors can be an integral part of the building fabric	High	Medium. Solar collectors can be an integral part of the building fabric	Low – medium. Requires fan power, however this could be provided by photovoltaics	Low

Renewable Energy Generation Technologies Overview							
Technology	Characteristics	Functionality	Cost Effectiveness	Reliability	Maintenance Requirement	CO_2 Saving Potential	Suitability for this project
Solar Cooling	Solar thermal energy used to drive absorption, adsorption or desiccant cooling	Medium. Requires matching of solar collector temperature with chiller operating temperature.	Low. Relatively high cost of absorption chillers and solar collectors	High	Low. Absorption chiller is low maintenance	Low-Medium	Low
Solar water heating	Solar energy used to heat water, usually for domestic hot water purposes	Medium. Proven technology with a range of collectors for different operational requirements	Medium	Medium – high. Circulation pump and valves are relatively reliable	Low	Medium. Circulating pumps can be PV powered	Low
Surface water cooling	Uses pumped water from the sea, lakes or rivers to provide a cooling medium	Low. Relatively few buildings close to suitable water sources	Low – medium. Depends on the length of piping required	Medium – high. Filtration required to prevent heat exchanger fouling	Low	Medium. Depends on the pumping power required	Low

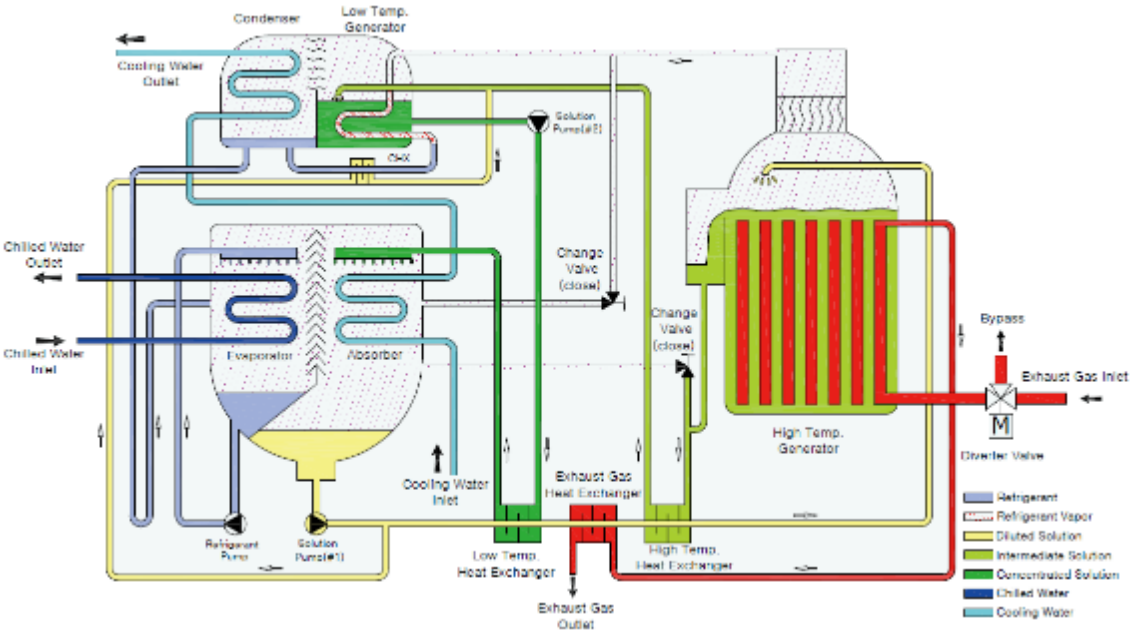
Renewable Energy Generation Technologies Overview							
Technology	Characteristics	Functionality	Cost Effectiveness	Reliability	Maintenance Requirement	CO_2 Saving potential	Suitability for this project
Water Conservation	Medium. Depends on the pumping power required	Can be used in a wide range of applications and building types	Medium. Depends on device	Generally reliable, but some devices may be susceptible to hard water	Low – medium. Waterless urinals require regular and correct maintenance	Low	High
Wind	Turbine/ generator converts wind energy to electrical power	Best performance in open, non-urban locations. Can be installed on, or integrated into, a building	Low. Depends greatly on available wind conditions. Actual power output likely to be much less than the rated output	Medium. Turbulent air conditions associated with urban locations may reduce lifespan of components	Medium. Requires regular maintenance. Access may be an issue	Low – medium. Large sized turbines in non-urban or off-shore locations will be more effective	Low
Natural ventilation	Openable vents to allow purging of hot air and to allow fresh cooler air to enter.	Can be used in warehouses or offices. If they are roof mounted then rain sensors will be required and vents cannot be placed above stock.	May use smoke vents by addition of manual controls. Otherwise expensive to install if not already present. More builderswork.	Generally reliable. Rain sensor will need to be regularly checked.	Medium. Access required onto roof.		Low

Appendix B

Detailed Review of All Renewable Energy Generation Technologies

Absorption Cooling		
Absorption cooling can be considered as an alternative to traditional chillers if one of the following factors applies:	Comment on Suitability for this project	Potential for this project
An existing combined heat and power (CHP) unit is present and not all of the waste heat is being used	No existing CHP present	Low
A new CHP installation is being considered	CHP is best utilised where there is a requirement for a constant heat source e.g. large hot water use, swimming pools etc. CHP will not be suitable as there is no constant heat requirement, in which case Absorption Cooling unlikely	
Waste heat is available from a process	No significant waste heat available from processes	
Renewable fuel sources can be used such as landfill gas.	Site Specific – none available	
The available heat source will determine the type of absorption chiller that is suitable for a specific application. Typical sources of heat include:		
Gas turbine CHP	Not applicable	
Reciprocating engine CHP	Not applicable	
Waste heat	None available - as usually associated with building process	
Hot water and steam.	None available - as usually associated with building process	

Absorption Cooling
Benefits
Can make use of waste heat
Refrigerants used have no global warming potential
Quiet and vibration-free
Reliable
Relatively low maintenance costs
Limitations
Low efficiency, and low coefficient of performance compared to conventional chillers
Relatively high cost compared to vapour compressors
Larger heat-rejection plant than conventional chillers
Slower to start up and slower to respond to changing loads



In a conventional vapour-compression chiller an electric motor is used to drive a compressor. In an absorption chiller a heat source drives the cooling process. Heat sources can include hot water, steam, hot air or hot products of combustion (exhaust gases) from the burning of fuel.

Allied technologies

- CHP
- Industrial processes producing waste heat
- Renewable sources producing heat

Biomass		
Biomass can be considered as an alternative to traditional Boilers if the following applies	Comment on Suitability for this project	Potential for this project
Ideally a consistent requirement for a steady heat load is present	Biomass is best utilised where there is a requirement for a constant heat source e.g. large hot water use, swimming pools etc. as boilers are not efficient at modulating loads This development does not have a requirement for constant heat	Low
Sustainable ethical Biomass fuel source is available e.g. • Wood • Wood pellet • Wood chip • Vegetable oil • Bioethanol • Biogas • Biodiesel	Not investigated as technology not suitable for this development	
Renewable fuel sources can be used such as landfill gas or anaerobic digestion.	Site Specific – none available	
Space available for fuel transportation and storage	Space is available	
Can meet the demand of sustainability targets and local legislation with regard to NOx emissions	UK Government NOx emission targets are getting more stringent and on-site combustion is being discouraged in lieu of green electricity	
Increased maintenance Maintenance of biomass boilers is significant – near daily	Will be required as part of the maintenance regime	

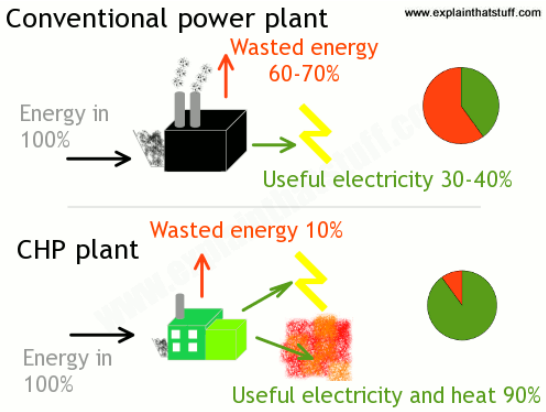
Biomass
Benefits
Biomass-fuels can be used to produce energy on a continuous basis (unlike renewables such as wind or solar energy)
Biomass can be an economic alternative to fossil fuels
Biomass is a potential source of both heat and electricity
Biomass technology is flexible and scaleable, from a single boiler to a power station
Limitations
Biomass fuels have a lower energy density compared to fossil fuels
Biomass systems have particular design management and maintenance requirements associated with sourcing, transportation and storage
Biomass can be less convenient to operate than mains-supplied fuels such as natural gas
Slower to start up and slower to respond to changing loads
Biomass systems are more management intensive and require expertise in facilities management
Sources of biomass can fluctuate, so boilers should be specified to operate on a variety of fuels without risk of overheating or tripping out
Use of land for growing fuel is questionable
Any form of on-site combustion will need to comply with increasingly stringent Gov/Local Authority emissions criteria

System description

Biomass is any plant-derived organic material that renews itself over a short period. Biomass energy systems are based on either the direct or indirect combustion of fuels derived from those plant sources. The most common form of biomass is the direct combustion of wood in treated or untreated forms. Other possibilities include the production and subsequent combustion of biogas produced by either gasification or anaerobic digestion of plant materials. Liquid biofuels such as bioethanol can also be used. The use of biomass is becoming increasingly common in some European countries (some countries such as Austria are heavily dependent on biomass). The environmental benefits relate to the significantly lower amounts of energy used in biomass production and processing compared to the energy released when they are burnt. This can range from a four-fold return for biodiesel to an approximate 20-fold energy return for woody biomass.

CHP Combined Heat & Power		
CHP can be considered either as an alternative or supplementary to traditional mains fed gas and electricity for heat and power	Comment on Suitability for this project	Potential for this project
A consistent requirement for a steady electricity base load and heat load is present	CHP is best utilised where there is a requirement for a constant heat source e.g. large hot water use, swimming pools etc CHP id not suitable for this project in which case Absorption Cooling also not suitable	Low
The hot water produced by a CHP unit can be used for a range of applications in buildings. These include: • Space heating • Domestic hot water for washing and cleaning uses • Water heating of swimming and leisure pools • Space cooling using absorption cooling	Only 3% of the building area is treated (heated) therefore CHP is not suitable	
Efficiency will be optimised if the CHP unit can be heat-led, and the generated heat is maximised	Technology not suitable	
Renewable fuel sources can be used such as landfill gas.	Site Specific – none available	
Typical units are Gas turbine CHP	Suitable gas supply available on-site without unreasonable infrastructure upgrade	
Can meet the demand of sustainability targets and local legislation with regard to NOx emissions	Any form of on-site combustion will need to comply with increasingly stringent Gov/Local Authority emissions criteria, this technology is generally being discouraged	
Increased maintenance	Will be required as part of the maintenance regime	

CHP
Benefits
Can produce electricity and heat
Can be powered using biofuels
High operating efficiencies can be achieved if heat generated is fully utilised
Can improve the quantity of the mains power supply by stabilising supply currents and voltages and providing independent supplies
Provides a continuous supply of electricity
Heat generated can be used to power absorption chillers
Limitations
Requires predictable and relatively constant loads for optimum performance
Requires full use of generated heat for optimum efficiency
Biomass can be less convenient to operate than mains-supplied fuels such as natural gas
Requires regular planned maintenance
Rarely installed to provide electricity or heat exclusively (usually provides heat load)
Typically, to be cost-effective, CHP systems will require to be operated for a minimum of four to five thousand hours per annum



System description

Combined heat and power (CHP), also known as co-generation, is the simultaneous generation of both usable heat and electrical power from the same source. CHP systems can be used in applications where there is a significant year-round demand for heating in addition to the electricity generated.
A CHP unit comprises an engine (referred to as the prime mover) in which fuel is combusted. The mechanical power produced by the engine is used to generate electricity using an integral electrical generator. The heat emitted from the engine (waste heat) is used to provide space heating or domestic hot water. The waste heat can also be used to provide space cooling when passed through an absorption chiller .

Fuel Cells		
Fuel can be considered either as an alternative or supplementary to traditional mains fed electricity	Comment on Suitability for this project	Potential for this project
Fuel; Cells can operate in parallel with the local utility while supplying power to a building's power distribution system. Maximum efficiency will be achieved when all the output from the fuel cell is used, and when mains power is only used for peak demands	Fuel Cells are not current DHL standard Pending DHL SC energy use data	Low
Heat is generated as part of the fuel cell operation which could be used within the building/services The grade of heat depends upon the type of cell	Subject to SC energy use profiles	
Fuel cell dimensions, coupled with free space requirements, will dictate the area required for a fuel cell installation. Fuel cells vary in size, but they are not small. As an example, commercial 200 kW phosphoric-acid fuel cells measure 3·0 m by 5·5 m with a 2·4 m spacing requirement on each side.	Subject to SC site planning	
Relatively new technology for use in buildings	Technology being refined for use in commercial projects, use in mainstream cars now available e.g. Toyota Mirai	
Source of hydrogen gas	Ideally fuel cells should be powered by hydrogen production as a by-product of the site operation otherwise the hydrogen gas will have to be transported to site	

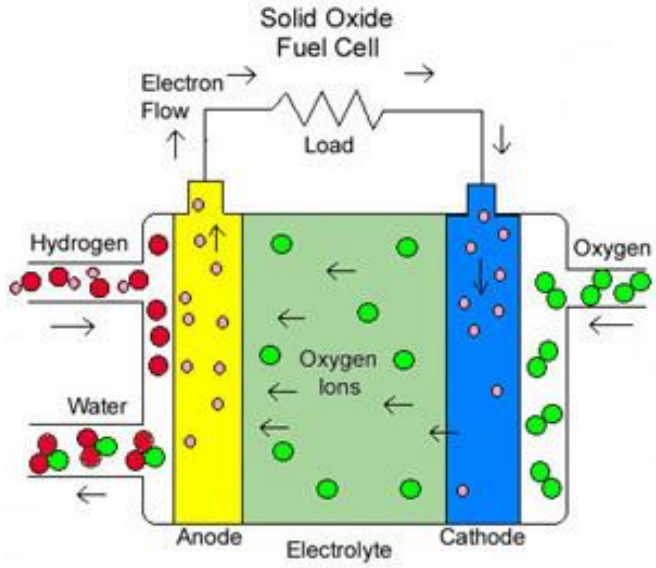
Fuel Cells
Benefits
Direct energy conversion (non-combustion)
No moving parts in the fuel-cell stack
Quiet operation. When compared with similar systems, such as CHP based on internal combustion engine technology, fuel cells are significantly quieter, enabling them to be positioned adjacent to occupied areas
Siting ability. Due to the reduced noise and emissions, compared with internal combustion engine CHP for example, fuel cells can be sited closer to the building. This enables shorter pipe runs for the services from the fuel cells
Fuel flexibility
Good performance at part load
Modular installation to match load and increase reliability
Suitable for remote/unattended operation

Fuel Cells
Limitations
High market entry cost. As the technology improves and becomes more commercially mature, so costs will fall and be less of a disadvantage. Fuel cells can be compared with current CHP units. While CHP is an ideal application for fuel cells, standard CHP units are not cheap (in terms of capital cost) and fuel cells are significantly more expensive. So cost will be an issue for some time to come
Unfamiliar technology. The need for infrastructure grows with greater uptake of the technology. All new technology causes problems, but with greater uptake the technology will become more familiar and systems will be put in place to cater for fuel cells
No infrastructure. There is no hydrogen infrastructure in the UK, although there is a very good natural gas infrastructure hence the majority of fuel cells are operated using natural gas. Currently limited expertise available to maintain
High maintenance cost. This is partially due to the technology being new; in the future this would be less of an issue
Short stack life. Much development work is in progress to increase the life of the stack
Sensitivity to pollutants - very small quantities of carbon monoxide or sulphur have the potential to cause failure of the fuel cell stack

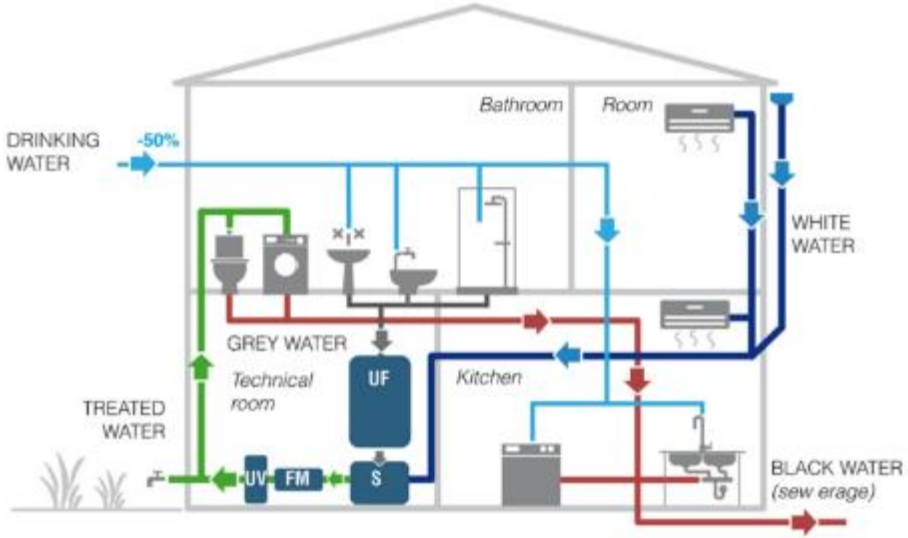
Fuel Cell System description

A fuel cell is an electrochemical device that converts the chemical energy of a reaction into electrical energy, with heat produced as a by-product.

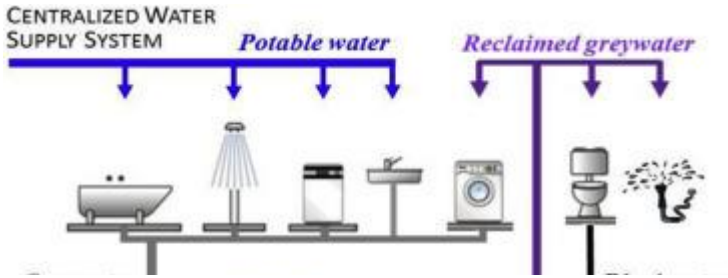
The basic components of a fuel cell are an electrolyte, an anode, and a cathode. Gaseous fuels are fed continuously to the anode while an oxidant (oxygen from the air) is fed continuously to the cathode. The anode and cathode are separated by the electrolyte. Ions flow through the electrolyte between the anode and cathode. Electrons generated at the anode flow through an external load to the cathode, completing the electrical circuit. Although all forms of fuel cells use similar technologies, there are differences between the various types.
The primary fuel source for fuel cells is hydrogen. This can be obtained (using a reformer) from a wide range of fuel supplies including natural gas, coal gas, methanol, landfill gas, biogas and other fuels containing hydrogen



Grey Water Recovery		
Grey Water can be considered either as supplementary to traditional mains fed water for certain limited applications	Comment on Suitability for this project	Potential for this project
Grey Water is water recovered on-site from water already used for; • Washing • Bathing/Shower • Laundry • Other water process	Hand wash only on this project	Low
Grey Water can be collected, stored and treated, then used for toilet flushing or irrigation of non-edible plants.	Insufficient grey water available	
Increased maintenance	Will be required as part of the maintenance regime	



Grey Water Recovery
Benefits
Re-use of waste water for toilet flushing and other non-potable uses
Can be used for single building or communal schemes
Wide range of water filtration techniques available
Limitations
Greywater must be treated before use
Greywater must not be stored for more than 24 hours untreated and for not more than three days after treatment
Providing sufficient greywater storage capacity may present problems
More suited to new build applications than retrofit
Installation and on-going costs may not justify savings
Pumps, filters and sensors can present operational problems



Ground Source Systems - Air		
Ground Source Systems - Air can be considered as supplementary to traditional heating and cooling system	Comment on Suitability for this project	Potential for this project
Also referred to as; • Earth Coupled Systems • Earth Tubes • Earth ducts	Only 3% of the building area is treated (cooled) therefore technology is not suitable	Low
Can be constructed from prefabricated piping/ductwork, cement, cement fibre, steel, or plastics	Not applicable	
Significant amount of underground infrastructure required to achieve savings.	Calculation and cost comparisons will be required Energy use profile does not warrant the system	

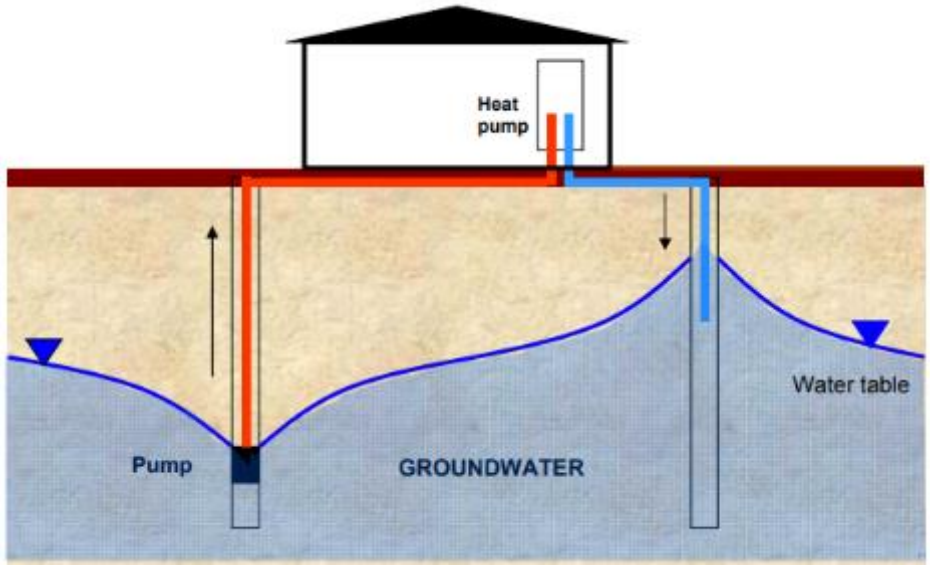
Ground Source Systems - Air
Benefits
Can pre-heat air in winter and pre-cool air in summer
Reduces or negates need for mechanical cooling – mechanical cooling may still be needed in addition to this system
Reliable – few (if any) moving parts
Low maintenance requirements, providing steps are taken to pre-filter air and avoid water ingress
Limitations
Costs of excavation in order to install pipes may be prohibitive
Water penetration may be an issue if the design and installation of the system is not correct
Sufficient space is required for the buried pipes

System description

Ground-coupled air systems are primarily used for pre-conditioning outdoor-air prior to heating and cooling. Ground-coupled air systems can comprise a length of piping placed underground, often under the foundations of the building. The piping is connected to an outdoor air intake within the site boundary and to the building ventilation system at the other end. During the summer, heat-transfer to the surrounding ground cools warm outside-air, while during the winter, cold outside-air is warmed. The cooled air can also be used for cooling the building's thermal mass within the building structure. The cooling/heating effect provided by the thermal mass of the ground can significantly reduce (or even remove) the need for mechanical cooling or space heating. However, temperature control within the building is not always possible.

Ground Source Systems - Water		
Ground Source Systems - Water can be considered as supplementary to traditional heating and cooling system	Comment on Suitability for this project	Potential for this project
A water source is required, typically an underground aquifer, or a river or lake.	Only 3% of the building area is treated (heat/cooled) therefore technology is not suitable	Low
A license is required to extract water from the source and return it after passing through the heat exchanger.		
The water can be used to provide heat (heat source) or to provide cooling by rejecting heat (heat sink)		
A large number of boreholes may be required when using aquifers.	Calculation and cost comparisons will be required Dependent upon DHL SC energy use profiles	

Ground Source Systems - Water
Benefits
Cool water from aquifers can be used to provide cooling.
Reduces or negates the need for mechanical cooling.
Can be combined with heat pump technology.
Low grade heating/cooling to the building can be provided directly, or used to reduce energy when producing higher temperatures (e.g. domestic hot water).
Limitations
The water source or favourable ground conditions may not be available.
Borehole costs may be high.
Consents and/or licenses are required.
Consequences of a leak into the water source causing environmental damage can be serious.
There are risks of biological fouling, blockages or silting up.
Ground conditions may change, affecting quality and quantity of water available.



System description

Ground water cooling through the use of aquifers makes use of the relatively stable ground/water temperature. Aquifers are water-yielding rock strata, either in unconsolidated (gravel, sand and other friable rocks) or consolidated permeable or porous rocks. At a depth of around 50 m the ground temperature is approximately the same as the mean ambient air temperature (11-12^{o}C). The cold water in aquifers can be used to provide space cooling within buildings or as a source of heat for preheating ventilation air. Water from aquifers can be pumped directly or indirectly to cooling systems and used as a heat source or sink for heat pumps.

Water sources may also be obtained from rivers, lakes or the sea (see Surface Water Cooling later in this report).

Ground Source Systems		
Ground Source Systems - can be considered as supplementary to traditional heating and cooling system	Comment on Suitability for this project	Potential for this project
A large area is required for the buried pipes.	Only 3% of the building area is treated (heat/cooled) therefore technology is not suitable	Low
Significant amount of underground infrastructure required to achieve savings.	Calculation and cost comparisons will be required	

Ground Source Systems
Benefits
Can be used for space heating or cooling, and to reduce energy consumption for domestic hot water.
Reversible to provide cooling.
Relatively few moving parts, no exposure to weather – high reliability.
Proven technology.
Long life expectancy – equipment up to 25 years, coils up to 50 years.
Low noise (no external condensers).
Limitations
Achieving high COP/EER will only provide relatively low temperatures in heating mode.
The cost of installing the ground pipes may be high.
A lot of space is required for the ground pipes.
Ground conditions may not be suitable.
Most effective heating mode (high COP) when used with underfloor heating or low temperature radiators.

System description

Ground-source heat pumps (GSHP) extract or reject heat from/to the ground using a closed loop water coil, using the year-round stable temperatures below ground (>2m deep) as a heat source (heating mode) or heat sink (cooling mode).
The water is used in a heat exchanger, or may be used as the heat source/sink for a heat pump system.
They are classified as either water-to-air or water-to-water units depending on whether the heat distribution system in the building uses air or water.

Photovoltaics		
Used to generate electricity from solar radiation	Comment on Suitability for this project	Potential for this project
A large area is required for the solar PV panels, typically 7-8m^2 per 1kW. Approximately 750kWh will be generated per annum per 1kW of installed PV.	Building services are all electric on this development therefore PV is compatible	High
The local electricity network will need to be assessed by the DNO to ensure they can accept the connection of the solar PV generation.	Given size of array and building load it may not be beneficial to connect to grid, consideration during detailed design stage required	
If roof-mounted panels are proposed then the roof structure needs to be sufficiently strong to support the weight. Personnel access and safety at roof level needs to be considered.	Roof mounted is most likely.	
Flat roofs (or near-flat) allow the best aiming of solar PV arrays typically 20-30 degrees.	A typical warehouse roof is suitable, particularly when designed from new so that the PV roof loading can be considered	

Photovoltaics
Benefits
Wide range of installation options – roof-mounted, ground mounted, facades or solar shading.
Can be connected to the building electrical installation to offset costs of importing electricity.
Low maintenance.
May be used in conjunction with electricity storage systems.
Limitations
Space is required for the system, and roof mounted systems require sufficiently strong structure and safe access arrangements. Requires the correct angle/positioning.
Most effective use is when the system is tailored to the building load.
Inverters may cause reliability issues so access should be considered
Approval is needed from the DNO if grid connected or not isolated
Relatively high cost.
PV panels may require regular cleaning.
CO_2 saving has reduced in recent years as the grid electricity becomes “greener”.

System description

Photovoltaic (PV) modules convert sunlight directly to D.C. electricity. The solar cells consist of a thin piece of semiconductor material, in most cases using silicon, mounted in a weatherproof panel and attached to mounting frames.

The PV panels are arranged in an array, at the optimum angle to collect as much daylight.

The D.C. output of the PV panels is converted to A.C.. mains voltage and connected to the building’s electrical distribution system.

The electrical energy generated is consumed by the building and any surplus can be exported to the external electricity grid.

Rainwater Recovery Systems		
Comment	Comment on Suitability for this project	Potential for this project
Rainwater can be collected for uses where clean water is required but is not used for consumption.	Turnover of water not sufficient	Low
Rainwater is typically collected from the roof where it is cleaner, but may also be collected from ground level.	Turnover of water not sufficient	

Rainwater Recovery Systems
Benefits
The use of rainwater for flushing and washing, irrigation and vehicle cleaning reduces the consumption of treated water.
May reduce surface water run-off and risk of flooding.
Limitations
The water is non-potable.
The collected water requires filtration and treatment. Roof condition will affect quality of water available.
Large storage tanks may be required.
The system requires maintenance to pumps, filters and sensors. Regular cleaning is required to remove debris to prevent contamination.

System description

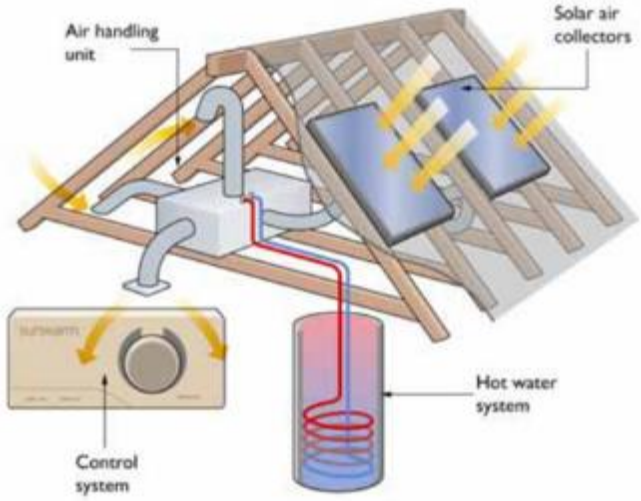
Rainwater can be collected from rooftops where there is less contamination and stored for a range of applications such as flushing toilets, washing machines, irrigation, cleaning vehicles, etc.
Storage tanks may be below or at ground level, relying on pumps, or at high level and relying on gravity.
Pumped systems either transfer the water to a header tank which acts as a gravity feed, or directly pump the water in a pressurised system.
The water is filtered and treated (e.g. ultraviolet sterilisation).
A mains water supply is still required to top up the tanks in periods of low rainfall.
An overflow drain is required for excess.

Header Tank Systems
Benefits
High reliability – water is provided by gravity if the pump fails, with top-up from mains water when running low.
Low cost pump and controller only required to keep header tank topped up.
Energy efficient – pump only runs when needed, at full flow.
Limitations
Low pressure if insufficient header tank height – WCs cisterns may fill slowly.
Space required for header tank.
Not a large range of suppliers for this type of system.

Direct Pumped Systems
Benefits
Good pressure.
Space not required for header tank.
Limitations
Water supply to WCs, washing, etc is not available if the pump fails.
Mains top-up controls can be complicated.

Solar Air Heating Systems		
Comment	Comment on Suitability for this project	Potential for this project
The ideal orientation for a solar air-heating system is due south as this provides maximum potential solar gain. However, a south-east or south-west orientation will also provide worthwhile solar gain	With a large roof area solar air heating is feasible albeit the development has a low heat/hot water demand	Low Unlikely

Solar Air Heating Systems
Benefits
Due to low thermal inertia of air (compared to water) the solar collectors can heat up quickly even with low levels of solar radiation.
The collectors can provide thermal buffering between the internal and external conditions.
Limitations
Low heat capacity of air means that thermal storage has to be achieved indirectly – either through the building fabric or a dedicated thermal store.
Poor heat transfer between the collector and the air.
A large volume and airflow rate are required, requiring electrical power to operate the fans.
They only work in direct sunlight, limiting the locations available. Facing due south is best, although south-east or south-west will also provide benefit.
They do not work at night or in poor weather, so an alternative heating system is still required.
Roof access and personnel safety needs to be considered. Additional roof loading.



System description

Solar air systems collect solar energy to heat air. The air can be used to pre-heat ventilation air, heat air inside a building, or to heat water. A basic system comprises a solar collector and a hot air distribution system. Solar air systems can also incorporate thermal storage using either the thermal mass of the building or dedicated thermal stores, such as a rock store. The solar collectors can be purpose-built panels or a glazed cavity over an existing façade.

Solar Cooling Systems		
Comment	Comment on Suitability for this project	Potential for this project
There are three main type of solar cooling: absorption, adsorption and desiccant. All rely on the use of a solar collector to provide a heat source to drive the cooling process.	With a large roof area solar air heating is feasible albeit the development has a low heat/hot water demand	Low

Solar Cooling Systems
Benefits
Solar thermal energy can be used to drive the cooling process.
Peak building load generally occurs at the same time as peak solar energy is being experienced.
Absorption chillers require low maintenance.
Limitations
Matching of the solar collector temperature and the chiller operating temperature is required. Higher temperatures are required for better performance.
Very limited experience in the UK.
High cost of equipment.

System description

There are three main type of solar cooling: absorption, adsorption and desiccant. All rely on the use of a solar collector to provide a heat source to drive the cooling process.
Absorption coolers require higher temperatures, using evacuated tube or parabolic reflector solar collectors.
Adsorption chillers require lower temperatures and can use cheaper flat plate solar collectors.
Dessicant cooling uses solar heat as part of an overall cooling process using a dessicant wheel in the ventilation system.

Solar Water Heating Systems		
Comment	Comment on Suitability for this project	Potential for this project
Solar water heating systems use the energy from the sun to heat water, most commonly for hot water needs (such as washing and cleaning requirements). Solar heating systems use a heat collector that is usually mounted on a roof in which a fluid is heated by the sun. This fluid is used to heat water that is stored in either a separate hot water cylinder or in a twin-coil hot water cylinder (the second coil is used to provide additional heating from a boiler or other heat source).	Only 3% of the building area is treated (heat/cooled) therefore technology is not suitable	Low

System description

Solar water heating systems use the energy from the sun to heat water, most commonly for hot water needs (such as washing and cleaning requirements). Solar heating systems use a heat collector that is usually mounted on a roof in which a fluid is heated by the sun. This fluid is used to heat water that is stored in either a separate hot water cylinder or in a twin-coil hot water cylinder (the second coil is used to provide additional heating from a boiler or other heat source).

There are two main types of solar collector: flat-plate or evacuated tube.

The system is installed with a mixture of antifreeze and water circulating through the collectors and a heat exchanger in the domestic hot water tank. The indirectly-heated water in the tank is then supplied to outlets such as taps and showers. A controller compares the temperature of the water in the collectors with the temperature of the water in the cylinder and activates a circulating pump whenever the water in the collectors is hotter. A conventional boiler is used to boost the stored hot water when required.

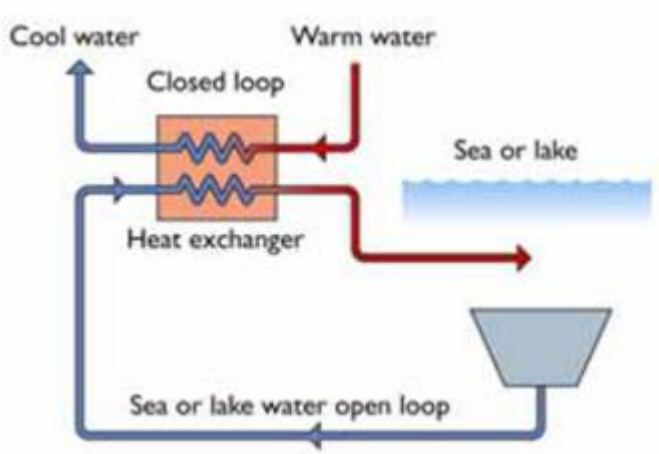
The energy savings from a solar heating system will depend on a large range of factors. The Energy Efficiency Commitment Scheme bases savings from solar water heating on an average figure of 454 kWh/m^2 per annum for flat-plate collectors and 582 kWh/m^2 per annum for evacuated tube systems.

Glazed Flat-plate Systems
Benefits
Simple and robust design.
Well developed technology.
Cheaper than evacuated tube collectors.
Good price to performance ratio.
Wide range of mounting options.
The flat glazed surface is more visually acceptable than the corrugated/ribbed appearance of the evacuated tube collector.
Limitations
Lower efficiency than evacuated tube collectors.
Requires more space than evacuated tube collectors.
Provides lower water temperature than evacuated tube system.
Additional roof loading.
Roof access and personnel safety needs to be considered.
Traditional water heaters are still required for when the system is not working or receiving insufficient energy.

Evacuated Tube Systems
Benefits
Higher temperatures can be achieved than flat-plate collectors.
High efficiencies are possible.
The collectors are smaller and lighter than flat-plate collectors for the same energy collection.
Direct through-flow collectors can be mounted horizontally.
Can produce electricity and heat
Limitations
Potential very high stagnation temperatures which can affect adjacent equipment or building fabric.
More expensive than flat-plate collectors.
Cannot be embedded in the building fabric.
If the evacuated tube system also includes heat pipes then they must be angled at no less than 25^{o} above horizontal.
Additional roof loading.
Roof access and personnel safety needs to be considered.
Traditional water heaters are still required for when the system is not working or receiving insufficient energy.

Surface Water Cooling Systems		
Comment	Comment on Suitability for this project	Potential for this project
		Low

Surface Water Cooling Systems
Benefits
Reduces the requirement for mechanical cooling.
Can be used to pre-heat ventilation during the heating system.
Can be used as a heat source or heat sink for a heat-pump system.
Limitations
Relatively few buildings are close to suitable water sources.
Water needs to be deep enough to provide water that remains sufficiently cool.
Cost of piping may be prohibitive.
Filtration may be required to prevent the heat exchanger from blocking.



System description

Surface water cooling involves pumping water from the sea, lakes or water courses and using it to provide some or all of a building's cooling requirements. Such systems are open loop, where water is extracted, passed through a heat exchanger then returned to the water source. The cooled water from the heat exchanger can be used for a range of cooling purposes:

- Supplying cooling, via a heat exchanger, to fan coils, chilled ceilings or beams, or to a slab cooling system
- To pre-cool return chilled water prior to further cooling by other techniques
- As a source of cooled water for the condenser of a mechanical vapour compression chiller or absorption chiller
- As a heat source or sink for a heat pump.

During the winter the water can be used to pre-heat ventilation air.

Water Conservation Systems		
Comment	Comment on Suitability for this project	Potential for this project
Different methods of reducing water usage are available:		High
• Waterless urinals	Suitable for use	
• Spray taps	Suitable for use	
• Water-efficient WCs	Suitable for use	
• Waterless and vacuum WCs	Not applicable	
• Water saving shower heads	Not applicable	

Water Conservation Systems
Benefits
Reduced water consumption.
Some devices are easy to install (e.g. spray taps, water efficient WCs, waterless urinals, water saving shower heads).
Limitations
Some devices require regular maintenance (e.g. waterless urinal cartridge replacement).

System description

Various devices can be fitted at the point-of-use to reduce the water flow and reduce water usage (e.g. showers or taps) or use less water on each operation (e.g. water efficient WCs).

Wind Power		
Comment	Comment on Suitability for this project	Potential for this project
Space is required for the wind turbine and associated switchgear at the base (large units are normally free standing).	Existing constricted site – re-build – not suitable	Low
Planning permission will be required. Proximity to airports or military may prevent installation.		
Agreement must be reached with the electricity networks operator to allow the output of the turbine to be connected to the grid.		
It may be possible to enter an arrangement with an energy company who will build and operate the turbine – the land owner has less responsibility and outlay, but also has a reduced return.		

System description

Wind turbines convert the kinetic energy in wind into mechanical energy that is then converted to electricity. Turbines are available in a range of sizes and designs and can either be free-standing, mounted on a building or integrated into a building structure.
There are two basic groups of wind turbines: horizontal-axis design and vertical-axis design.
Horizontal-axis wind turbines are the most common type and can range in size from a few hundred Watts to several megawatts. This type of turbine has a horizontal rotor shaft and generator typically located at the top of a tower. Propeller-type blades are used (usually three, although two can be used) and these are orientated into the wind, using a wind vane (yaw control) for small turbines, or wind sensors used in conjunction with servomotors for larger turbines. Vertical-axis turbines have a rotor shaft orientated vertically. This avoids the need for a tower and the generator is located at ground level. Another advantage is that no yaw mechanism is required to turn the rotor into the wind. The main disadvantages of vertical-axis turbines are that the efficiencies are lower than horizontal-axis turbines and they are not self-starting.

A turbine system will include the following:

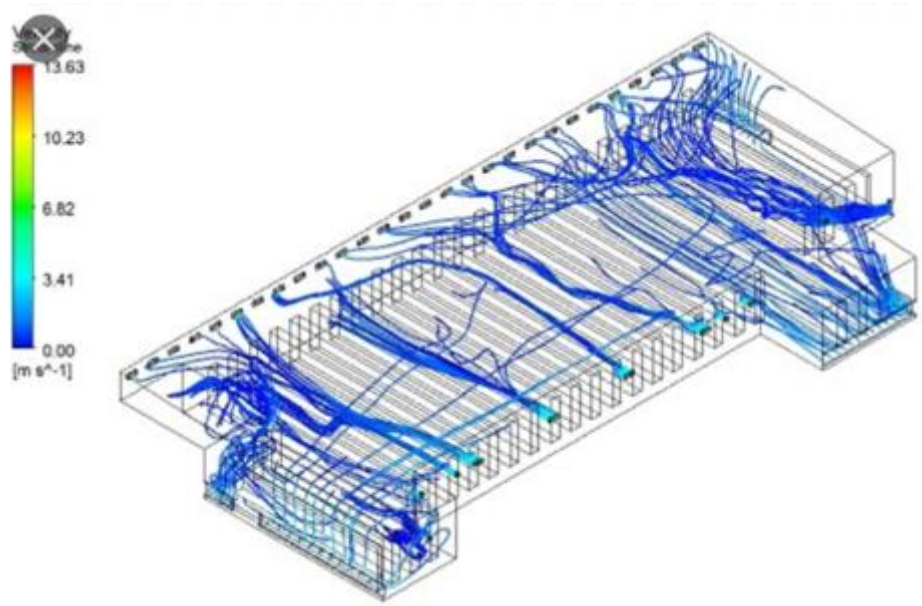
- A rotor, or blades, which convert the wind's energy into rotational shaft energy
- A nacelle containing a drive train, usually including a gearbox (some turbines operate without a gearbox)
- A tower to support the rotor and drive train
- Electronic equipment such as controls, electrical cables, ground support equipment, and inter-connection equipment.

Wind turbines can provide electrical power either directly to a load or via a battery system.

Wind Power
Benefits
Allows for on-site generation of electricity.
Can be grid connected.
Turbines can be free standing, building mounted or building augmented.
Limitations
Best performance will be obtained in non-urban locations e.g. off-shore
Actual electrical power generated may be considerably less than the rotated output of the turbine.
Building mounted turbines may create structural, vibration and noise implications.
Potentially damaging air turbulence may be created.
Access for maintenance or replacement of components may be an issue.
Costs can be high in relation to the electricity generated.
There may be environmental or Planning issues.

Natural Ventilation		
Comment	Comment on Suitability for this project	Potential for this project
Can be installed in the roof or walls.	Speculative warehouse cannot predict required environmental conditions for future operator	Low
Allows for “free” cooling by allowing natural ventilation.		

System description

Openable vents are used to allow hot air to escape through natural convection, and cooler external air into the building.
In a warehouse these are normally in the roof or at high level in the walls. Other vents may be required at low level to allow cool air to enter at low level.
These can be automatically controlled, with rain sensors, or manually operated using override switches.
For offices a cross flow path is best, requiring vents at opposite ends of the room.
Systems for offices require more complicated controls to maintain comfortable conditions – they may be best used for overnight purging which limits their use to warmer times of the year.

Natural Ventilation
Benefits
Allows for free cooling/purging of hot air.
Most economical if vent equipment is existing and can be utilised by additional override controls, e.g. smoke venting louvres.
Very low energy use.
Limitations
Additional builderswork and equipment required if not already present (e.g. smoke vents).
Control is difficult and the system may not provide adequate ventilation rates without supplementary fans, or may allow draughts.
Needs to be controlled to prevent AC/heating operating at the same time.
Requires favorable external conditions.
Access for maintenance or replacement of components may be an issue, requiring roof access.
Rain sensors required. Vents are best if not positioned over stock/sensitive areas.
Bird mesh required. Low level vent may require additional security bars.