Renewable Energy Feasibility Study

Derbyshire Eco Centre

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Revision B : 10th February 2010
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DERBYSHIRE County Council
Improving life for local people

EXECUTIVE SUMMARY

In creating this feasibility study a number of assumptions have had to be made and these have been used in predicting the energy profiles for the Derbyshire Eco Centre. All data pertaining to renewable energy sources such as wind speed and solar irradiation have been compiled using historical data from several sources and simulation programmes.

The most appropriate technologies have been considered with selection being refined using CIBSE Technical Memorandum TM38 and using the TM38 toolkit, CIBSE Guide F and L and the feasibility study. These concluded that the following LZC technologies should be used.

Air Source heat pump (internal unit) – to generate the low grade hot water which would be ideally suited for the underfloor heating system.

Solar thermal hot water panels – to generate the hot water requirements. This would be associated with an electrical emersion heater to be used when the sun cannot generate enough heat alone.

Solar photovoltaic panels – a large array to be installed to power the electrical equipment on site. However, due to financial restriction to install a PV array for demonstration and education purposed only. This will also generate a small amount of electricity for the site.

In addition we recommend that the following should be installed to assist the end user.

Interactive touch screen – this educational aid would be useful for the centre in demonstrating the LZC technologies that have been installed. Students and visitors would be able to access information relating to energy consumption, carbon emissions, water, gas and electricity meter readings.

Rain water collection – the most appropriate system for this project would be the collection of the water off the roof and into rainwater butts. However, a full system can be installed providing more a demonstration and educational tool rather than looking at the installation as a financially viable solution

We consider the above installed systems would help reduce the carbon footprint of the building, whilst meeting the objectives of the project.

In order is assist in the implementation of these technologies for this project several financing streams are available.

SALIX Finance

The Local Authority Energy Financing Fund (LAEF) was launched in 2004, it is an 'Interest Free Loan' which funds energy efficiency projects. The technologies will deliver ' high carbon savings' with a maximum payback of 5 years. Technologies which could be considered for this project are; boiler installation, heating controls, hot water (point of use), building installation and office equipment improvements.

BERR Low Carbon Buildings Phase 2 (LCBP2)

BERR offer grants for the installation of microgeneration technologies, the current programme has now been extended until April 2011. The grant funds up to 50% of the cost of installing improved technologies, up to a maximum of £200,000, there is a £9m pot available for Solar PV.

This report also recommends that the following be considered;

- Supply and installation of a suitable solar photovoltaic system. This will decrease the demand of grid supplied electricity that is required to provide much of the environmental conditions for this building

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COSTS, PAYBACK PERIODS, AND CO2 REDUCTION

Table 1 : cost, payback period and CO_2 reduction

	LZC technology	Indicative installation costs	payback period (years)	CO2 reduction (kg)	CRC indicative cost saving pa
	solar thermal hot water	£8,152	65.5	680.0	£8.16
*	air source heat pump	£20,290	11.5	5,300.0	£63.60
**	solar photovoltaic phase 1	£10,580	24.3	474.8	£5.70
	solar photovoltaic phase 2	£78,000	15.8	5,380.5	£64.57
	rain water harvesting	£7,560	268.7		£0.00
	total	£124,582		11,835.3	£142.02

* payback period compared with installing a natural gas supply to the site

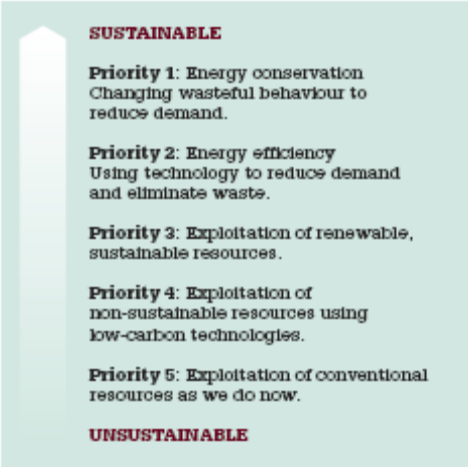
** only phase 1 will be installed within the building works, phase 2 to be considered at a later date when funding stream can be found.

Energy Demand Assessments

THE ENERGY HIERARCHY

The Energy Hierarchy offers an effective framework to guide energy policy and decision making. By prioritising demand-side activities to reduce wastage and improve efficiency, the Hierarchy links closely to the principles of sustainable development and offers an integrated, easy to use approach to the management of energy demand and supply. Put simply, a common-sense, cost-effective, sustainable energy policy should aim to reduce energy use before seeking to meet remaining demand by the cleanest means possible.

- **Priority 1**: Energy conservation – changing wasteful behaviour to reduce demand
- **Priority 2**: Energy efficiency - using technology to reduce demand and eliminate waste
- **Priority 3**: Exploitation of renewable, sustainable resources
- **Priority 4**: Exploitation of non-sustainable resources using low-carbon technologies
- **Priority 5**: Exploitation of conventional resources as we do now



ENERGY POL ICY STAT EMENT: 09/03

Figure 1 : contribution of Energy Hierarchy

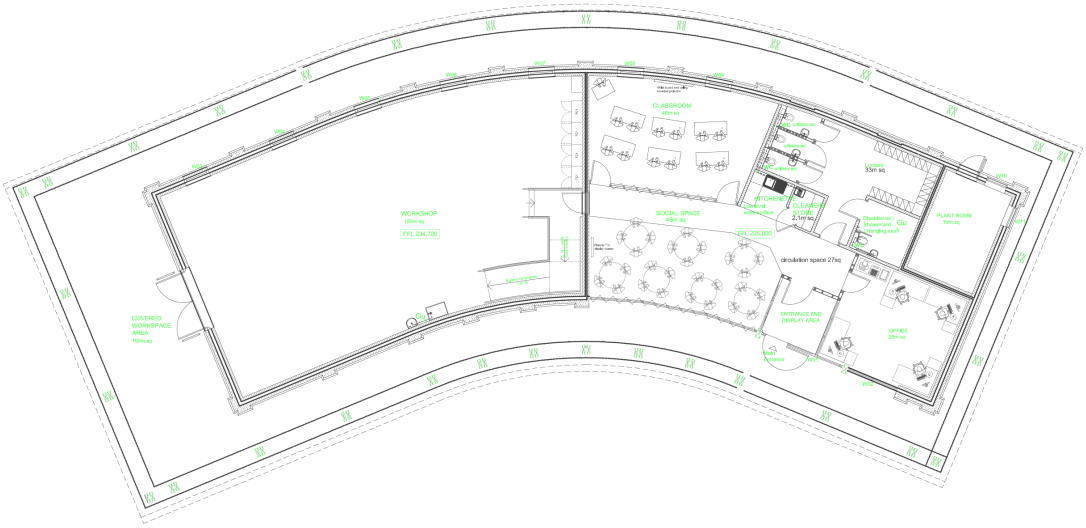
priorities to global emissions reductions, to achieve a 50% overall reduction 2005–2050 (c. 80% reduction compared to baseline).
■ Conservation & Efficiency (Priorities 1 & 2) [54%]
■ Renewables (Priority 3) [21%]
■ Nuclear + Carbon Capture & Storage (Priority 4) [25%]
Source: IEA BLUE Map scenario

BUILDING REGULATIONS PART L COMPLIANCE

The Building Regulation ADL2A (conservation of fuel and power) came into force in April 2006 and is a methodology in which the emissions from a building design can be assessed, from this it can be determined where energy is being used and by incorporating energy efficiency measures the carbon footprint of the building can be reduced.

BUILDING ENERGY USAGE REQUIREMENTS AND OBJECTIVES

Figure 2 : general plan layout – floor plan area

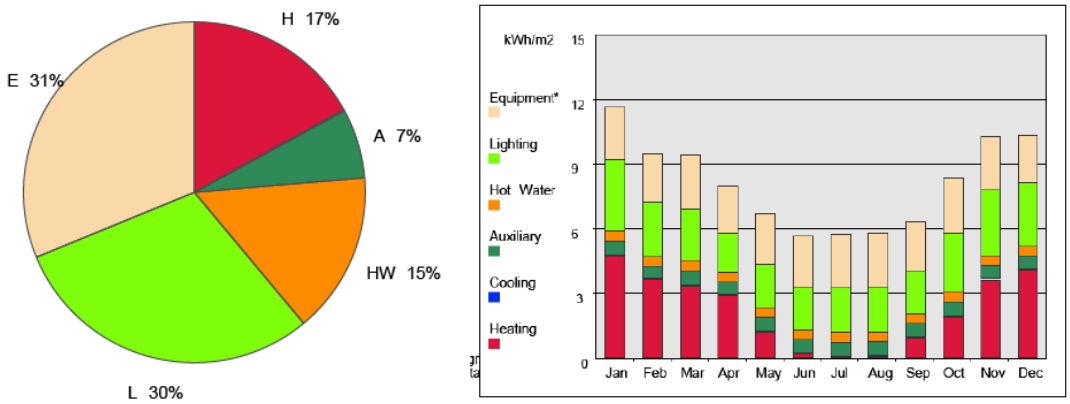


The energy usage and demand has been estimated by using HEVACOMP v.25 software

Table 2 : energy usage of building

	kWh/m^2 of total
Space heating	19.22
Domestic hot water	17.36
Lighting	33.81
Auxiliary	7.47

Figure 3 : annual energy consumption including equipment



From the data calculations, we estimate that the building will emit 32.3 kgCO^2/m^2

Site energy requirements

The estimated heating annual energy consumption for the this building is 263 GJ which is the equivalent to 73,056 kWh with the hot water being 13.5GJ (3,750 kWh)

It has been estimated that the building will be open 6 days a week form 7:00 to 17:00 hours.

Table 3 : design conditions used

Room	Temperature
Workshop	16
Office areas	21
Classroom	21
Toilets	16
Changing	20
External	-1

Table 4 : current cost of fuel using standard fuels

Gas cost per unit kW/h	Standing charge	Electricity cost per unit kW/h		Standing charge
1.6195p/kWh	92p/day	day 7.721p/kWh	night 5.221p/kWh	45p/day

* as from when this report was written Nov 09

Carbon reduction measures

There are a number of energy efficiency measures that can be used on this project to reduce its carbon footprint before we consider renewable technologies.

- Efficient lighting fittings and controls.
- Good controls and equipment for the heating system.
- The use of quality materials for the buildings envelope and ensuring air tightness.

In the next chapter we will outline the considered low carbon and renewable technologies and demonstrate how they can effect the carbon emissions of the building .

RENEWABLE AND LOW CARBON ENERGY TECHNOLOGIES

INTRODUCTION

The Government is under pressure to reduce the carbon emissions to enable it to meet its commitments under the Kyoto Climate Change Treaty, in addition to this Derbyshire County Council though the Climate Change Levy is penalised for the amount of carbon it realises into the atmosphere from all its building stock.

Using renewable energy and low carbon technologies is one way in which Derbyshire County Council can reduce its Carbon Footprint becoming less reliant on fossil fuel and subsequent price deviations.

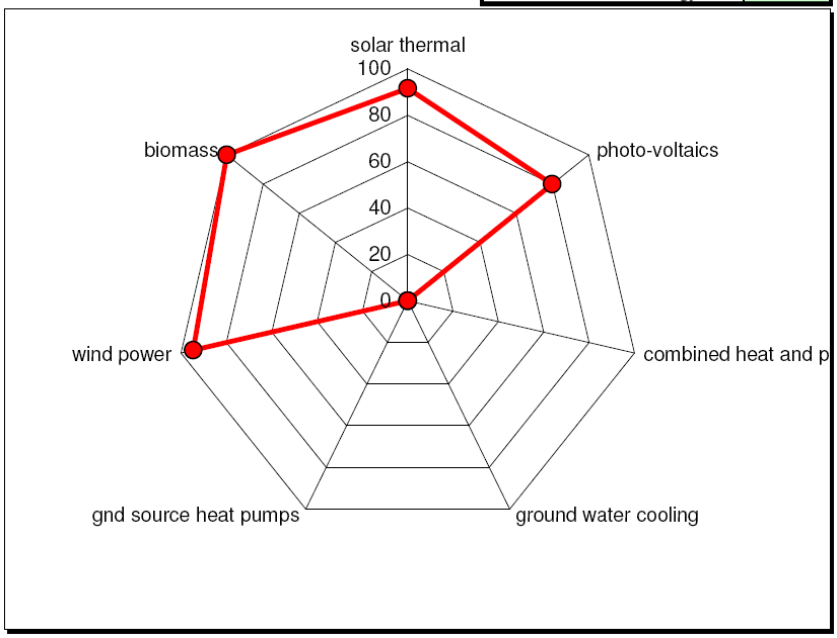
The CIBSE TM38 Tool provides guidance on the consideration of renewable energy source at the early stages of building design when ideas are being considered and the outline direction of the design is developed. This tool also help with some of the most important decisions relating to the overall appearance, orientation, building mass, heating and ventilation strategies which can also have a direct influence on the renewable energy source. This tool also demonstrates to stakeholders why a particular renewable energy source is preferred.

From the TM38 tool it can be seen from the chart below which renewable energy sources are preferable.

Table 5 : TM38 tool results

Building Information	
Type	educational buildings
Location	rural
Exposure	sheltered

Ranking	
Cost Effectiveness:	3
Carbon Savings:	5
Marketing / Image:	3
Technology Risk:	3



From the conception of the project it was expressed that a biomass boiler installation was not desirable due to staffing and the additional maintenance that would be required in the operation of this type of installation, as such this has been eliminated from this feasibility report. However, this is the preferred method of heat generation for the site using the chart above.

This particular tool does not take into account air source heat pumps (ASHP) However, their operation is much the same as ground source heat pumps (GSHP) but without the capital costs associated with ground works (bore holes and trench pipe coils)

SOLAR THERMAL HOT WATER GENERATION

Solar thermal systems or solar hot water systems use the energy from the sun to provide for the requirements of the hot water provision in the building. The systems comprise of a collector, this is generally roof mounted in which water or refrigeration fluid is used and is heated by the sun. This heat is then transferred to a special tank, which comprises of two heat exchangers, or transfer to a storage tank (buffer vessel). Dependent on location and the use of the building the collectors should be south facing elevation. However south-east and south-west can also provide sufficient requirements.

Table 6 : typical temperatures in Derbyshire

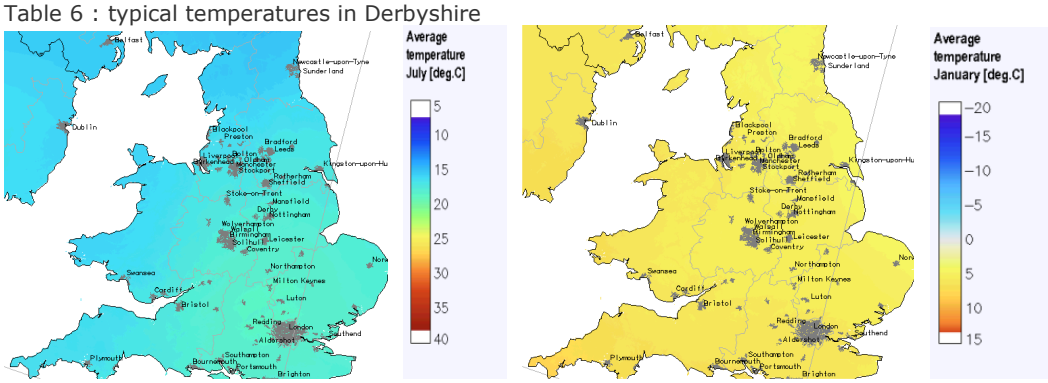


Table 7 : annual UK solar irradiation kWh/m^2

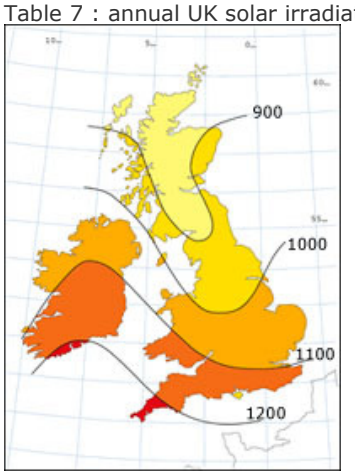
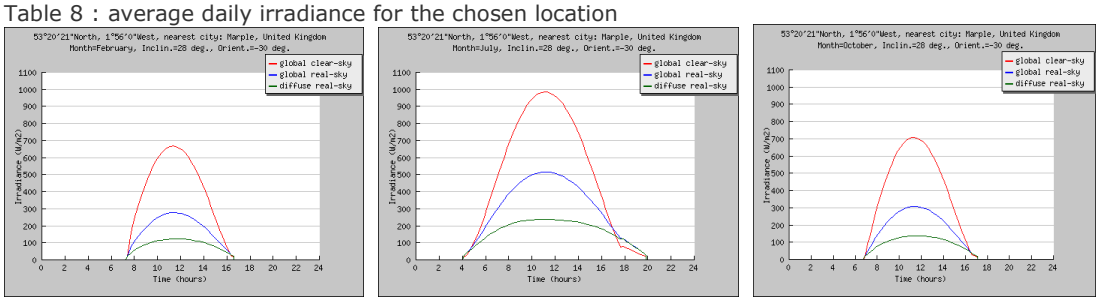


Table 8 : average daily irradiance for the chosen location



From Table 8 it can be seen that the average solar irradiation available for the Derbyshire area is up to 1000 kWh/m^2 (peak). The energy that can be extracted by the solar systems would generally be 40% - 60% of this. (dependent on system design)

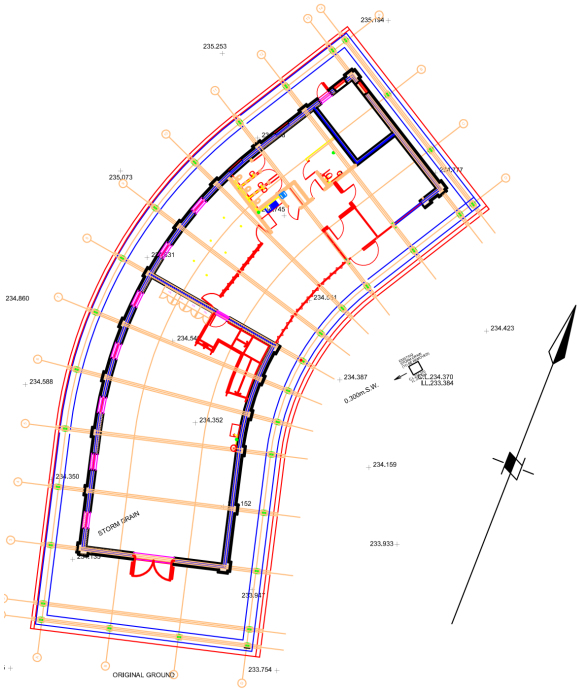
The two main types of collectors, these are flat plate and evacuated tube. The evacuated collectors are more efficient and hence occupies a smaller area, but can be more expensive. Both type of collector can be mounted on, or integrated within an existing or new roof structure

Figure 4 : evacuated tube collector

Figure 5 : flat plate collector

Site Assessment

Figure 6 : site plan layout with north direction



Ideally, solar panels should be orientated between south-east and south-west to maximise energy capture and be tilted at an angle of approximately 30 deg.

For this building the solar installation cannot be installed on the roof as this is intended to be planted with calvareous grass (green living roof). An alternative location can be the cycle store as this will also give adequate roof area to mount the panels and also faces an optimum direction to use the solar energy.

The hot water demand on page 7 Figure 3 can be seen as using 6% of the total energy requirements for the site, this equates to 13.5 GJ (3,750 kWh).

Performance calculation and carbon savings

Table 9 demonstrates the possible way in which solar can contribute to lowering the carbon dioxide emission from a building.

Table 9 : energy gained from solar panels

Aperture area of solar collector	4.6	sqm
Zero loss efficiency	0.75	
Collector heat loss efficiency	6	
Collector performance ratio	8	
Annual solar radiation	997	kWh/sqm
Overshading factor	1	
Solar energy available	3440	kWh
Energy content of hot water	3901	kWh/yr
Distribution loss	688	kWh/yr
Solar to load ratio	0.75	
Utilisation factor	0.74	
Collector performance factor	0.64	
Dedicated solar storage volume Vs	250	litres
Total volume of bivalent cylinder	250	litres
Effective solar volume	250	litres
Daily hot water demand	215	litres
Volume ratio	1.16	
Solar storage volume factor f	1	
Solar input Qs	1612	kWh

Given that the system has the potential to offset 1612 kWh of fuel this would equate to a CO_2 reduction of;

680 $KgCO_2$ per year compared to electrical emissions if electricity were used.

Site Access and maintenance considerations

Using the cycle store there should be no problems with access. However, extra protection should be considered for the solar collectors so as to avoid vandalism.

Maintenance requirements are minimal. The system requires an annual check and clean, with the antifreeze in the system being replaced every 5 years. The design should take into account the Health and Safety implications of the access requirement onto the roof and a person working at high level.

Suggested solar thermal installation

A standard solar thermal system should be sized to supply around 50% of the annual domestic hot water supply. However, for this project the solar thermal hot water panel and store will be sized to meet 100% at its peak efficiency.

Indicative Capital Costs

Table 10 : solar thermal hot water installation costs

Item	Costs
Solar panels	£4,087
Optional extras	£1,008
Installation	£3,057
total	£8,152

* Prices do not include VAT. Installation taken as 60% of equipment price

Estimated Fuel Costs

Table 11 : solar thermal hot water simple cost saving and payback

Elec price p/kWh	Cost saving £/year	Payback years
7.721	£124.46	65.5
8.49	£136.91	59.5
9.34	£150.60	54.1
10.28	£165.66	49.2
11.30	£182.23	44.7

*** assume 100% of solar hot water generating site requirements**
*** 10% rise in fuel costs have been used for examples**

Comparison of HWS generation fuels

Table 12 : solar thermal hot water - comparison of HWS generation fuels

Elec price p/kWh	Elec HWS cost	Gas price p/kWh	Gas HWS cost	Difference
7.721	£453.79	1.6195	£396.53	£57.26
8.49	£482.74	1.7815	£396.53	£86.21
9.34	£514.59	1.9596	£409.28	£105.31
10.28	£549.62	2.1556	£416.63	£132.99
11.30	£588.16	2.3711	£424.72	£163.45

*base upon HWS generation of 3750 kwh

Carbon Reduction Commitment Energy Efficiency Scheme (CRC)

Derbyshire County Council will be paying an indicative cost of £12 per tonne of carbon dioxide released. In providing a solar thermal hot water system at this site, would reduce our CRC commitment by:

Carbon dioxide emissions saving from solar thermal hot water system; 0.68 x £12 /tonne = £ 8.16 pa

Also in providing a solar thermal hot water system Derbyshire County Council are reducing their reliance on fossil fuels.

Suitability for proposed project

Since this site currently has no mains natural gas supply, electricity would be used to generate the hot water demand. As can be seen from Table 11 it would seem that any contribution from the solar thermal hot water system would have a financial benefit in the running costs of the building. The system would also provide a visual and educational tool demonstrating the use of solar energy in reducing CO_2 emissions, whilst reducing the buildings reliance on fossil fuels. Should this system prove beneficial then it can be expanded.

AIR SOURCE HEAT PUMP

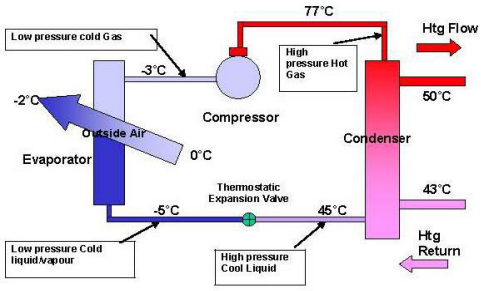
An air source heat pump (ASHP) works in exactly the same way as a ground source heat pump. The only difference benig the ASHP uses heat from the air instead of the ground and dependent on the unit, can heat water (air-water system), or the air in the building (air-air).

The advantage of an ASHP over a GSHP is that the unit and installation requires far less space and is less complicated to install. One of the main advantages is that the system requires no excavations. This makes ASHP far less expensive and complicated to install.

As with a GSHP the heating distribution is ideal of underfloor heating (low grade heat) as the temperature generated is within the maximum operating efficiency of the unit and requires no extra energy. For systems requiring higher operating temperatures (above 43°C) then additional electrical input may be necessary.

Figure 7 : air source heat pump

Figure 8 : how ASHP works



An ASHP can be used with an external air temperature as low as -15°C. However, at these lower external temperatures less heat output is obtained and at peak demand the unit may have to use a supplementary heating unit e.g. electrical emersion heater.

ASHP generally have a coefficient of performance (COP) of 2 to 3 . However, at the lower ambient air temperatures this will decrease.

Dependent on the ASHP unit planning permission and an acoustic assessment may be required.

Table 13 : assumed current cost of fuels for site for space heating

Gas cost per unit kW/h	Standing charge	Electricity cost per unit kW/h		Standing charge
1.6195p/kWh	92p/day	day 7.721p/kWh	night 5.221p/kWh	45p/day

*as from when this report was written Nov 09

Indicative Capital Costs

Table 14 : ASHP installation costs

Item	Costs
Unit price	£9,252
Required additional equipment	£2,839
Commissioning	£590
Installation	£7,609
total	£20,290

* Prices do not include VAT. Installation taken as 60% of equipment price

Estimated Fuel Costs

Table 15 : ASHP - comparison of LPHW generation fuels

Elec price p/kWh	Elec heating cost ASHP	Gas price p/kWh	Gas heating cost	Difference	Elec heating cost
7.7210	£2,044.47	1.6195	£1,635.96	£408.51	£5,804.90
8.4931	£2,232.49	1.7815	£1,765.97	£466.52	£6,368.97
9.3424	£2,439.31	1.9596	£1,908.99	£530.32	£6,989.44
10.2767	£2,666.82	2.1556	£2,066.31	£600.51	£7,671.96
11.3043	£2,917.08	2.3711	£2,239.36	£677.72	£8,422.73

Table 16 : ASHP, simple payback of main gas infrastructure

Gas price p/kWh	Saving £/year	Payback years
1.6195	£408.51	11.5
1.7815	£466.52	10.1
1.9596	£530.32	8.9
2.1556	£600.51	7.8
2.3711	£677.72	6.9

* in order to supply natural gas to the site an approximate capital cost of £8,000 has been taken into account, but is dependent on Transco allowing connection.
* average COP taken as 3
* average gas boiler efficiency 91%
* 10% rise in fuel costs has been used for examples

Table 17 : ASHP - kg CO2 emissions from fuel sources

CO^2 emissions Electricity	CO^2 emissions Gas
10276.5	15414.0

Table 18 : ASHP - equivalent fuel cost and CO^2

	Efficiency of unit	Cost p/kWh	CO2 emissions
GSHP	300%	7.721	0.422
Gas boiler	91%	5.339	0.582

* efficiency assumes unit with a published COP of 3
* figures do not reflect any use of emersion heater operation

Performance calculation and carbon savings

Table 19 demonstrates the possible way in which an ASHP can contribute to lowering the carbon dioxide emission from a building.

Table 19 : ASHP - Performance calculation method

annual heating demand for heating and hot water provision	73056	kWh
percentage of heating demand met by GSHP which may be 100% for electricity heated dwellings or less for non-domestic or community heating appliances	100%	%
annual heating supplied by heat pump	73056	kWh
CoP of the GSHP	300%	%
resulting electrical energy consumption of the heat pump	24352	kWh
electrical energy consumption of circulating pump for ground loop	0	kWh
carbon dioxide burden of the power supply to the heat pump	0.422	kg/CO2/kWh
resulting carbon dioxide emissions due to the operation of the GSHP	10277	kg/CO2/kWh
seasonal efficiency of conventional heating plant (boiler)	91%	%
fuel input to the conventional heating plant to provide equivalent output to the GSHP	80281	kWh
carbon dioxide factor for fuel supply to the conventional heating plant	0.194	kg/CO2/kWh
resulting carbon dioxide emissions due to the operation of the conventional plant.	15575	kg

Carbon dioxide emissions saving from Air Source Heat Pumps 5298.0

* table derived from ODPM. Low or zero carbon energy sources: strategic guide

Carbon Reduction commitment

Derbyshire County Council will be paying an indicative cost of £12 per tonne of carbon dioxide. In providing an ASHP at this site, would reduce our CRC commitment by:

Carbon dioxide emissions saving from an ASHP system; 5.3 tonne x £12 /tonne = £ 63.60 pa

Suitability for proposed project

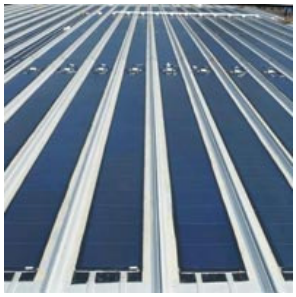
Since this site currently has no gas supply then electricity is the alternative given the clients brief that can be used in the generation of LTHW. As can be seen from Table 11 the cost of installing a gas supply to the site would have a significant payback and using gas as a fuel source would actually increase the carbon footprint of the building. Given the fact that the cost of bringing a gas supply onto the site an ASAP would seem a genuine alternative.

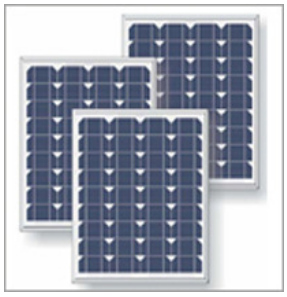
SOLAR PHOTOVOLTAIC

Solar electricity systems capture the sun's energy using photovoltaic (PV) cells. The cells convert the sunlight into electricity, which can be used to run appliances and lighting. The energy produced by the PV is dependent on the amount of sunlight hitting the PV cells. The PV systems efficiency is dependent on many natural variations and as a result the actual electricity generated in a year cannot be accurately predicted, as cloud & atmospheric conditions can greatly reduce the output from these units.

There are four types of PV systems that are currently on the market;

Amorphous
Polycrystalline
Monocrystalline
Hybrid





PV can be used in the same way as a wind turbine

Connected to the electricity grid network
Connected to a battery system for standalone power supply
Connected to the building with the excess feeding into the electrical grid network

At the time of writing this report there is no intension or obligation for the electricity supply companies to take the excess electricity produced by an installation and although batteries may be used to store the excess this greatly adds the capital, installation, and maintenance costs. A suitable room would also have to be found to use for this purpose.

PV requires little maintenance and is suitable for buildings with a high daytime demand and a summer load. When used to offset the buildings grid supplied electricity they become more viable.

The quantity of energy generated by the PV system will be depended on the roof area, the orientation from south and the angle they can be mounted.

Table 20 : PV - estimated amount of electric power/month

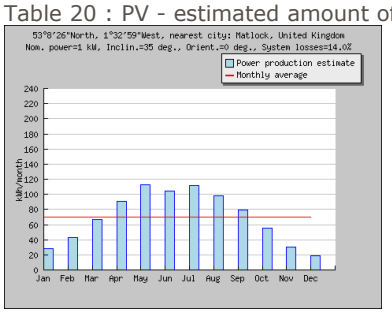


Table 21 : PV - July estimated irradiance

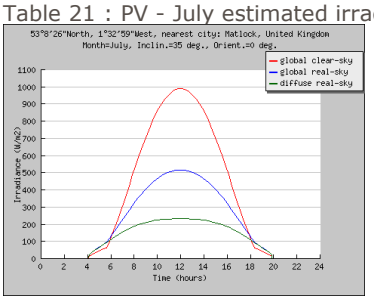
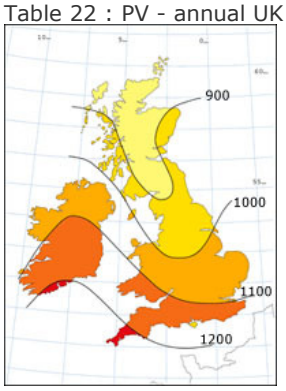


Table 22 : PV - annual UK solar irradiation kWh/m2



As can be seen from the tables the optimum generation is in July, between 9:30 to 14:00 hours. Should the demand not correspond with the buildings operational times or an alternative solution should be made to harness the total power obtained from the installation.

Feed in tariffs are currently being proposed, these Feed-in Tariffs are intended to support all renewable electricity generation sources used below 5MW. The Proposed tariff levels for PV installations are;

Table 23 : FIT for photovoltaic

PV[1] (New build[2])	<4kW	36.1	- 7 %
PV[1] (Retrofit[2])	<4kW	41.3	- 7 %
PV[1]	4-10kW	36.1	- 7 %
PV[1]	10–100kW	31.4	- 7 %
PV[1]	100kW–5MW	29.3	- 7 %
PV[1] (stand alone[2])	<5MW	29.3	- 7 %

For new systems installed after April 2011 the tariff levels will be adjusted based on the average 'degression rate' shown in the final column. Tariffs last for 20 years for all technologies except PV where they will apply for 25 years.

Site Assessment

Option 1

The brief for the this project was to provide a photovoltaic system that could be used to demonstrate a PV installation to visitors and students. The proposed design is based on a 1.5 kWp pole mounted array of approx 12m². This should give a yield of around 1,125 kWhrs per annum.. The capital equipment costs including installation and commissioning is approx £10,580.00. (excluding VAT and associated costs for civil works)

Figure 9 : pole mounted PV array

Table 24 : PV option 1 - simple cost saving and payback

Elec price p/kWh	Cost saving £/year	Feed in tariff generated income	Payback years
7.72	£86.86	£406.13	21.5
8.49	£95.55	£406.13	21.1
9.34	£105.10	£406.13	20.7
10.28	£115.61	£406.13	20.3
11.30	£127.17	£406.13	19.8

* assumed ideal condition all year round electrical generation for kWh output
* payback in years does not take into account any export tariffs
* capital costs taken as £10,580 excl. VAT and associated civil and installation costs
* FiTs taken as 31p

Table 25 : PV option 1 - potential CO^2 saving

CO^2 emissions reduced (kg)
474.8

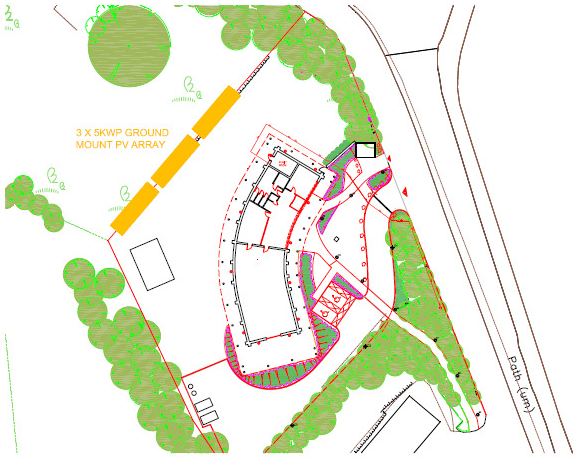
Considerations

The system designed for the original client brief will not generate sufficient electricity to off-set the grid supplied electricity which will be used on this site. However, for future consideration the PV system could be developed further should funding become available.

Option 2

A PV system designed not for demonstration but to supply the site would have to be in the region of 15 kW, an array of 60m^2 would be required to meet this demand. This could be accommodated by installing three number arrays located on the north west boundary if the site.

Figure 10 : large scale PV location plan



This would involve a large amount of civil works including the removal of part of the grass bank the formation of a retaining wall and levelling the platform for the mounting structure. As with the solar thermal hot water consideration would have to be given to possible vandalism and a means of protecting the equipment.

Figure 11 : large scale PV array

Figure 11 show how the array would look, consisting of 28 sharp 180 w mono-crystalline panels arranged in two rows of 14. With this design a yield of 12,750 kWhrs per annum could be generated with a capital cost of £78,000 plus (excluding VAT and associated costs for civil works)

Table 26 : PV option 2- simple cost saving and payback

Elec price p/kWh	Cost saving £/year	Feed in tariff generated income	Payback years
7.721	£984.43	£4,602.75	14.0
8.49	£1,082.87	£4,602.75	13.7
9.34	£1,191.16	£4,602.75	13.5
10.28	£1,310.27	£4,602.75	13.2
11.30	£1,441.30	£4,602.75	12.9

* assumed ideal condition all year round electrical generation for kWh output
* payback in years does not take into account any export tariffs.
* capital costs taken as £78,000 excl. VAT and associated civil and installation costs
* FiTs taken as 31p

Table 27 : PV option 2 - potential CO^2 saving

CO^2 emissions reduced (kg)
5380.5

Carbon Reduction Commitment Energy Efficiency Scheme (CRC)

Derbyshire County Council will be paying an indicative £12 per tonne of carbon dioxide. In providing a solar PV at this site it would reduce our CRC commitment by:

Option 1 : 1.5 kWp array

Carbon dioxide emissions saving from solar PV system; 0.48 tonne x £12 /tonne = £ 5.76 pa

Option 2 : 15 kWp array

Carbon dioxide emissions saving from solar PV system; 5.38 tonne x £12 /tonne = £ 64.56 pa

Suitability for proposed project

Option 1 could be carried out as the projects brief, to install a solar PV system for demonstration and educational purposes. However, if the site is looking towards being carbon neutral then the only way this can be accomplished using solar PV is to install a larger system, option 2.

Possibilities for both systems exist in providing financial support for the installation. BERR Low Carbon Buildings Phase 2 (LCBP2) offer grants for the installation of microgeneration technologies including solar PV. Organisations may apply for up to 50% of the cost of installing approved technologies up to a maximum of £200,000 (though maximum grant levels may depend on the nature of the organisation.)

Other financial streams and Government policies are also coming within the next few years. It is currently being discussed that an 'export' tariff will be offered to those with solar PV systems installed, this will offer a fixed amount per kwh produced. However, this is in discussion and as of writing this feasibility study is not finalised.

* for more details http://www.energysavingtrust.org.uk/Generate-your-own-energy/Sell-your-own-energy/Search-for-buy-back-tariffs/(size)/6/(filter)/min/(technology)/3/(export)

With the site using a large amount of electricity for its every day operations then solar PV would contribute to off-setting any grid supplied electricity and reduce the electrical consumption and therefore running cost. Also in providing a solar PV system Derbyshire County Council are reducing their reliance on fossil fuels.

RAIN WATER HARVESTING

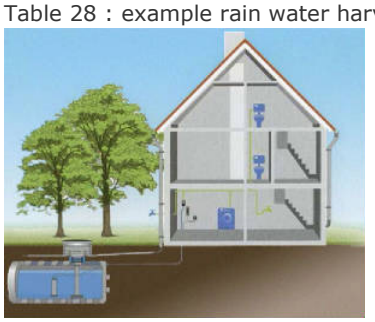
Rainwater harvesting is simply collecting rain which falls onto the roof, then storing it in a holding tank before distributing the water to the point of use.

The advantages of installing a rain water harvesting system are:

- Saving money by reducing your dependence on mains water usage
- The volume of water in the tank is kept out of the storm-water system, thereby helping to reduce flooding risks.
- You are not using water of 'drinkable quality' to flush toilets, mix mortar.

Rainwater harvesting systems can be as simple as a water butt located under a down pipe from your guttering or as complex as a full system incorporating controls and backup systems. Some of the larger systems have PV panels to generate the power to drive the pumping and water management to ensure that the system is topped up by mains water when rainwater is scarce. These provide a suitable flow with a mains cold water back up that make it suitable for WCs and any other outlets that are not used for drinking water.

Table 28 : example rain water harvesting system



Above ground tank

below ground tank

Indicative Capital Costs

Table 29 : rain water installation costs

Item	Costs
aquaprof top 30/50	£2,026
tank	£1,729
connection kit	£340
expansion vessel	£85
inline filter	£279
accessoires	£265
installation	£2,834.88
total	£7,560

* assumed 60% installation cost on capital

Table 30 : rain water - simple cost saving and payback

m3 11.376 cost

Water/sewerage Price pence/m³	Cost saving £/year	Payback years
247.30	£28.13	268.7
272.03	£30.95	244.3
299.23	£34.04	222.1
329.16	£37.44	201.9

* Price pence /m3 includes standing / drainage charges

Calculating rain water yield

Average rain fall for the area (nearest station Sheffield) 842.7mm (from met office)

Table 31 **:** rain water harvesting **-** approximate annual yield of rainwater m^3

	Plan roof area m^2				
mm rain/year	50	75	100	125	150
500	15	22.5	30	37.5	45
1000	30	45	60	75	90
1500	45	67.5	90	112.5	135
2000	60	90	120	150	180

* figures obtained from environment-agency
* approximate capital cost of £8,000

Table 32 : rain water harvesting - drainage factors for different roof types.

Roof type	Drainage factor
Pitched roof tiles	0.75 - 0.9
Flat roof smooth tiles	0.5
Flat roof with gravel layer	0.4 - 0.5

* roof drainage factor for calvareous grass (green living roof) taken as 0.4 as this is the only data available. However, it is anticipated that for this roof it would be a lower factor

Using the formula : roof area (m2) x drainage factor x filter efficiency x annual rainfall (mm) x % of annual yield (5%) we can calculate the amount of water collected per annum. (Table 33).

Table 33 : rain water harvesting - estimated collected yield

Roof area m^2	drainage factor	filter factor	annual rain	m^3 collected
750	0.4	0.9	842.7	11.376

Suitability for proposed project

The most appropriate system for this project would be the collection of the water off the roof and into rainwater butts. However, a full system can be installed that will be more of a demonstration and educational tool rather than looking at the installation as a financially viable solution.

Several problems do arise on the proposed site which could influence the design and installation of the system, these are;

Location of storage tank. It may not be possible to conceal the tank below ground due to the solid ground conditions and therefore the tank may have to be located above ground and subject to a planning application being approved.

Should the tank be above ground then problems can arise when warm, nutrient-rich grey water is stored, as it incubates bacteria. This water may have to be chemically treated or periodically 'dumped' after a period of inactivity. Problems with freezing could also occur during the winter months and may result in either draining the tank completely or in the worse case the storage tank could fracture.

The buildings design has a calvareous grass (green living roof) as part of one of its features to help it blend into its surroundings. Whilst this improves the building it is designed to attenuate water and reduce the risk of flooding, this will have an adverse affect on the performance of the rain water harvesting system.

Table 34 : carbon energy reduction targets

Derbyshire Eco centre

Summary of results and CO_2 emission

Floor area m²	Building energy requirements		Energy consumption (input)			CO_2 emissions			
	Fossil Fuels	Electricity	Fossil Fuel	Electricity	Total	Fossil Fuel	Electricity	Total	
	kWh	kWh	kWh	kWh	kWh	kg/CO²/yr	kg/CO²/yr	kg/CO²/yr	
362	71,712	20,815	80,576	20,815	101,391	15,470	8,784	24,254	
			76,547	19,774	96,321	14,697	8,345	23,042	with energy reduction target 5%
			72,518	18,734	91,251	13,923	7,906	21,829	with energy reduction target 10%

Results from using LZCs systems

LZC technology proposed	Energy used / offset kWh	Energy reduction % achieved in using LZC		CO_2 offset (kg)		Total	Actual total % reduction CO_2
		Fossil Fuel	Electricity	Fossil Fuel	Electricity		
Air source heat pump	23904	30%		4590			
Solar thermal hot water	1,612	2%		310			
Solar PV option 1	1125		5%		475		
Solar PV option 2	12750		61%		5381		
Option 1	total			4,899	475	5,374	22%
Option 2	total			4,899	5,381	10,280	42%

APPENDICES

Appendix A : Part L Compliance

Appendix B : EPC Compliance