Liverpool Schools Investment Programme
St Julies
Liverpool
Renewable Energy Report/Statement

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CAVEAT

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Specification Origin

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Rev Statement 1 – 18th December

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SECTION 1.0 EXECUTIVE SUMMARY

This report has been carried out at the request of Kier Construction as an initial assessment to give an indication of the most appropriate low or zero carbon technologies (LZC) for 10,000 sq m new build school.

Where cooling is required to control over heating in summer then VRF and/or split air conditioning systems will be of the reversible type to provide air source heating to these areas.

Based on previous school projects it is anticipated that approximately 300 square meters of Photovoltaic (PV) panels may be required to achieve building regulation compliance (Part L2A 2013). However, where possible the improvement in energy saving technologies will be targeted to reduce this need for PV. This will include the wide use of quality LED light fittings.

300 Square meters of PV shall be included on planning drawings at this stage and should be seen as a maximum size of the array. However, where possible the need for PV will be offset by energy saving technologies when Part L modelling is carried out.

SECTION 2.0 PREAMBLE

Sustainability:

> "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

THE BRUNTLAND DEFINITION

Clancy Consulting is committed to providing a service which is both forward thinking and committed to excellence. Our goal is to support clients and architects through the development of innovative and creative building designs that meet evolving environmental responsibilities.

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Simulation Team Leader

SECTION 3.0 INTRODUCTION

3.1 Background

This initial assessment has been prepared at the request of Kier Construction to investigate low or zero carbon technologies to establish the most appropriate for the proposed development

3.2 Development Area Plan

The development is new secondary school with a gross floor area of approximately 10,000m^2 over four storeys.

3.3 Land Use

The initial enabling works will consist of removing some of the buildings to allow for the new building; however eventually all the other buildings on the site will be removed. The image below shows the location of the development and its surroundings.

3.4 Local Planning Criteria

Location of proposed low/zero carbon technologies should be indicated on plans and included within the planning application.

3.5 Noise

The site is located approximately 100m away from residential buildings and has trees and vegetation separating the proposed building and residential buildings. Noise from selected technologies must be considered to reduce disturbance to the local residents, although surrounding tress and shrub land should provide some attenuation. The selected technology should be quiet in operation and if it operates during typical sleeping hours, then should be very quiet or silent in operation

3.6 Presumed Building Energy Usage

The statement has been prepared with energy usage derived from a previous secondary school which was assessed on the new Part L 2013 Regulations.

3.7 Reasons for Investigation

The building is required to meet compliance with Building Regulation Part L2A (2013). This report is to consider potential renewables that maybe required to achieve this.

3.8 Delimitation

This report has been carried out to indicate viable solutions and to dispense with any impractical ones. A full site specific analysis has not been carried out for each low or zero carbon technology. Any viable solutions which have agreement to progress further will require additional detailed analysis and cost estimates.

SECTION 4.0 SUSTAINABILITY – PROPOSED STRATEGY

4.1 Hierarchy of measures for energy/carbon reduction

To maximise the effectiveness of low or zero carbon technologies, energy has to be minimised as much as possible. Low carbon or renewable energy sources often have a maximum or optimum size. For example PV is generally limited to flat or south east to south west facing roofs. Wind turbines can be limited to a physical size and number. Therefore, the strategy for reducing carbon dioxide emissions from the development should:

4.2 Be LEAN (Use less Energy)

Be **Lean** (Use less energy)

Be **Clean** (Supply energy efficiently)

Be **Green** (Use low carbon or renewable sources)

4.2.1 Lighting

To maximize daylight, use high efficiency lighting systems with photoelectric dimming and occupancy control where appropriate.

4.2.2 Heating, Ventilation and Air Conditioning (HVAC)

Use free cooling when external conditions permit.

4.2.3 Building Fabric

Aspire to achieve improved U-values beyond L2A requirements for building. Aspirational management procedures to be put in place during construction to improve the quality of the construction by ensuring that the contractors pay attention to quality control at site level.

4.3 Be CLEAN (Supply Energy Efficiently)

4.3.1 Lighting

Avoid tungsten lighting fittings.
Use of LED lighting in rooms with high lighting needs

4.3.2 Heating, Ventilation and Air Conditioning (HVAC)

Mechanical ventilation systems to aim to improve on minimum specific fan powers (SFP).

Areas of buildings requiring mechanical ventilation would be considered for heat recovery.

It is imperative that all of the buildings, their engineering services and renewable energy systems are properly and accurately commissioned to ensure that their performance meets the design expectations.

In addition to the normal building operating and maintenance manuals, building log books will be prepared for the development so that the users of the building understand how the systems are intended to work and what actions they can take to influence the energy consumption and associated carbon dioxide emissions from the building during the buildings usable life time.

4.4 Be GREEN (Use low carbon or renewable sources)

Use of low carbon or renewable sources can be used to replace or offset carbon emissions which cannot be removed through the ‘be lean’ and ‘be clean’ options above. The options for low carbon and renewable sources are covered in the next sections.

SECTION 5.0 SUMMARY OF THE LOW CARBON & RENEWABLE ENERGY OPTIONS APPRAISAL

In this section the technical feasibility of each of the low carbon and renewable energy technologies for the site have been assessed in order to rule out unfeasible options.

Technology	Generation		Benefits	Issues Surrounding Technology Considered by this Report	Note
	Thermal	Electricity			
Wind (roof or independent mounted)		✓	▪ Low maintenance/ongoing costs ▪ Excess electricity can be exported to Grid	▪ The wind speed database suggests that the average wind speed for the site is 5.6m/s. When this is corrected for local terrain an average of 4.38m/s @25m is likely. This is below the minimum recommended wind speed of 5 m/s ▪ Turbulence from local obstructions requires consideration ▪ Noise needs considering ▪ Often opposed by neighbours due to their aesthetic impact on the local environment ▪ May require planning consent/permission	✗ *(Wind speed is below the suggested minimum economic speed of 5m/s [corrected] at hub height. See appendix B for Calculation)*
Solar PV		✓	▪ Low maintenance as no moving parts ▪ Easily integrated into building ▪ No ongoing costs ▪ Excess electricity can be exported to Grid	▪ Expensive technology to install ▪ Any overshadowing of panels effects output performance ▪ East and west pitched roof reduces performance below optimum. ▪ Could be eligible for feed-in-tariff if a micro generation certification scheme (MSC) approved product is installed by a contractor registered on (MSC)	✓

Solar Thermal	✓		▪ Low maintenance ▪ Low ongoing costs ▪ Tested technology ▪ Silent Operation	▪ Must be sized on the domestic hot water heating requirements of building ▪ Ideal for developments with high year-round domestic hot water loads ▪ East and west pitched roof reduces performance below optimum. ▪ Could be eligible for Renewable Heat Incentive.	✗ *(Schools are often closed during summer period when solar yield is highest. Technical issues with low use of hot water in summer can occur with some solar designs)*
Biomass Heating	✓		▪ Supports local community ▪ Reduces fuel poverty for properties off gas network ▪ Provides further diversity of primary energy	▪ Space required for fuel delivery and storage and plant room (unit, hot water buffer storage etc) ▪ Reliable fuel supply chain required ▪ Regular maintenance required/ash disposal ▪ Could be eligible for Renewable Heat Incentive. ▪ Often sized for base loads with alternative heat generators for peak demand	✗ *(Initial design has a lack of plant space. Useable space is premium for the school)*
Energy from waste CHP	✓	✓	▪ Reduces waste ▪ No impact on farming land ▪ Provides further diversity of primary energy	▪ Sized to the base heat requirement of the development ▪ Reliable fuel supply chain required ▪ Pay back periods highly dependent on ROC's prices	✗ *(Inadequate base load for this technology)*
Ground Source Heating (Horizontal system)	✓		▪ High energy output per energy input ▪ Unobtrusive technology ▪ Minimal maintenance	▪ Large area required for horizontal pipes ▪ Full ground survey must be carried out ▪ Low temperature water heating circulation required for optimum performance ▪ Areas of permeable car parking surface recommended to maintain ground moisture conditions ▪ Could be eligible for Renewable Heat Incentive.	✗ *(Generally high temperature heating will be required for radiant panels and the small area of underfloor heating will not warrant the installation of a ground array)*

Air Source Heating/Cooling	✓		▪ High energy output per energy input ▪ Small footprint ▪ Option where ground conditions are not suitable for GSHP	▪ Low temperature water heating circulation required for optimum performance ▪ Lower COP than ground source heat pump. ▪ Multiple systems may lead to noise issues. ▪ Could be eligible for Renewable Heat Incentive.	✓ *(Ideally suited when cooling is required – system can be reversible to provide heat).*
CHP (Non-renewable: gas or diesel fuelled)	✓	✓	▪ Efficient use of fuel (approx 80%) ▪ Easily integrated into building ▪ Excess electricity can be exported to grid ▪ Small packaged plant good option for office buildings	▪ Sized to year-round base load heating or hot water requirement of development ▪ Fuelled by gas or diesel ▪ Regular maintenance required ▪ Must run for 4500 Hrs/Year to be viable and have a summer heat demand	✗ *(Inadequate base load for this technology*
CHP Community Energy	✓	✓	▪ Allows for more diverse heat load for the CHP ▪ Often allows for longer running period for CHP increasing viability	▪ More ideal for where community heat loads are closer to CHP location ▪ Minimise heat distribution network to keep additional capital cost low to maximise viability	✗ *(No known heat networks in area*)

Note: √ = Considered a Viable Option for this site
x = Not Considered Viable
? = Detailed Study Required, Borderline Option for this s

Low Carbon and Renewable Energy Options
To aid in assessing the following low carbon and renewable options, Low or Zero Carbon Technologies Calculations have been carried out in line with DCLG strategic guide. The full calculations can be seen in Appendix A.

The initial assessment of the site suggested that:-

5.1 Solar Thermal Water Heating
The installation of a solar thermal collector system could be applied to the domestic hot water system. However, the peak solar heating occurs during the summer holidays when there is very little hot water usage. This can cause technical difficulties for some types of system as high temperatures can degrade the inhibitor properties of the heating medium. Often heat dissipation equipment is needed to prevent this which rejects the heat usually to atmosphere.

Due to these technical difficulties and the fact that the majority of solar energy in the summer holidays is likely to be wasted does not deem this technology as a good application in this instance.

5.2 Air Source Heating
Air source heat pumps are ideal for low temperature heating such as under floor heating, domestic hot water pre heat or where a Variable Refrigerant Flow (VRF) heating and cooling system is used.

There is radiant heating proposed in some areas, which due to its heating characterises require higher temperatures for the heating medium. It is therefore likely that under floor heating will be blended down to cover the small area of under floor heating anticipated.

Where cooling is required to control over heating in summer then VRF and/or split air conditioning systems will be of the reversible type to provide air source heating to these areas.

5.2.1 Grants/Allowances for ASHP
Enhanced Capital Allowances (ECAs) can be claimed for air to air (including Variable Refrigerant Flow (VRF) systems) and air to water systems. The air source heat pump needs to comply with the Energy Technology List (ETL) criteria and be on the Energy Technology List (ETL). A business can then claim 100% first-year capital allowances on their spending on qualifying plant and machinery. This can deliver a helpful cash flow boost and a shortened payback period.

Renewable Heat Incentive (RHI) Air to air systems such as VRF and multi splits are currently not covered by RHI

5.3 Ground Source Heating
Ground source heat pumps are ideal for low temperature heating such as underfloor heating. The use of ground source heat pumps would be uneconomical to cover the small area of underfloor heating and therefore is not proposed for this scheme

5.4 Biomass Heating

The use of biomass heating to the commercial buildings development will require large storage areas for pellets (Approx 7 x 4m) as well as a separate boiler room for the biomass and peak load boilers. It has a relatively high capital cost and a reliable fuel source is required. The fuel itself is considered carbon neutral as the carbon absorbed in crop growth is equal to the carbon released during burning. The small amount of carbon related to this fuel is to account for the carbon emission from transportation in connection with delivery; hence local supply (within 50km) should be sought. A biomass boiler generally is sized to meet the base heating load with gas boilers assisting to meet peak loads.

Currently there is limited plant space allocated within this building for this option and space is premium for educational usage therefore this technology has not been considered further.

5.5 Wind Power

It is recommended that the wind speed [corrected for terrain] should be at least 5m/s or greater to make wind generation viable. The uncorrected wind speed from the DECC wind data base for this area was 5.6m/s at 10m from ground level. When this is corrected for terrain the average wind speed for the site is likely to be 4.38m/s at 25m from ground level. This is below the minimum recommendation and hence wind generation has not been considered further.

5.6 Gas Fired Micro Combined Heat & Power (CHP)

CHP's are engines that produce electricity with waste heat being recovered from this process and provided to the heat load of the building. As engine wear increases with an increase in start/stops, it is more ideal in providing for a heating base load of the building, as the unit will run more continuously. Buffer vessels are also ideally used to help dampen fluctuations in heat demand.

The building does not provide an adequate base load for such a technology and therefore is not a viable option

5.7 Energy from Waste (EFW) Combined Heat & Power (CHP)

As with Gas CHP the building does not provide an adequate base load for such a technology and therefore is not a viable option

5.8 Photovoltaic Panels (PV)

For optimum performance, photovoltaic panels should face between south-east and south west at an elevation of 30-40 degrees. Where PV panels are installed on flat roofs the panels need to be spaced apart to prevent self-shading. Where there is limited room the panels can be inclined at a minimum angle of 10° which enable more panels to be installed with minimal loss of efficiency. This provides a higher energy yield per square meter of flat roof. The 10° incline maintains self-cleaning of the panel.

Details of Technology assessed:

PV peak output – 45 kWp

PV Panels provide a payback within approximately 11 years once the feed in tariff is accounted for based on the size of panel area assessed.

An area for solar panels would need to be included on the planning drawings so that either photovoltaic can be incorporated into the design subject to its feasibility.

5.9 Feasibility of Exporting Energy

It is feasible to export electricity by complying with the G59-2 Regulation.

5.9.1 Grants/Allowances for PV

If the PV panels used are registered with the Micro Generation Certification Scheme (MSC) and installed by a MSC installer then the energy produced could be eligible for the feed in tariff which is currently set at 12.13 per kWh for system size of 10kW-50kW

SECTION 6.0 RESULTS

Table 1: Results of renewable energy technology required to achieve a 10% reduction in carbon emissions.

Estimate Energy Use based on previous high school part L thermal modelling

End Use	kWh	Carbon Factor for fuel	Carbon emmision of each fuel
Total Gas	439,917	0.216	95022.072
Total Elec	146,511	0.519	76039.0014

Total Building Carbon Emission Estimate	171,061	KgCO2/annum
Total Building Energy Estimate	586428	kWh

Low or Zero Carbon Technology	Selected For Building	Carbon Dioxide Saving per Yr	Percentage of building CO2 emission displaced	System Estimate	Equipment Life Expectancy	Capital Cost per tonne CO_2 saved over equipment lifetime	Simple Payback Period (Yrs)	FIT or RHI generation tarrif (p/Kwh) or ROC p/MWh	Estimated possible income from Generation Tarrif	CRC Saving (£12/ tCO_2)	Simple Payback when generation tarrif & CRC are included
Air Source Heat Pump	✓*	**Not Selected**	**Not Calculated**		**20**			**2.5**	**£0.00**	**£0.00**	
Photovoltaics	✓	**17,311.4**	**10.1%**	**£90,000**	**25**	**£0.21**	**21**	**12.13**	**£3,960.00**	**£207.74**	**11**
Total from Selected Technologies		**17,311.4**	**10.1%**	**£90,000**							

*Air Source Heat Pump technology has not been selected as a renewable strategy but will be utilised where rooms which require cooling. The amount of energy savings from Air Source Heat Pump will be known at a later stage of design at which stage associated carbon savings can be calculated

SECTION 7.0 LIFE CYCLE COST

The life cycle costs of the following technologies have been considered.

7.1 Photovoltaic Panels (PV)

Despite the high capital costs of the system, the above results identify a payback period of approximately 11 years. On-going maintenance of the unit is minimal, but the system will require new inverters once or twice in a 25 years period.

The PV system will degrade over time and have a reduced output. The industry standard output warranty is 90% output in year 10 and 80% output in year 25. Many solar panels won't degrade this much and hence this should be considered worst case scenario.

Photovoltaic panels have a salvage value and hence will reduce life cycling costs marginally.

SECTION 8.0 CONCLUSIONS AND RECOMMENDATIONS

Where cooling is required to control over heating in summer then VRF and/or split air conditioning systems will be of the reversible type to provide air source heating to these areas.

Based on previous school projects it is anticipated that approximately 300 square meters of Photovoltaic (PV) panels may be required to achieve building regulation compliance (Part L2A 2013). However, where possible the improvement in energy saving technologies will be targeted to reduce this need for PV. This will include the wide use of quality LED light fittings.

300 Square meters of PV shall be included on planning drawings at this stage and should be seen as a maximum size of the array. However, where possible the need for PV will be offset by energy saving technologies when Part L modelling is carried out.

8.1 Limitations of the Report

The DCLG calculations for carbon reduction and costs are of a basic nature and should only be considered as a guide. All low carbon and renewable technologies should be subject to further investigations during the design process to continually consider viability and optimum use of each technology.

The report is based on the reduction in carbon emissions achieved for a building provided with heating and hot water via a gas boiler.

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APPENDIX A – SUMMARY OF LOW OR ZERO CARBON TECHNOLOGIES (DCLG CALCULATIONS)

Estimate Energy Use based on previous high school part L thermal modelling

End Use	kWh	Carbon Factor for fuel	Carbon emmision of each fuel
Total Gas	439,917	0.216	95022.072
Total Elec	146,511	0.519	76039.0014

Total Building Carbon Emission Estimate 171,061 KgCO2/annum
Total Building Energy Estimate 586428 kWh

Low or Zero Carbon Technology	Selected For Building	Carbon Dioxide Saving per Yr	Percentage of building CO2 emission displaced	System Estimate	Equipment Life Expectancy	Capital Cost per tonne CO_2 saved over equipment lifetime	Simple Payback Period (Yrs)	FIT or RHI generation tarrif (p/Kwh) or ROC p/MWh	Estimated possible income from Generation Tarrif	CRC Saving (£12/ tCO_2)	Simple Payback when generation tarrif & CRC are included
Air Source Heat Pump	✓*	Not Selected	Not Calculated		20			2.5	£0.00	£0.00	
Photovoltaics	✓	17,311.4	10.1%	£90,000	25	£0.21	21	12.13	£3,960.00	£207.74	11
Total from Selected Technologies		17,311.4	10.1%	£90,000							

Energy Costs for electricity based on 13 p/kWh
Energy Costs for gas based on 3.5 p/kWh
Energy Costs for electricity export based on 13 p/kWh
Energy Costs for LPG based on 5.63 p/kWh
Energy cost for Biomass 4 p/kWh
Energy Costs for waste oil based on 7.5 p/kWh

The following calculations are based on the DCLG document 'Low or Zero Energy Sources: Strategic Guide'. The calculations are simplified manual procedures which will provide an estimate of the reduction in carbon emissions resulting from an application of an LZC technology.

*Air Source Heat Pump technology has not been selected as a renewable strategy but will be utilised where rooms which require cooling. The amount of energy savings from Air Source Heat Pump will be known at a later stage of design at which stage associated carbon savings can be calculated.

Project No **7/4987.1** Date: 17/12/2014
Project **St Julies**
Title **Calculations for LZC technologies**

DCLG Photovoltaics (PV) Performance Calculation Method

Photovoltiac modules convert sunlight directly into DC electricity and can be integrated into buildings. PV systems can be incorporated on sloped roofs; flat roofs; in facades, atria; and shading devices. Modules that are incorporated into the building fabric (eg PV roof tiles) are known as Building Integrated PV's (BIPV)

Description	Symbol	Units	Derived from or value	PV details
Total carbon emissions regulated by Part L	C_{tot}	$kgCO_2$		171,061
% carbon emissions saving target	**C_s%**	**%**		10.1%
Carbon emission savings target	C_s	$kgCO_2$	C_{tot} x C_s%	**17311.38**
Maximum annual irradiation at the specific location	I_{max}	kWh/m2/y		950.0
Module conversion efficiency	K_E	%		15.4%
Positioning factor based on system's tilt and orientation	K_P	%		95.0%
Inverter efficiency	K_I	%		90.0%
System losses	K_L	%		90.0%
Packing density	K_D			1.0
Output per functional unit installed	U	kWh/m2	I_{max} x K_E x K_P x K_I x K_L x K_D	112.3585425
Module rated output	R	kWpeak/m2		0.15366
Carbon factor for grid electricity	Cf_e	$kgCO_2$/kWh	0.529	0.529
Annual electricity output to meet carbon target	Q_e	kWh	C_s / Cf_e	32724.73
Area of the PV system required (constrained to available area)	A	m2	Q_e / U	291.3
Energy Saved		kWh		32724.7
PV system rated output	P	kWpeak	R x A	44.75
System Capital and Instalation cost				£80,000
Builderswork/Plantroom space				£500
G59 Application				£3,000
Interface with M&E	**2.0%**			**1,610.0**
Contractors P.P & O & Fees	**5.0%**			**4,255.5**
System Estimate				£89,366
Cost per tonne CO_2 /annum Saved				£5,162.24

Payback Calculation

Amount of Fuel saved by PV	32724.7 kWH
Cost of Electricity	£4,254.21
Yearly Saving	£4,254.21
Simple Payback Period	21.01 Years

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APPENDIX B – WIND SPEED DATABASE QUERY

Meeting Energy Demand > Wind > Windspeed database

WINDSPEED DATABASE QUERY RESULTS

FOR THE 1KM GRID SQUARE 342 386 (SJ4286)

Wind speed at 45m agl (in m/s)

6.8	6.5	6.2
6.8	6.7	6.4
6.6	6.7	6.5

Wind speed at 25m agl (in m/s)

6.4	6	5.6
6.4	6.3	5.9
6.1	6.2	6

Wind speed at 10m agl (in m/s)

5.7	5.2	4.9
5.7	5.6	5.1
5.5	5.6	5.4

Blank squares indicate areas outside the land area of the UK - i.e. areas at sea or of neighbouring countries.
agl = above ground level.
Squares surrounding the central square correspond to wind speeds for surrounding grid squares.

THE DECC WINDSPEED DATABASE
The wind speed database gives estimates of the annual mean wind speed throughout the UK. It uses an air flow model to estimate the effect of topography on wind speed, and makes no allowance for the effect of local winds such as sea, mountain or valley breezes. It does not take account of topography on a small scale, or local surface roughness (such as tall crops, stone walls or trees, or the built environment), which may have a considerable effect on the wind speed

To correct for local surface roughness an equation in BS 5929 has been used to derive a corrected wind speed for wind turbines rated at 10-50kW at various hub heights.

Um	5.6	m/s free wind speed @ 10m

K	0.35	Urban			
a	0.25	Urban			
z	18	25	36	m	Hub Height
U	**4.04**	**4.38**	**4.80**	m/s	Corrected Wind Speed