



ENERGY ASSESSMENT REPORT
DOCUMENT 6
March 2008

1 Introduction

- 1.1 RPS Oxford (RPS) has been asked to carry out a predictive energy assessment as part of a Master Plan for the development of Curborough in support of the outline planning application. Curborough is to be located near Lichfield, Staffordshire and will consist of 5000 dwellings and a mixture of uses including schools, retail and leisure provisions. It is important to understand the implications for a site of this size to ensure that sufficient space and resources are available to allow for the specification of alternative energy sources. This would help reduce the traditional methods of energy used in development and help the Curborough Consortium decide how best to meet the energy demand in the most sustainable way.

- 1.2 RPS has been given information regarding the number of dwellings to be built on the site as well as retail and other building types. It is expected that the dwellings at Curborough will be built in a phased approach over a period of time and the energy demands of the site will need to comply with the energy standards as required in the Code for Sustainable Homes (the Code) for the residential dwellings at the time the related reserved matters phase. The commercial elements are also likely to require standards of performance compared with today's regulations.

- 1.3 From the information provided that has been provided to RPS, it has been possible to make predictions regarding the energy consumption once the development has been built at today's standards and the total Carbon Dioxide (CO₂) emissions that the site will emit.

2 Methodology

- 2.1 RPS has carried out preliminary energy demand calculations for the residential and none residential buildings for the Curborough site. The residential dwellings calculations have been produced using accredited SAP software and information from the Code. Information for calculating the none residential energy demands has been used in conjunction with information taken from the BSRIA Guide - Guidelines for Building Services, which provides details of energy consumption in a range of different buildings. A 'Baseline' and 'Improved Building Design' calculations have been provided, which show energy demand and CO₂ emissions and are shown in Appendix A. The information on building sizes has been provided by the client and the information for schools by Staffordshire County Council. Staffordshire County Council predicts that Curborough will have 1950 school children and therefore they have requested one secondary school and two primary schools be provided.

3 Renewable Energy Technologies for Curborough

- 3.1 The drive to conserve natural resources and protect the environment is likely to become an everyday concern for those living at the Curborough development. The use of zero or low carbon emission energy sources can contribute to these savings as they can lead to reduced emission of green house gases as well as conserving fossil fuel resources. The government has set targets of 10% of the UK energy being generated from renewables by 2020 and therefore the greater the number of dwellings at Curborough which utilise these technologies, the easier this national target will be achieved.
- 3.2 In order to comply with the Code for Sustainable Homes it is likely that a number of renewable energy technologies will need to be incorporated at Curborough. Although the retail aspects of the development are not covered by the Code, utilising renewable technology over the whole site can assist in meeting their necessary targets. It is important to review which are most suitable for Curborough. The following technologies have been considered;
- Wind Turbines
 - Ground Source Heat Pumps
 - Photovoltaics
 - Solar Hot Water
 - Biomass
 - Biomass Combined Heat and Power
 - Community Heating
- 3.3 It is important to note that without full site plans it is not possible to give accurate renewable technology specifications. Below are explanations of the Renewable Energy Technologies, and are then evaluated in terms of their feasibility with respect to the Curborough development. The development will involve large-scale new building and as such, the decisions taken on energy will have a major effect on the overall CO₂ emissions in the long term.
- 3.4 In light of this, a full feasibility study will be required for each of the Renewable Energy Technologies selected once the building design and planning permission has been agreed. This will need to take into consideration many factors including location, building orientation, building size, demand for particular energy at any given time, degree days, wind speeds, availability of biomass fuels and any license or planning issues. It is recommended that the use of Renewable Energy Technologies for the Curborough development is incorporated into the early design stage.

3.5 Wind Turbines

- 3.5.1 One of the most cost effective methods of renewable power generation; wind turbines are available in a vast range of sizes. For a residential development the use of large scale wind farms can be considered provided there is appropriate spacing, reliability wind and wind speed. The use of small turbines mounted at roof level may be possible, though this is a growing market in its early stages at present. Small-scale turbines are less likely to have a negative impact during community consultation than large-scale wind farms, when typical concerns would be raised on visual impact and noise levels.

3.6 Photovoltaic's (PV)

- 3.6.1 Photovoltaic systems use light from the sun and turn it into electricity. A PV cell is a small energy conversion system that converts the sun's energy directly into electricity. Such conversion is achieved by utilising the properties of semi-conducting materials, such as silicon, which release electrons when exposed to light. When daylight strikes the specially designed PV cell, it creates an electric field across two or more layers of silicon, and generates an electric current. The amount of electricity generated is related to the number of cells employed and the intensity of the light. However, modern PV cells do not require direct sunlight, so normal daylight is sufficient to produce electricity.
- 3.6.2 A single PV cell is very small and produces little electrical current, so it is usual for many cells to be grouped together into a module. A number of modules can be combined to form an array (or panel) that is sized to suit the electricity demand of the premises. Typically, an array covering 10m² generates 1.5 kilowatt peak (kWp) and each kWp saves approximately 455kg of CO₂/year. Residential buildings can integrate larger PV arrays into the fabric of the building, known as embedded PV systems, which are able to replace traditional building materials, such as cladding and roofing.

3.7 Ground Source Heat Pumps (GSHP)

- 3.7.1 The earth's surface acts as a huge solar collector, absorbing radiation from the sun. In the U.K, several meters below the surface, the ground maintains a constant temperature of 11 to 13°C. In the winter this temperature is warmer than the air above it. GSHP are used to extract this heat and transfer it to a building, where heat is required. GSHP extract heat from the ground to provide space and water heating to buildings, using the refrigeration cycle. Water or another fluid is circulated through pipes buried in the ground and passes through a heat exchanger in the heat pump system. The heat pump extracts this ground source heat and using refrigeration technology, upgrades and transfers this heat to the building heating system, which would typically be an under floor heating system. The GSHP may partially or totally replace the traditional system boiler, dependent upon the size of the development.

- 3.7.2 Buried Pipes are an integral element of the system, and also represent the largest difference to a traditional heating system. Very long lengths of pipe are required to provide adequate heat transfer. Lengths of plastic pipe are buried in the ground, either in a borehole or a horizontal trench. The pipe is a closed loop, which is filled with a water/antifreeze mixture. This mixture circulates in the pipe, absorbing heat from the ground. Horizontal trenches are drilled to a depth of 1 to 2 meters and can cost less than boreholes, but require a greater area of land. Placing coiled piping in horizontal trenches will enhance the performance compared with straight piping. A borehole is drilled to a depth of between 15 to 100 meters and will benefit from higher ground temperatures than the horizontal trench, although installation costs will be greater.
- 3.7.3 The GSHP process can also be reversed to generate Ground Source Cooling. This is needed where there is a demand for cooling, typically commercial spaces or prestige domestic developments where the stable temperature of the ground can be utilised for providing part or all of the cooling demand. In the summer months the ground temperature is often cooler than the air on the surface. Cooling is extracted from the ground by either an open or closed system in a similar method to ground source heating, utilising pipes in trenches or boreholes. The function of a ground source heat pump can be reversed and used as a cooling mechanism, or where more temperate cooling water temperatures are required fluid direct from the borehole loop can be utilised.

3.8 Solar Hot Water (SHW)

- 3.8.1 SHW systems employ a roof mounted solar collector to gather solar radiation. The heat produced is at a low temperature (below 90°C) and is normally used for heating domestic hot water or swimming pools, but not normally water for space heating. SHW systems are usually integrated with conventional water heating systems to ensure year round hot water. During elongated periods where there is no sunlight solar collectors will not provide hot water, therefore a dual system is required. Typically SHW can provide around 50% of the annual energy required for domestic hot water and can be used for hand washing and shower systems. SHW systems comprise solar collectors (panels), a heat transfer system (pipes) and a hot water store (domestic hot water cylinder).
- 3.8.2 Most commonly, the fluid is circulated through a closed loop system by means of a pump. A pipe carries the hot fluid to the domestic hot water cylinder, where a coiled pipe (inside the cylinder) gives up the heat to the water. The fluid in the coil then cools down and is pumped back, through another pipe, to the collector. The system forms a continuous loop that brings heat to the cylinder and returns cold fluid to the collector for re-heating by the sun. Adequate space for and orientation of solar collectors is essential for a SHW system to be feasible.

3.9 Biomass Heating

- 3.9.1 Biomass is organic matter of recent origin. It doesn't include fossil fuels, which have taken millions of years to evolve. The CO₂ released when energy is generated from biomass is balanced by that absorbed during the fuel's production. We call this a carbon neutral process. Biomass is often called 'bioenergy' or 'biofuels'. These biofuels are produced from organic materials, either directly from plants or indirectly from industrial, commercial, domestic or agricultural products. Biofuels fall into two main categories:

1. Wood based biomass

This includes forest products, untreated wood products, energy crops and Short Rotation Coppice (SRC), such as willow.

2. Non-Wood based biomass

This includes animal waste, industrial and biodegradable municipal products from food processing and high energy crops, e.g. sugar cane and maize.

- 3.9.2 Woodchip is mainly used in a commercial setting in larger boilers for power generation. Wood pellets are used in specially designed pellet stoves and boilers; they are a compressed form of wood with very low moisture content so they burn away almost completely. A central Biomass system would be of similar design to a community heating system, incorporating an energy centre which distributed heated water around the site, with the exception that the central boiler plant is fired by biomass fuel.

- 3.9.3 Biomass is a technology in its infancy at large scale with various methods of extracting heat from the matter available, though wood chip burning is the most common. Other methods include gasification/pyrolysis. The main considerations are local air quality from biomass processes, availability and transportation of fuel, storage of fuel on site and disposal of ash. Long transportation distances cause the renewable energy proportion of the technology to be reduced due to burning of fossil fuels in the transportation process. Close liaison with the local authorities and with fuel supply organisations with regard to fuel availability and its transport is essential at the early stages in planning.

3.10 Biomass Combined Heat and Power (CHP)

- 3.10.1 An enhancement of Biomass Heating, Biomass CHP allows the fuel to generate electricity alongside generating heat. CHP is a fuel-efficient energy technology that, unlike conventional forms of power generation, puts to use the by-product heat that is normally wasted to the environment. CHP can increase the overall efficiency of fuel use to more than 75%, compared with around 40% from conventional electricity generation. Furthermore, because it often supplies electricity locally, CHP can also avoid transmission and distribution losses.

3.10.2 The best system for CHP is thought to be gasification whereby the biomass is converted into gaseous fuel that is used for an internal combustion engine driving an electric generator. The site base heating and electrical loads are critical to the feasibility of CHP Biomass and detailed analysis is required for correct sizing. The lack of a year round thermal base load would normally rule out a CHP scheme therefore a summer load such as domestic hot water, or swimming pool is essential. It should be noted that gas or diesel fired CHP is not a renewable source of energy, though very energy efficient. CHP can only be regarded as renewable energy when fired by a fuel from a renewable source.

3.11 Community Heating

3.11.1 Energy from Waste represents an increasingly important fuel source. It can provide a safe and cost-effective disposal option for wastes that could otherwise present significant disposal problems. It can help reduce CO₂ emissions, through displacement of fossil fuels. Methane is 23 times more damaging than CO₂ for global warming. If biodegradable waste is diverted from landfill, methane emissions can be avoided.

3.11.2 Any energy that is recovered from biological wastes can be regarded as renewable energy. It comes from plant material and when this biomass material is used as a fuel, the CO₂ is returned to the atmosphere in a "carbon neutral" cycle. If biomass is used to displace fossil fuels instead of being left to decompose naturally, it will actually help to limit the emission of CO₂ and methane into the air.

3.11.3 There are many ways of combining waste disposal with energy recovery. A number of well established technologies are available for generating heat or power from wastes. There are also new technological developments, especially in power generation, which have the potential to increase the efficiency of energy recovery. Recovering energy from wastes from municipal or industrial sources can turn the problem of waste disposal into an opportunity for generating income from heat or power sales. The safe and cost-effective disposal of these wastes is becoming increasingly important worldwide, especially with the demand for higher environmental standards of waste disposal and the pressure.

4 Renewable Energy Recommendations for Curborough

4.1 Wind Turbines

- 4.1.1 Preliminary investigations indicate that significant potential exists to utilise energy generated from large wind turbines or roof mounted small scale wind turbines, although this is dependant upon a detailed feasibility study of the technology and precise locations. This study would assess its technical specifications, wind conditions and roof elevations, visual aesthetics, noise impact, and vibration associated for building mounted turbines. It would also assess the potential to link into any such existing or planned wind turbine sites in the area. However, wind turbines do offer the potential to significantly reduce carbon emissions for the site.

4.2 Photovoltaics (PV)

- 4.2.1 PV panels integrated into building fabric, such as cladding, roof surface or brise soleil are feasible for Curborough. This would only be possible if the south-east to south-west elevations were utilised and were un-shaded. PV panels can be prone to vandalism, which may be likely in an urban area which may restrict use as well as how cost effective on large scale single installation it would be. However, PV panels integrated into the building fabric are a viable option for Curborough.

4.3 Ground Source Heat Pump (GSHP)

- 4.3.1 This renewable energy technology is suited to under floor heating. When combined with central solar domestic hot water, precludes the need for gas distribution. GSHP can be considered but only as a way of contributing to the renewable energy requirements and not as the sole contributor. The borehole requirements and ground conditions may reduce the amount that could be implemented for Curborough development and therefore would make it unviable. GSHP are also likely to increase CO₂ emissions to the fuel switch and therefore would require a second technology to meet the Local Authority requirements.

4.4 Solar Hot Water

- 4.4.1 A high proportion of roof area in comparison to accommodation provides good potential for positioning of solar collectors. This system could be a feasible option for Curborough, however, it should be noted that Solar Hot Water is only efficient on 2 storey dwellings. It may not be possible to achieve a high efficiency for flats or houses on 3 storeys or more as it becomes less efficient at transferring the heat over a further distance. In the case of buildings at this height, confirmation will be required to eliminate the potential of Solar Hot Water and the likelihood of utilising another Renewable Energy Technology.

4.5 Biomass Heating

- 4.5.1 For Biomass heating, wood chips are used as primary fuel. This means that a local source of wood chip/pellet needs to be available, and this would need to be investigated, including the necessary transportation of wood chips. This technology provides space heating and domestic hot water and is viable for the Curborough development. Wood chip and ash storage on site would need to be taken into consideration during the design phase.

4.6 Biomass Combined Heat and Power (CHP)

- 4.6.1 Biomass CHP adopts the same principles as Biomass Heating, however, part of the central plant will be utilised to provide power generation for the site and distribution back to the National Grid. This technology is applicable to a community heating system when used in conjunction with Biomass Fuel. Feasibility issues as described in the Biomass Heating apply. CHP does reduce the overall site carbon emissions due to very good efficiencies, therefore reducing the overall amount of renewable energy sources required for the site. However, at present, the technology is in its infancy and not readily available or reliable at present, so this Renewable Energy Technology is not recommended for the early stages of Curborough but it may be possible in the later phases.

4.7 Community Heating

- 4.7.1 Possible methods of utilising Energy from Waste include Mechanical Biological Treatment with anaerobic digestion or mechanical biological treatment with refuse derived fuel and anaerobic digestion. Gasification and pyrolysis can also be used as well as using Energy from Waste which provides Combined Heat and Power. A Community Heating scheme such as one of the above would be suitable for Curborough provided that enough waste could be collected on site so as to generate enough energy.

4.8 Summary

- 4.8.1 Before renewable energy recommendations can be considered it is important to first calculate the predicted energy demand of the buildings and to then attempt to improve the energy efficiency. This is shown in the energy calculations in Appendix A. The first table shows the baseline energy demand for the Curborough development based on Building Regulations and has been calculated using SAP Assessments and data from the BSRIA Guide - Guidelines for Building Services, which provides details of energy consumption in a range of different buildings. The second table represents the energy demand where improved energy efficient designs are used. Based on RPS expert knowledge, it is estimated that this energy demand would be 20% less than the Building Regulations table. The tables indicate that by using efficient building design, which will include improved u-values, a low Air Permeability Rate, low energy lighting and improved thermal bridging at the Curborough development; it is possible to achieve Code level 3. Improved energy efficient design will also limit the CO² generated on the development and therefore limit the amount of renewable technologies required to reduce overall CO² levels.

5 Conclusion

- 5.1 This Energy Assessment Report has been produced specifically to support the current outline planning application for the Curborough new settlement and clearly is confined to the application site boundary. This assessment includes preliminary energy demand calculations for the residential and non residential building proposed for Curborough, using SAP software and information from the Code. Attached at Appendix A is the result of this assessment, which provides 'Baseline' and 'Improved Building Design' calculations.
- 5.2 Based upon this assessment, this outline planning application commits to Code Level 3 of the Code for Sustainable Homes for the residential properties on the site. This can be achieved through improved u-values, low air permeability and the use of either solar thermal or PV as a Renewable Energy Technology. The higher levels of the Code require further energy reductions, and this can be achieved through the use of further Renewable Energy Technologies. In this regard, the applicant is undertaking feasibility assessments on land within its control, which although not forming part of this current planning application, is adjacent to the site to the east of the A38. This feasibility assessment is examining the potential use of renewable energy technologies from the site, including the use of energy from waste plant and the potential of wind turbines as a way of meeting higher Code levels.
- 5.2 Whilst this outline planning application commits as a baseline to a Code Level 3 (based upon today's standards) given that the construction phase is to last in the region of a 15 year period, it is likely that higher level codes can be achieved for the latter phases of the development. It is therefore recommended that each reserved matter phase of the site will be accompanied by a separate energy assessment report which will detail the code level to be achieved and the technologies and construction methods to be used for that phase of the development. It is recommended this can appropriately be controlled through the use of a planning condition imposed on the outline planning consent.

Appendix A

Curborough Energy Assessment

Curborough Calculations - Baseline

Type	Size (GFA m ²)	Number	Energy Consumption benchmarks (kWh/m ² /yr)		Total (kWh)	
			Fossil Fuels	Electricity	Fossil Fuels	Electricity
			Retail			
Supermarket	2,500	1	200	915	500,000	2,287,500
Restaurant	150	1	1,100	650	165,000	97,500
Take away	100	1	480	820	48,000	82,000
Other retail	1,000	3	80	200	240,000	600,000
Health Care (GP Surgery) *	500	1	174	65	87,000	32,500
Sports Centre	1400	1	573	152	802,200	212,800
Community Centre	600	1	125	22	75,000	13,200
Schools **						
Primary Schools	2500	2	126	20	630,000	100,000
Secondary School ***	12000	1	136	24	1,632,000	288,000
Total					4,104,200	3,700,300
CO² Emissions					779,798	1,591,129
Total CO² Emissions					2,370,927	

* **Note:** The GP Surgery dimension is approximated from Neufert Architect's Data handbook (3rd ed.) for 6 GPs.

** **Note:** Secondary School may also include dual community uses such as a library.

*** **Note:** These figures are estimates at the current time based on the limited information available. They will require testing and verification as the project proceeds.

The below data is based on real data from previous work carried out by RPS Oxford

	Percent	Total	Dwellings/Ha	Ha	Area (m ²)	Energy Consumption benchmarks (kWh/m ² /yr)			Total (kWh)	
						Fossil Fuels	Electricity for		Fossil Fuels	Electricity
							Cooking	Electricity		
Flats	20%	1000	90	11	45	4,640	800	810	4,640,000	1,610,000
2 bed (semi & 2 storey terrace)	5%	250	37	7	65	5,450	1,200	1,645	1,362,500	711,250
3 bed (semi, 2 storey terrace, some detached)	33%	1650	45	37	80	6,790	1,350	2,355	11,203,500	6,113,250
3 & 4 bed (3 storey terraced)	25%	1250	50	25	100	8,300	1,400	3,110	10,375,000	5,637,500
4 bed (detached)	17%	850	30	28	120	9,875	1,500	3,985	8,393,750	4,662,250
Dwellings	100%	5000	46	108						
Total						35,055	6,250	11,905	35,974,750	18,734,250
CO² Emissions									6,835,203	3,559,508
Total Site kWh									40,078,950	22,434,550
Total Site CO²										12,765,637

Curborough Calculations - Improved Building Design

Efficient building design which includes the use of improved U-Values, increased Air Permeability Rate (APR), Thermal Bridging, Daylighting, Energy Efficient lighting and the use of Night Time Ventilation can improve energy consumption by up to 20% for a dwelling development. The energy consumption for Curborough based on this 20% saving is shown below.

Best Practice energy consumption data will be used as Curborough will be built to BREEAM excellent.

Type	Size (GFA m ²)	Number	Energy Consumption benchmarks (kWh/m ² /yr)		Total (kWh)	
			Fossil Fuels	Electricity	Fossil Fuels	Electricity
Retail						
Supermarket	2,500	1	160	700	400,000	1,750,000
Restaurant	150	1	880	520	132,000	78,000
Take away	100	1	384	820	38,400	82,000
Other retail	1,000	3	72	160	216,000	480,000
Health Care (GP Surgery)	500	1	140	58	70,000	29,000
Sports Centre	1,400	1	51	126	71,400	176,400
Community Centre	600	1	20	103	12,000	61,800
Schools						
Primary Schools	2,500	2	102	18	510,000	90,000
Secondary School	12,000	1	110	19	1,320,000	228,000
Total Retail and School kWh					2,757,800	2,913,400
CO² Emissions					523,982	1,252,762
Total CO² Emissions					1,776,744	

We need to calculate the energy use, for the houses using Code level 6 criteria. This will require calculating the cooking and appliances data

	Energy Consumption benchmarks (kWh/m ² /yr)					Total (kWh)				
	Percent	Total	Dwellings/Ha	Area (m ²)	Fossil Fuels	Electricity for Cooking	Electricity	Fossil Fuels	Electricity	
Flats	20%	1000	90	11	45	3,710	800	645	3,710,000	1,445,000
2 bed (semi & 2 storey terrace)	5%	250	37	7	65	4,360	1,200	1,315	1,090,000	628,750
3 bed (semi, 2 storey terrace, some detached)	33%	1650	45	37	80	5,430	1,350	1,885	8,959,500	5,337,750
3 & 4 bed (3 storey terraced)	25%	1250	50	25	100	6,640	1,400	2,485	8,300,000	4,856,250
4 bed (detached)	17%	850	30	28	120	7,900	1,500	3,185	6,715,000	3,982,250
Dwellings	100%	5000	46	108						
Total						28,040	6,250	9,515	28,774,500	16,250,000
CO² Emissions									5,467,155	3,087,500
Total Site kWh									31,532,300	19,163,400
Total Site CO²										10,331,399