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WATER-BASED QUARRY RESTORATION: OPPORTUNITIES FOR SUSTAINABLE RURAL REGENERATION AND NATURE CONSERVATION

MA/6/2/013

DRAFT VERSION 1
March 2008

Report prepared for:

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OPPORTUNITIES FOR SUSTAINABLE RURAL REGENERATION THROUGH QUARRY RESTORATION

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1 INTRODUCTION

Sub-watertable mineral extraction has been undertaken for hundreds of years, resulting in the creation of large areas of wetland and numerous waterbodies. Many of these have significant ecological and public amenity benefit and are important resources at regional and national levels. Historically the majority of restoration was generally passive and unplanned. However, increasing public awareness, greater understanding of the water environment and progressive tightening of planning regulations and European Union (EU) directives have placed a greater emphasis on the optimisation of water-based restoration design. This is appropriate given the long-term effects of restoration compared with the relatively short operational life of a quarry and the proven potential for schemes to make a major beneficial contribution to the surrounding area.

Hafren Water in conjunction with quarry operators, nature conservation organisations and regulatory authorities, has recently completed a research project funded by the Minerals Industry Research Organisation (MIRO) entitled 'Water-based quarry restoration: methodologies, technologies and approaches' (MA/5/2/2005) (www.quarry-restoration.com).

The project identified several innovative approaches to restoration which have been developed further under the research project title, 'Water-based Quarry Restoration - opportunities for sustainable rural regeneration and nature conservation' (MA/6/2/013).

1.1 Report layout

For ease of reference the project has been sub-divided into two self-contained reports relating to the different research topics. This report relates to the assessment of opportunities for sustainable rural regeneration through quarry restoration as discussed below:

1.2 Sustainable rural regeneration

Sustainability is without question a broad and diverse subject affecting all elements of life on earth. Definitions abound but the actual mechanics to achieve "sustainability" can be subjective and at most elusive. There is, however, in the light of recent global agreement and subsequent national policy drivers, a need for organisations, institutions and individuals to better understand how planned changes to the environment can contribute to the sustainability agenda. In particular the harmonisation and balance of social, environmental and economic needs necessitates an understanding of how the original vision for sustainability can be achieved.

The quarry and mineral industry is one such sector which has a role to play in contributing to the implementation of sustainability. Within the industry there is a firm commitment to leaving a lasting legacy for post-extraction sites and also emerging demands to meet prescribed performance targets for sustainability. There is now a growing shift towards more progressive thinking about how land use planning can meet the needs of local people, creating new opportunities for wildlife and continuing economic growth by joining forces with planners, developers and local communities. This "social conscience" is not restricted to urban areas where perhaps the effect of industrialisation is most evident. Rural areas also suffer from social depreciation, environmental damage and relatively poor economic progress and it is here that the quarry and mineral industry has a potential role to play in realising new opportunities for sustainable development.

1.3 Why quarries?

Quarries and mineral extraction sites present interesting locations for exploring sustainability issues. In particular, the following elements are pertinent:

Planning: The mineral industry has a history of specific planning legislation and provides a framework for consideration within a rural location. In addition local consultation as part of the planning process and specific planning conditions enable a long-term view of potential restoration options.

Environmental Impact Statement: In most circumstances new quarry sites are subject to specific detailed environmental impact assessments for a range environmental issues ie landscape, ecology, atmospheric pollution. This presents an opportunity to evaluate and test likely impact of proposals and conclude mitigation measures.

Mineral resource: The mineral resource is finite and the residual value of minerals may be assessed collectively with any proposed site after use and combined to maximise overall financial viability.

Design: Progressive restoration coupled with master planning have the potential to provide alternative land uses at varying stages of a quarry's lifecycle.

Landscape: The position of quarry sites within wider landscape or ecological units allows for consideration of a number of options. The extended and wider landscape can be considered as part of quarry restoration.

Infrastructure: The development and planning of engineering works for road networks, storage areas and local hydrology in relation to proposed extraction can also have a secondary use for proposed landuse.

Environmental resources: Quarries are often located near watercourses with significant hydro electricity generation potential. Mineral extraction often results in large waterbodies supported by groundwater and surface water inflows and storing a considerable amount of thermal and potential energy (gravity flow). Solar and wind energy and biomass fuel are also potential options to be considered.

Energy costs and carbon offsetting: The quarrying industry consumes a significant amount of energy in its extraction, processing and distribution activities. This has financial and environmental costs, and potential exists to reduce both through the use of sustainable energy. Energy schemes incorporated within the operational life of the quarry may be financially attractive and would also continue to benefit the local community during site after use. Potential exists to off-set an operators global emissions against long term reductions in carbon emissions for the site and the surrounding community.

Engineering resources: Sufficient land is often available for the construction of the required facilities and necessary engineering works may be undertaken during the restoration. Sufficient expertise may be available on site or within the operating company for any routine maintenance requirements.

It may be possible to utilise the available energy within the proposed restoration schemes, which often include return to agricultural usage, wildlife habitat creation, recreational or residential usage. Of particular interest may be the use of heat pump systems to provide heating for residential, commercial, aquaculture or agricultural (greenhouse) purposes and micro hydro-electric generation.

The availability of these sustainable resources may complement the creation of an ecologically friendly development or 'eco park'. The use of sustainable energy and water resources will add value to the final restoration, reduce carbon emissions and potentially benefit the surrounding community through income generation and creation of sustainable, affordable rural housing.

2 PROJECT OBJECTIVES

The project objective was to assess the potential for sustainable rural regeneration through quarry restoration. A discussion of sustainability and the drivers to achieve it within the quarry setting was undertaken.

The project focussed on the creation of sustainable developments as part of restoration to promote rural regeneration. This incorporated utilisation of available sustainable energy resources at a site, including thermal (solar, heat pumps) and potential energy (hydro power,wind), to regenerate a site and provide income in the locality. Broad design and assessment was undertaken for a case study site assessing a range of end use developments. These will provide an indication to landowners of a range of end uses including industrial, retail, leisure and eco-homes.

The use of sustainable energy to supplement quarry operational consumption and reduce carbon emissions was also addressed. This may potentially provide a significant economic incentive to incorporate sustainable energy uses during the operational phase which may carry over into the final end use.

3 APPROACH

As part of MIST Thematic Priority 2: *Site design, operation and closure*, a review of the methodology and approaches used for the two elements of the research project was undertaken within published literature and through discussions with interested parties. The research into sustainable rural regeneration entailed site visits and a desk study based upon a selected case study site at Tarmacs sand and gravel quarry in Scorton, North Yorkshire. A review of local and UK policy and drivers was undertaken. A key part of the assessment involved use of the RETScreen International Clean Energy Project Analysis Software, a tool for facilitating feasibility analysis of clean energy technologies. The project involved input from experts in the fields of landscape, planning, hydrogeology, hydrology, sustainable energy, engineering and quarry operations. A steering group was set up composed of partner members who monitored progress and provided input to the investigation.

Priority was given to the dissemination of information through the website (www.quarry-restoration.com) and presentations to the Steering Group Committee. The project aimed to provide practical guidance to promote innovative approaches to future water-based restoration schemes.

3.1 Data sources

Data was obtained from the operating company and regional data including river levels, rainfall and groundwater levels were obtained from the Environment Agency. Published data was obtained from the scientific literature and detailed internet searches. Site visits were made and discussions held with interested parties including quarry operators, restoration managers and reserve trusts.

3.2 Project partners

Considerable support was provided for this project from quarry operators (Tarmac and Lafarge), Natural England and North Yorkshire County Council.

The project was a collaborative venture between industry, academia and public sector organisations including:

- Hafren Water – Dr P Ellis (Hydrogeologist), Mr C Leake (Director)
- Mr M Hammond (Wildlife Consultant)
- Pleydell Smithyman – Mr N Healy, Mr R Smithyman,
- Energyworx – Mr A Ward
- Mannpower – Mr S Moore
- Tarmac – Mr C Arditto (Geological Manager), Mr M Young (Estates Manager)
- Lafarge Aggregates – Mr D Park (Restoration Manger),
- Natural England – Mr T Kohler
- North Yorkshire County Council – Mr M Barnett (Principal Landscape Architect) and Mr G Megson (Natural Environment Team Leader)

3.3 Website

The project website (www.quarry-restoration.com) has been operational since October 2005 and will be maintained for several years following completion of the project. Interested parties are encouraged to use, contribute and link to it.

4 SUSTAINABILITY

4.1 Defining sustainability

By definition, sustainability is a characteristic of a process or state that can be maintained at a certain level indefinitely. The term, in its environmental usage, refers to the potential longevity of vital human ecological support systems, such as the planet's climatic system, systems of agriculture, industry, forestry, and fisheries, and human communities in general and the various systems on which they depend. Emphasis is on how to make human economic systems last longer and have less impact on ecological systems, and particularly relates to concern over major global problems such as climate change and the depletion of fossil fuel reserves.

Sustainability can be defined both qualitatively in words, as an ethical/ecological proposition and quantitatively in terms of system life expectancy and the trajectory of certain factors or terms in the system. One of the original qualitative definitions was developed by the Bruntland Commission as development that *"meets the needs of the present without compromising the ability of future generations to meet their own needs".*

A quantitative definition of sustainability is required in order to set sustainability goals and to monitor success. Specified indicators, such as CO_2 emissions, can be used to assess whether certain practices are more sustainable than others. The Stern report, on the economics of global climate change, estimated that 1% of GDP will now need to be invested to save 20% of GDP, because of failures to date by most global markets sectors to integrate sustainability in the metrics they have governed with.

The following operational rules to achieve sustainability were suggested by H E Daly (Chief Economist, World Bank):

1) renewable resources such as fish, soil, and groundwater must be used no faster than the rate at which they regenerate;
2) non-renewable resources such as minerals and fossil fuels must be used no faster than renewable substitutes for them can be put into place, and
3) pollution and wastes must be emitted no faster than natural systems can absorb, recycle or render them harmless.

A significant gap exists between the developed and developing world and potentially, according to ecological footprint analyses, it would be necessary to have 4 or 5 additional planets engaged in nothing but agriculture for all those alive today to live a western lifestyle. A number of studies have suggested that the current population of the Earth, already over six billion, is too many people to support sustainably. At current material consumption levels, this challenge for sustainability is distributed unevenly. According to calculations of the ecological footprint, the ecological pressure of a US resident is 12 times that of a resident of India and 24 times that of a Somali resident.

Globally we are not even meeting the needs of the present generation, let alone considering the needs of future generations. As the world's population continues to increase we already see a world where over a billion people live on less than a dollar a day (www.sustainable-development.gov.uk).

In general people are likely to agree with the principles of sustainable development, the problem is to enact them. A decisive move toward sustainable development is required in the long-term interest on both a local and global scale.

4.2 Sustainable development

Building on the principles of sustainability, the field of sustainable development can be considered as three constituent parts: environmental sustainability, economic sustainability, and social-political sustainability. Ideally a balance can be achieved between the competing relationships of social, economic and environmental objectives and achieve sustainable development. Classically the traditional economic 'world view' places infinite demands on a finite resource. This assumes that prosperity is only restricted by supply of labour and resources and that there are no social or environmental consequences. For example, standard economic models when applied to deforestation would consider the relative value as straightforward costs associated with the marketed product i.e. clearance, extraction, sale and conversion to produce as opposed to the non-marketed value attributed to air pollution, biodiversity, heritage, carbon storage and medicinal or scientific value. This Total Economic Value (TEV) defined by Barbier (1991) presents a clearer understanding of the intrinsic value of tropical forests; however it would perhaps not satisfy the demands of farmers in the Amazonian Basin struggling to raise their basic standard of living through economic and (eventually) social gain.

Historically governments have expressed *economic growth* as a measurable entity, which is normally reported and expressed as Gross Domestic Product (GDP). This is the basic form of growth and argues that the advancement of societies is assessed in the additional income its economy can generate or *economic capital*. This unfortunately does not necessarily mean that the growth is equitable. In an attempt to address this issue the UK Government produced the White Paper 'Building Partnerships for Prosperity: sustainable growth, competitiveness and employment in English regions' (1997) set out the new Regional Development Agencies "to promote sustainable economic growth and social and physical regeneration", in effect man's need for jobs, an improved standard of living and community renewal or *social capital.*

A third aspect of sustainable development may be considered the value of the environment or *natural capital*. Natural capitalism seeks to establish new business strategies where the intrinsic value of the earth's resources are measured and accounted for. Amory et al (1999) explain that this is not just about conservation but also about efficient use of resources to improve productivity and competitiveness. In summary this is explained as:

- Dramatically increasing the productivity of natural resources by reducing wasteful practice through improved efficiencies
- A shift towards biologically inspired production models by eliminating the concept of waste as part of the production cycle
- A move towards a solution-based business model whereby a new perception of value is established. Rather than material gain, health and well-being is considered equal (if not more) important
- Re-investing in natural capital through the restoration of the planet's ecosystems
- Implementing whole system design by reviewing the process of production and creating new efficiencies

4.3 The UK perspective

The UK government has identified four priority areas for immediate action, shared across the UK, these are:

- Sustainable consumption and production
- Climate change and energy
- Natural resource protection and environmental enhancement
- Sustainable communities

Creating sustainable communities everywhere is a challenging task. It requires us to integrate the delivery of social, economic and environmental goals, to take a co-ordinated approach to delivering public services that work for everyone, including the most disadvantaged, and to think strategically for the long-term.

At the local level, the Government's Sustainable Communities agenda aims to improve people's lives by delivering better neighbourhoods; cleaner, safer, greener, healthier communities; homes for all; stronger neighbourhood engagement; and will catalyse action on sustainable development in both urban and rural areas in England.

> "*Creating Sustainable Communities means putting sustainable development into practice. Sustainable Communities must combine social inclusion, homes, jobs, services, infrastructure and respect for the environment to create places where people will want to live and work now and in the future". (Rt Hon John Prescott MP, Deputy Prime Minister, February 2005).*

4.4 Key drivers for change

Within the UK sustainability framework there are several initiatives and policies that are currently compelling businesses, developers, communities and local government to think and act in a more sustainable manner. Although obviously integrated to a large degree, these drivers can be summarised within the following themes.

4.4.1 CO_2/climate change

The Stern Report published during 2006 by a former Chief Economist of the World Bank brought home the consequences of climate change and the capabilities of developed countries is now of economic concern. Stern, although openly optimistic in his assessment, used formal economic models and concluded that a lack of co-ordinated action on climate change would be equivalent to *'losing 5% Gross Domestic Product now and forever'*. This impact on economic growth assumes that even moderate levels of climatic warming will have a combined impact on world output, human life and the environment. Stern goes on to argue that the cost of not addressing climate change now will have a direct impact on continued economic prosperity. As a consequence government policies have been influenced into accepting that environmental degradation has a direct consequence for economic well-being in contrast to straightforward economic regeneration. At the company level, evidence of 'climate proofing' can enhance an organisations reputation with its stakeholders. Adaptation can also protect investments, reduce health risks and reduce insurance costs.

Planning Policy Statement 1: Delivering Sustainable Development recommends that *"In preparing development plans, planning authorities should seek to address, on the basis of sound science, the causes and impacts of climate change*." In addition, *"Regional planning bodies and local planning authorities should ensure that development plans contribute to global sustainability by addressing the causes and potential impacts of climate change - through policies which reduce energy use, reduce emissions (for example, by encouraging patterns of development which reduce the need to travel by private car, or reduce the impact of moving freight), promote the development of renewable energy resources, and take climate change impacts into account in the location and design of development."*

4.4.2 Biodiversity

Biodiversity is the variety of life on earth. It includes not only the variety of individual species but also the genetic diversity within species and the range of ecosystems that support them. The UK government has committed to two important international targets to protect biodiversity. In 2001, European Union Heads of State or Government agreed that biodiversity decline should be halted with the aim of reaching this objective by 2010. This was followed in 2002 when Heads of

State at the United Nations World Summit on Sustainable Development committed themselves to achieving a significant reduction by 2010 of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth.

The promotion and development of biodiversity has a key role to play in achieving sustainability. Planning Policy Statement 1: Delivering Sustainable Development states that planning authorities should seek to *"enhance as well as protect biodiversity".* This is further reinforced by Planning Policy Statement 3: Housing, which states that in the design stage proposed developments should *"provide for the retention or re-establishment of the biodiversity within residential environments".*

4.4.3 Housing

A decent, affordable home is a key requirement of a sustainable community. The total number of households in England is expected to increase by nearly 190,000 per year to 2021. Many of them will be single-person households, reflecting wider trends in society such as changing family relationships, longer lives and greater personal wealth. A principal strategy for meeting the housing needs is informed by Policy Planning Statement 3 for Housing which states that planning policy should be used to deliver:

- High quality housing that is well designed and built to a high standard
- A mix of housing, both market and affordable, particularly in terms of tenure and price, to support a wide variety of households in all areas, both urban and rural
- A sufficient quantity of housing taking into account need and demand and seeking to improve choice
- Housing developments in suitable locations, which offer a good range of community facilities and with good access to jobs, key services and infrastructure
- A flexible, responsive supply of land – managed in a way that make efficient and effective use of land, including re-use of previously developed land, where appropriate

Sustainable development has a key role to play in achieving the above objectives and the use of a *"sustainability appraisal is a key means of ensuring housing policies help to deliver sustainable development objectives, in particular, seeking to minimise environmental impact, taking account of climate change and flood risk".*

4.4.4 Rural regeneration

Rural regeneration brings together elements of the UK framework and focuses on tackling social exclusion, economic activity and poverty in rural areas. As a catalyst for rural-focused rural regeneration, Policy Planning Statement 7: Sustainable Development in Local Areas (2204) states:

"Recognising that diversification into non-agricultural activities is vital to the continuing viability of many farm enterprises, local planning authorities should: be supportive of well-conceived farm diversification schemes for business purposes that contribute to sustainable development objectives and help to sustain the agricultural enterprise, and are 16consistent in their scale with their rural location. This applies equally to farm diversification schemes around the fringes of urban areas. In addition where relevant, give favourable consideration to proposals for diversification in Green Belts where the development preserves the openness of the Green Belt and does not conflict with the purposes of including land within it".

Local government may promote rural regeneration in various ways. For example, in Shropshire the Rural Regeneration Zone has identified a number of Activity Themes which describe the focus of the current and future work of the Zone. These include:

Sustainable Business Growth: mainly through funding the two Business Links in the Zone to target rural start-up businesses and those ready to grow

Diverse and High Value Economy: for example, through supporting the creative industries and tourism sectors

Accessible and Responsive Learning and Skills: particularly through investment into training facilities

Improved Connections: for example, through funding Switch on Shropshire

Sustainable Sites and Premises: by investing in industrial and business sites and premises

Sustainable Resource Use: by promoting environmental excellence and investing in the environmental economy, including environmental industries and the land based sector

Sustainable Communities: focusing particularly on the role of Market Towns as social, economic and cultural centres; investing in multi-use community facilities; seeking funding for building the capacity of the voluntary and community sectors; affordable housing; making a stronger link between the Health Sector and the regeneration of the Zone.

Many of the issues facing rural regeneration are related to affordable housing. Planning Policy Statement 3: Housing (2006) complements other planning policy documents with the specific objectives which include: *"to create sustainable, mixed communities in all areas both urban and rural".* In particular the Government now recognises the need to:

- identify and release appropriate land for local economic development and affordable rural housing provision, working in conjunction with local government, parish councils and land owners;
- investigate the potential for increasing the provision of living/work space within rural communities, and
- assess the local implementation of new planning rules on rural housing following the recommendations of the Affordable Rural Housing Commission.

4.4.5 Carbon footprint

The current government target is to reduce CO_2 emissions by 60% by 2050. This should be the minimum that new development achieves, although it should ideally be capable of being carbon neutral. This requires a fundamental change in approach to master planning, especially at a neighbourhood or city scale – typically around 2,000 homes or 5,000 people and a full range of uses.

More Local Authorities are following the London Borough of Merton and seeking to adopt a renewable energy and emissions policy, for example "Delivering Sustainable Energy in North Yorkshire: Planning Guidance" recommends introducing a requirement that all major developments *"incorporate on-site renewable energy".* The need to reduce carbon emissions is directly related to the Kyoto Agreement and has a direct bearing on industry. For example, Tarmac's sustainability policy is to "*proactively manage the impact of our business on the environment, society and the communities in which we operate"* and they are committed to *"developing products and solutions in collaboration with our customers that help to reduce the carbon footprint of the built environment."*

4.4.6 Farm diversification

A recently emerging trend (and some would argue necessity) is the diversification of agri-business related industries or farm diversification. Within rural areas this is seen as a key opportunity to alleviate poverty and eradicate dependency on agricultural subsidies whilst at the same time continuing the husbandry of the landscape. The Government recognise that "*Farm diversification – the use of farm assets for other activities, in particular tourism – is an activity* *which has great potential for contributing to sustainable rural communities, not just to farmer incomes". (*David Milliband, 2006).

DEFRA define farm diversification as *"any activity, excluding mainstream agriculture and external employment by members of the farm family, which makes use of farm assets to generate additional income"* and have prepared a draft Rural Development Programme for England 2007-2013 which states *"diversification can help to broaden the business base of farmers and reduce their reliance on mainstream agricultural production. In England, the opportunities for diversification have led to a high rate of involvement in farm property conversion for business, industrial, tourism or residential purposes."*

4.4.7 Sustainable buildings- construction and design

Greater cost savings and benefit to the environment are possible when sustainability principles are incorporated into new buildings right from the design and construction phase. The definition of sustainability as applied to buildings is not fixed, but 'green' or sustainable buildings are sensitive to:

- the environment - local and global
- resource, water and energy consumption
- the quality of the work environment - impact on occupants
- financial impact - cost-effective from a long-term, full financial cost-return point of view
- long-term energy efficiency over the life of the building

Issues in relation to sustainable buildings are particularly pertinent to this study. How and what sustainable energy technologies are incorporated into a development will depend on the overall scale, from a few houses or buildings to a major development or regeneration project. Implementation that meets the seemingly competing aims of maximising value for money, while achieving environmental and social objectives, will require a diverse range of approaches and technologies. Rural-urban fringe location housing densities are likely to be low. There will be great potential for building integrated renewables due to high solar and wind access. Availability of space and opportunities to provide biomass can generate income which may be an important factor in technology choice. Sustainable energy networks can supply groups of buildings or homes, although lower densities mean that the opportunities are likely to be less than in urban or suburban locations.

A key requirement is to reduce energy demand for discreet groups of dwellings and other uses. Sustainable design at street/block scale must be based on a more detailed analysis of the site and its microclimate. The starting point for this will be incorporating the daily and seasonal movement of the sun, as well as assessing local wind speed and direction.

Within the UK there has been an increase in the energy efficiency of new homes, as a result of the various revisions to the Building Regulations. A study undertaken for the TCPA (2006) indicates the following changes in energy consumption in the UK built environment for a ‘typical’ residential property.

TABLE 4.1: Typical annual energy consumption in the built environment (TCPA, 2006)

	Annual Kwh/m^2		
Type	Space heating	Hot water	Lighting and appliances
Victorian	150	60	40
Typical	110	50	40
02 Building Regs	70	50	35
06 Building Regs	40	45	35

The standard form, location and density in which communities are constructed play a significant role in determining energy demand. Electricity is produced mainly by fossil fuels in large centralised power plants and distributed via national and local grids; this is a system which results in enough energy being wasted each year to power all the buildings in the UK.

There are currently a large number of benchmarks and checklists that can help ensure buildings are energy efficient and contribute towards all aspects of sustainable development. These include the Millennium Communities Standard, Building for Life, SPeAR, AECB standards, EST Energy Efficiency Best Practice in Housing, BREEAM/EcoHomes and the Government’s forthcoming Code for Sustainable Homes.

High levels of insulation in the walls, roofs, floors, doors and windows are paramount in reducing winter heat loss and therefore energy demand. It also helps keep buildings cool during summer, an increasingly important issue as the climate changes. In addition to energy saving, consideration should be given to the materials used. For example, while windows should be at least double-glazed with low emissivity coatings, PVC frames use harmful chemicals in their manufacture and are unlikely to be suited to national parks or conservation areas.

Air-tight construction and ventilation are important. Care must be taken in the construction detailing to avoid thermal bridges where heat can find an easy route through the fabric. The 2006 revision to Part L of the building regulations will require air-tightness and pressure tests. Wherever possible, natural ventilation, such as passive stack ventilation allowing natural movement of air in the building, should be preferred over energy intensive mechanical means. Where this is not possible, mechanical ventilation should include heat recovery to reduce heat loss.

Thermal mass should be exposed internally to absorb solar radiation received during the winter months. During the summer it helps to store cool air absorbed during the night. Summer temperatures are predicted to increase significantly over the next few decades and so thermal mass, cooling and ventilation should be increasingly important considerations.

Glazing is important for solar gain and for allowing light into a building. The greatest heat loss is through windows and so larger areas of glazing should be on the south-facing side of the building. Again, consideration should be given to the potential for overheating now and in the future, and to the suitability of large areas of glazing in design and locational terms. In some cases sun/light pipes may be useful, particularly since a growing number of flats now have no windows in kitchens and bathrooms.

Increasing use of higher efficiency appliances and lighting is reducing energy consumption in buildings. However, it is happening at a slower rate than for space heating and hot water. This is mainly due to the higher insulation levels demanded by the building regulations.

For new buildings, the elemental method of calculating heat loss from each individual part of a building is to be eliminated in favour of a Standard Assessment Procedure (SAP) rating for the building as a whole. In other words, compliance will be based on a more holistic approach based on the energy and carbon performance of the whole building. The revised building regulations for dwellings Part L1 (for dwellings) make air pressure leakage testing mandatory, and by showing where there is unacceptable air leakage, improve compliance. Poor levels of air-tightness in buildings can contribute significantly to heat loss. A key requirement for new dwellings is a minimum overall energy performance standard, in terms of a Target carbon dioxide Emission Rate (TER). Calculating a Dwelling carbon dioxide Emission Rate (DER) for the actual dwelling and ensuring that this is no greater than the TER will be part of the overall requirement to demonstrate compliance.

A further key requirement will be for the performance of the building fabric and the fixed building services to be no worse than specific design limits set out in the approved document. The aim is to reduce heating demand by limiting heat loss through the fabric of the dwelling and place limits on design flexibility to discourage excessive and inappropriate trade-off (for example dwellings with poor insulation levels made to comply by using renewable energy systems).

A range of best practice guidance is available to download from the Energy Saving Trust (www.EST.org.uk).

In keeping with the European Union's Energy Performance of Buildings Directive (EPBD) and our own Government's Energy White Paper further amendments of Part L are likely in 2010 and 2015.

4.4.8 Water usage

Total water usage for the various land use options may be calculated according to the British Water (2005) Code of Practice, loads and flows. For standard residential buildings the volume discharged to sewer per day is 200 litres per person. In order to reduce this it is recommended to use appliances with low water consumption:

- WCs should consume a maximum of 4 litres
- Showers should not deliver more than 8 litres/min
- Installed washing machines should use less than 50 litres per wash
- Dishwashers should use less than 16 litres per wash
- Avoid ‘dead legs’ in piping where possible. Where these do occur, they should not contain more than 1.5 litres of water (a maximum run of 10 m of 15 mm copper pipe). In systems using mains pressure hot and cold water, outlets should be fitted with dynamic flow regulators.

5 ENERGY EFFICIENT AND RENEWABLE ENERGY TECHNOLOGIES

5.1 Background

The use of energy efficient and renewable energy technologies has increased greatly, providing cost-effective alternatives to conventional, fossil fuel-based systems. Governments and various agencies are keen to promote its use and information is readily available on the internet. A very useful source used in this review is the RETScreen International Clean Energy Decision Support Centre (www.RETScreen.net) funded by the Canadian Ministry of Natural Resources.

Clean energy technologies consist of energy efficient and renewable energy technologies (RETs). Both of these reduce the use of energy from “conventional” sources (eg fossil fuels). Clean energy technologies that fall into the energy efficiency category typically include combined heat and power systems, efficient refrigeration technologies, efficient lighting systems, ventilation heat recovery systems, variable speed motors for compressors and ventilation fans, improved insulation, high performance building envelopes and windows.

Normally, project planners should apply cost-effective energy efficiency measures first, and then consider RETs. Typically there are inefficiencies that can be reduced with fairly minimal investments, yielding significant reductions in energy consumption; achieving the same reductions with RETs is often more costly. Furthermore, by reducing the energy that must be supplied by the RETs, the efficiency measure permits a smaller renewable energy system to be used. Since RETs tend to have high initial costs, the investment in efficiency can make RETs more financially attractive.

5.2 Factors for consideration

Renewable energy technologies transform a renewable energy resource into useful heat, cooling, electricity or mechanical energy. A renewable energy resource is one whose use does not affect its future availability. Clean energy technologies are receiving increasing attention from governments, industry, and consumers. This interest reflects a growing awareness of the environmental, economic, and social benefits that these technologies offer.

5.2.1 Environmental reasons

Environmental concern about global warming and local pollution is the primary impetus for many clean energy technologies. This warming trend is generally attributed to increased emission of greenhouse gasses, which slow the escape of heat from the earth.

Rapid changes in climate have the potential to cause massive ecological and human devastation. Impacts include sea level rise and inundation of low-lying areas. Average temperatures will rise and an increase in extreme weather events is anticipated.

There is consensus among scientists that our conventional energy systems are in large part responsible for this environmental problem. Clean energy technologies address this problem by reducing the amount of fossil fuels combusted.

Conventional energy systems pollute on a local scale releasing particulates; sulphur-containing coal causes acid rain. Noise and visual pollution can be significant and fuel spills.

5.2.2 Economic reasons

Much of the recent growth in clean energy technology sales has been driven by the associated low life-cycle costs. Over the long-term, clean energy technologies are often cost-competitive compared to conventional energy technologies.

Also of significant concern is uncertainty associated with conventional energy costs. Several times over the past decade, unforeseen spikes in the price of conventional energy have caused severe financial difficulties for individuals, industry, and utilities. This is of concern to governments, which are held accountable. Conventional energy costs will rise in the coming decades. New oil reserves are declining, while demand is rising. Remaining reserves are concentrated in a few countries. Rising energy prices and the risk of price shocks makes clean energy technologies more attractive.

5.2.3 Social reasons

Clean energy technologies are associated with a number of social benefits. Clean energy technologies generally require more labour per unit of energy produced than conventional energy, creating more jobs. The additional cost of the labour required is offset by the lower cost of energy inputs. Energy efficiency measures maximise the use of existing resources and RETs utilise more dispersed, dilute energy resources as opposed to conventional energy technologies which exploit concentrated energy resources in a capital-intensive manner and constantly new sources of energy.

Fuel imports drain money from the local economy whilst energy efficiency measures and RETs make use of local resources. Transactions tend to be between local organisations and money stays within the local area. For example, compare a biomass combustion system making use of waste woodchips to a boiler fired with imported oil. In the latter case, money goes to oil companies located far from the community. This is certainly of interest to local governments, and a driver for their interest in clean energy technologies.

The International Energy Agency (IEA) has forecast that worldwide energy demand will have tripled by 2050 (IEA, 2003). New technologies and fuels are required to meet this demand.

5.3 Characteristics of clean energy technologies

There are several characteristics of clean energy technologies compared to conventional energy technologies. When used correctly clean energy technology provides energy benefits at an environmental cost far below that of conventional technologies, particularly fossil fuel combustion.

Clean energy technologies tend to have higher initial costs than competing conventional technologies. However it is important to also consider operational and maintenance costs before concluding clean energy technologies are too expensive. Unfortunately in the case of property developers the benefit of installation of clean energy technologies will go to occupier rather than the developer and therefore there is less incentive to include such systems.

Clean energy technologies tend to have lower operating costs than conventional technologies.

5.4 Life cycle costs

The key is to consider all costs over the lifetime of the project. These include:

- Initial costs (feasibility assessment, engineering, development, equipment purchase and installation)
- Annual costs for fuel and operation and maintenance
- Costs for major overhauls or replacement of equipment
- Costs for decommissioning of the project (potential pollution clean-up)
- The costs of funding the project, such as interest charges

5.5 Favourable project conditions

As an initial guide, the conditions indicating good potential for successful clean energy project implementation typically include:

Need for energy system. Proposing an energy system while there is an energy need is a strong favourable pre-requisite to any energy project, and especially so for clean energy projects where awareness barriers are often the main stumbling blocks.

New construction or planned renovation. Outfitting buildings and other facilities with clean energy technologies is often more cost-effective when done as part of an existing construction project. The initial costs of the clean energy technology may be offset by the costs of the equipment or materials it supplants, and early planning can facilitate the integration of the clean energy technology into the rest of the facility.

High conventional energy costs. When the conventional energy options are expensive, the usually higher initial costs of clean energy technologies can be overcome by the lower fuel costs, in comparison with the high conventional energy costs.

Interest by key stakeholders. Seeing a project through to completion can be a protracted, arduous affair involving a number of key stakeholders. If even just one key stakeholder is opposing the project, even the most financially and environmentally attractive projects could be prevented from moving to successful implementation.

Hassle-free approvals process. Development costs are minimised when approvals are possible and easily obtained. Local, regional or national legislation and policy may not be sensitive to the differences between conventional and clean energy technologies, and as such may unfairly disadvantage clean energy technologies.

Easy access to funding and finance. With access to finance, subsidies and grants, the higher initial costs of clean energy technologies need not present a major hurdle.

Adequate local clean energy resources. A plentiful resource (eg wind) will make clean energy technologies much more financially attractive.

In many cases a new quarry integrated with an innovative site afteruse will meet all of the above criteria. Assessing these favourable conditions first could serve as valuable criteria for finding opportunities for clean energy project implementation. As part of an initial filtering or pre-screening process, they could also be used to prioritise clean energy projects, and to select which ones to invest in a pre-feasibility analysis.

Some of the viability factors related to clean energy projects are listed below, with examples for a wind energy project:

- Energy resource available at project site (eg wind speed)
- Equipment performance (eg wind turbine power curve)
- Initial project costs (eg wind turbines, towers, engineering)
- “Base case” credits (ie comparison with alternative conventional system) (eg diesel generators for remote sites)
- On-going and periodic project costs (eg cleaning of wind turbine blades)
- Avoided cost of energy (eg wholesale electricity price)
- Financing (eg debt ratio and term, interest rate)
- Taxes on equipment and income (or savings)

- Environmental characteristics of energy displaced (eg coal, natural gas, oil, large hydro, nuclear)
- Environmental credits and/or subsidies (eg green power rates, GHG credits, grants)
- Decision-maker's definition of cost-effective (eg payback period, IRR, NPV, Energy production costs)

5.6 Sustainable energy technologies

Sustainable energy technologies fall into two distinct categories: *renewable electricity generation* and *renewable heat generation* (**Appendix1**). The main applications of these technologies can be summarised as follows.

5.6.1 Renewable electricity generation

Renewable electricity generation includes: wind energy, photovoltaics, small hydro and biomass combustion power technologies which can be used to provide power to a central grid, an isolated grid or an off-grid load.

Wind energy systems. Wind energy systems convert the kinetic energy of moving air into electricity or mechanical power. They can be used to provide power to central grids or isolated grids, or to serve as a remote power supply or for water pumping. Wind turbines are commercially available in a range of sizes from as small as 50 W to 200 kW. The largest turbines installed on central grids are generally between 1 and 2 MW.

A good wind resource is critical to the success of a commercial wind energy project. The energy available from the wind increases in proportion to the cube of the wind speed, which typically increases with height above the ground. At minimum, the annual average wind speed for a wind energy project should exceed 4 m/s at a height of 10 m above the ground. Certain topographical features tend to accelerate the wind, and wind turbines are often located along these features such as ridge crests.

Wind energy technology is the fastest growing electricity generation technology in the world, where a good wind resource and the central grid intersect, wind energy can be among the lowest cost provider of electricity, similar in cost to natural gas combined-cycle electricity generation.

Small hydro systems. Small hydro systems convert the potential and kinetic energy of moving water into electricity, by using a turbine that drives a generator. Small hydro systems are a reliable and well-understood technology and may be either run-of-river systems or include a water storage reservoir.

Small hydro projects generally have installed capacities of less than 50 MW and they seldom require the construction of a large dam as is the case with large hydro projects. Small hydro projects can be less than 1 kW in capacity for small off-grid applications.

The energy available from a hydro turbine is proportional to the quantity of water passing through the turbine per unit of time (ie the flow), and the vertical difference between the turbine and the surface of the water at the water inlet (ie the head). Since the majority of the cost of a small hydro project stems from up-front expenses in construction and equipment purchase, a hydro project can generate large quantities of electricity with very low operating costs and modest maintenance expenditures for 50 years or longer.

Key advantages that small hydro has over wind, wave and solar power are:

- A high efficiency (70 - 90%), by far the best of all energy technologies.
- A high capacity factor (typically >50%), compared with 10% for solar and 30% for wind

- A high level of predictability, varying with annual rainfall patterns
- Slow rate of change; the output power varies only gradually from day to day (not from minute to minute).
- A good correlation with demand ie output is maximum in winter
- It is a long-lasting and robust technology; systems can readily be engineered to last for 50 years or more.

It is also environmentally benign. Small hydro is in most cases “run-of-river”; in other words any dam or barrage is quite small, usually just a weir, and little or no water is stored. Therefore run-of-river installations do not have the same kinds of adverse effect on the local environment as large-scale hydro projects. Further details including a down-loadable manual are available from the British Hydropower Association (www.british-hydro.org).

Photovoltaic systems. Photovoltaic systems convert energy from the sun directly into electricity. They are composed of photovoltaic cells, usually a thin wafer or strip of semiconductor material, which generates a small current when sunlight strikes them. Multiple cells can be assembled into modules that can be wired in an array of any size; the largest arrays have capacities in excess of 5 MW.

Photovoltaic systems are cost-effective in small off-grid applications. Water pumping is a notable application for domestic water supplies, agriculture and in developing countries. These power systems are relatively simple, modular, and highly reliable due to the lack of moving parts.

Unfortunately, without subsidies, on-grid applications are rarely cost-effective due to the high price of photovoltaic modules, distributed generation is the path for future cost-effective on-grid applications.

5.6.2 Renewable energy heating and cooling technologies

The main applications of renewable heating and cooling technologies include: biomass heating, solar air heating, solar water heating, passive solar heating, and ground-source heat pump technologies.

Biomass heating systems. Biomass heating systems burn organic matter - such as wood chips, agricultural residues or even municipal waste - to generate heat for buildings, whole communities or industrial processes. More sophisticated than conventional woodstoves, they are highly efficient heating systems, achieving near complete combustion of the biomass fuel through control of the fuel and air supply, and often incorporating automatic fuel handling systems.

Biomass heating systems consist of a heating plant, a heat distribution system, and a fuel supply operation. The heating plant typically makes use of multiple heat sources, including a waste heat recovery system, a biomass combustion system, a peak load heating system, and a back-up heating system. The heat distribution system conveys hot water or steam from the heating plant to the loads that may be located within the same building as the heating plant, as in a system for a single institutional or industrial building, or, in the case of a “district heating” system, clusters of buildings located in the vicinity of the heating plant.

Biomass fuels include a wide range of materials (eg wood residues, agricultural residues, municipal solid waste, etc) that vary in their quality and consistency far more than liquid fossil fuels. Because of this, the fuel supply operation for a biomass plant takes on a scale and importance beyond that required for most fossil fuels and it can be considered a “component” of the biomass heating system. Biomass heating systems have higher capital costs than conventional boilers and need diligent operators. Balancing this, they can supply large quantities of heat on demand with very low fuel costs, depending on the provenance of the fuel.

Quinn et al (2004) and Brierley et al (2005) have conducted comprehensive assessments sustainable biomass production and the use of low carbon energy production for the mineral industry. These studies have indicated that restored quarries may provide suitable locations for the growth of energy crops for harvest and combustion. The species employed are fast growing and include willow and poplar grown as short rotation coppice (SRC) and grass species such as *Miscanthus* and switch grass. A plentiful water supply is a primary requirement for high productivity, particularly for SRC. Quarry restoration design would need to be optimised to ensure an adequate water supply and easy access for harvesting machinery.

SRC is the growing of willow and poplar at high densities (in excess of 10,000 ha^{-1}) for rotations of two to five years. The silviculture of SRC involves planting unrooted cuttings of 20-25 cm length, 0.8-1.5 mm diameter at close spacing. After one year the shoots arecut back to produce the stool. Then the stools are harvested on a three year rotation. Yields vary depending on conditions but trials, in the UK and Sweden, have yielded up to 14 odt $ha^{-1}yr^{-1}$

There are two sources of income from the production of SRC: sale of wood and subsidies. Generally output is measured in terms of oven dry tonnes (ODT) which equates approximately to 50% of the fresh weight of material at harvest. Brierley et al (2005) used a figure of £42.50 ODT^{-1} for willow in their assessment which was considered realistic at the time based on data from RMC Ltd. Yields of between 10 and 30 ODT ha^{-1} per 3 year cutting cycle are considered feasible. The logistics of delivering biomass from where it might be grown, on restored quarries, to a power plant is an important consideration.

Based on short rotation willow coppicing, Brierley et al (2005) concluded that, on a purely financial assessment a subsidy is required in order for SRC as a site end use to be competitive with other agricultural end uses. However, increased fuel prices and on-site use may increase the attractiveness of this type of restoration if integrated with other site afteruse options. Updraft gasification systems were found to be the most financially attractive in the range of 0.1 MW-10 MW with an assumed wood price of €3.8 GJ^{-1}. A grate firing system was economically viable within the range of 10 – 20 MW.

Solar air heating systems. Solar air heating systems use solar energy to heat air for building ventilation or industrial processes such as drying. These systems raise the temperature of the outside air by around 5 to 15ºC (41 to 59ºF) on average, and typically supply a portion of the required heat, with the remainder being furnished by conventional heaters.

For example, mounted on an equator-facing building wall, a collector absorbs incident sunshine and warms the layer of air adjacent to it. A fan draws this sun-warmed air through perforations, into the air space behind the collector and then into the ducting within the building. Controls regulate the temperature of the air in the building by adjusting the mix of re-circulated and fresh air or by modulating the output of a conventional heater. These represent an inexpensive, robust and simple system with virtually no maintenance requirements and efficiencies as high as 80%.

Solar air heating has potential in industrial processes, which need large volumes of heated air, such as in the drying of agricultural products.

Solar water heating systems. Solar water heating systems use solar energy to heat water. Depending on the type of solar collector used, the weather conditions and the hot water demand, the temperature of the water heated can vary from tepid to nearly boiling. Most solar systems are meant to furnish 20 to 85% of the annual demand for hot water, the remainder being met by conventional heating sources, which either raise the temperature of the water further or provide hot water when the solar water heating system cannot meet demand (eg at night).

Passive solar heating systems. Passive solar heating is the selective use of solar energy to provide space heating in buildings by using properly oriented, high-performance windows, and selected interior building materials that can store heat from solar gains during the day and release it at night. In so doing, passive solar heating reduces the conventional energy required to heat the building. A building employing passive solar heating maintains a comfortable interior temperature year round and can reduce a building's space heating requirement by 20 to 50%.

Improvements to commercial window technologies have facilitated passive solar heating by reducing the rate of heat escape while still admitting much of the incident solar radiation.

Passive solar heating tends to be very cost-effective for new construction since at this stage many good design practices - orientation, shading, and window upgrades - can be implemented at little or no additional cost compared to conventional design.

Passive solar heating is most cost-effective when the building's heating load is high compared to its cooling load. Cold and moderately cold climates are most promising for passive solar heating design.

Ground-source heat pumps. Ground-source heat pumps provide low temperature heat by extracting it from the ground or a body of water and provide cooling by reversing this process. Their principal application is space heating and cooling, though many also supply domestic hot water.

A ground-source heat pump (GSHP) system has three major components: the earth connection, a heat pump and the heating or cooling distribution system. The earth connection is where heat transfer occurs. One common type of earth connection comprises tubing buried in horizontal trenches or vertical boreholes, or alternatively, submerged in a lake or pond. An antifreeze mixture, water or another heat-transfer fluid is circulated from the heat pump, through the tubing, and back to the heat pump in a “closed loop”. “Open loop” earth connections draw water from a well or a body of water, transfer heat to or from the water, and then return it to the ground (eg a second well) or the body of water.

Since the energy extracted from the ground exceeds the energy used to run the heat pump, GSHP “efficiencies” can exceed 100%, and routinely average 200 to 500% over a season. Due to the stable, moderate temperature of the ground, GSHP systems are more efficient than air-source heat pumps, which exchange heat with the outside air. GSHP systems are also more efficient than conventional heating and air-conditioning technologies, and typically have lower maintenance costs. They require less space, especially when a liquid building loop replaces voluminous air ducts, and, since the tubing is located underground, are not prone to vandalism like conventional rooftop units. Peak electricity consumption during cooling season is lower than with conventional air-conditioning, so utility demand charges may be reduced.

Heat pumps typically range in cooling capacity from 3.5 to 35 kW. A single unit in this range is sufficient for a house or small commercial building. Larger commercial and institutional buildings often employ multiple heat pumps (perhaps one for each zone) attached to a single earth connection. This allows for greater occupant control of the conditions in each zone and facilitates the transfer of heat from zones needing cooling to zones needing heating. The heat pump usually generates hot or cold air to be distributed locally by conventional ducts.

Ventilation heat recovery and efficient refrigeration systems. Heating, cooling and ventilation consume vast amounts of energy, but a number of efficiency measures can reduce their consumption. Simultaneous heating and cooling loads are often within large buildings, such as supermarkets and in industrial complexes. Efficient refrigeration systems can transfer heat from the areas needing cooling to those needing heating. Heat which is normally lost when ventilation air is exhausted from a building can be recuperated and used to preheat the fresh air drawn into the building. Such ventilation heat recovery systems routinely recuperate 50% of the sensible heat.

Variable speed motors. Motors consume much of the world's electricity, around 65% of total industrial electricity consumption in Europe. The rotational speed of a traditional motor is directly related to the frequency of the electric grid. Variable speed drives result from power electronics which analyse the load and generate a signal to optimise the motor at the speed required by the application.

Daylighting and efficient lighting systems. Lighting is another major consumer of electricity that has been made more efficient by new technologies. In commercial buildings, which tend to overheat, more efficient lighting reduces the cooling load, a further energy benefit. Designers are also making better use of daylight to lower artificial lighting energy consumption.

Combined Heat and Power (CHP) technologies. The principle behind combined heat and power (or "cogeneration") is to recover the waste heat generated by the combustion of a fuel in an electricity generation system. This heat is often rejected to the environment, thereby wasting a significant portion of the energy available in the fuel that can otherwise be used for space heating and cooling, water heating, and industrial process heat and cooling loads in the vicinity of the plant. This cogeneration of electricity and heat greatly increases the overall efficiency of the system, anywhere from 25-55% to 60-90%, depending on the equipment used and the application.

Combined heat and power systems can be implemented at nearly any scale, as long as a suitable thermal load is present. Large scale CHP for community and industrial energy systems can have electrical generating capacities of up to 500 MW. Independent energy supplies, for hospitals or small communities, may have capacities of 10 MW. Small-scale CHP systems typically use reciprocating engines to provide heat for smaller loads. It can also make sense to integrate a cooling system into the CHP project.

The electricity generated can be used for loads close to the CHP system, or feeding the electric grid. Heat is not as easily transported as electricity and is normally used for loads located nearby by supplying a local district heating network. This "distributed" energy approach allows for the installation of geographically dispersed generating plants, reducing losses in the transmission of electricity, and providing space and process heating.

A CHP installation comprises four subsystems: the power plant, the heat recovery and distribution system, an optional system for satisfying heating and/or cooling loads and a control system. A wide range of equipment can be used in the power plant, with the sole restriction being that the power equipment rejects heat at a temperature high enough to be useful for the thermal loads at hand. In a CHP system, heat may be recovered and distributed as steam (often required in thermal loads that need high temperature heat, such as industrial processes) or as hot water (conveyed from the plant to low temperature thermal loads in pipes for domestic hot water, or for space heating).

5.6.3 Emerging technologies

Bio fuels (ethanol and bio-diesel). Fermentation of certain agricultural products, such as corn, generates ethanol. Ethanol is used as a transportation fuel that is often blended with conventional gasoline. Similarly, plant and animal oils, such as soybean oil and used cooking grease, can be used as fuel in diesel engines. When crops are purpose-grown for their oils or alcohols, the agricultural practices must be sustainable in order to be considered as a renewable energy fuel.

5.7 Community/district heating schemes

5.7.1 Community energy system

In a community energy system heat, refrigeration or electricity is generated from a central source or sources and distributed via a network (of pipes or private wires for example) to buildings.

Community heating and cooling enables more efficient creation of heat and power from primary energy sources. Heat, usually in the form of hot water produced by a centralised boiler or more commonly combined heat and power (CHP), is distributed to customers via super-insulated underground pipes (Appendix 2).

Community energy systems make use of a biomass heating plant and a district heating system to service clusters of buildings or even an entire community. Such community energy systems can provide space heating, heating of ventilation air, water heating, and process heat. These can be supplied to individual buildings, such as institutional (eg hospitals, schools, sports complexes), commercial (eg offices, warehouses, stores), residential (eg apartments) and industrial buildings. They can also provide heat to individual homes, especially if the houses are newly constructed and in groups. The integration of solar hot water technology from collectors on each house for hot water with the district heating scheme may be used to increase the efficiency of the system.

Private wire networks (PWNs) distribute electricity and can utilise the same generating plant and infrastructure as community heating or cooling. Local supply of power, delivered independently from the national grid, minimises the energy that is lost via distribution, leading to greater energy efficiency and lower CO_2 emissions.

The potential for utilising power and heating networks in new and existing developments is significant; schemes range in size from one building to city-wide links connecting residential, public and commercial buildings. They can be developed relatively swiftly using technologies currently available. Well-configured modern systems can significantly reduce a development's carbon emissions in cost-effective ways. They should therefore be considered as part of a local authority's energy plan as well as being utilised as part of any master planning process.

Community energy and PWNs can make use of a wide range of energy sources, including conventional boilers using traditional fossil fuels, CHP, energy from waste, geothermal, fuel cells and renewable energy (see Section 5 for a description of these technologies). The most efficient and lowest carbon technologies should be prioritised to maximise CO_2 reduction. However, networks are flexible and allow conventional energy technologies to be replaced by renewable sources as fossil fuels become less viable. Community energy and PWNs can also be linked together to provide a greater security of supply. PWNs also allow for export and import of electricity.

For communal heating and cooling networks to be viable in cost and efficiency terms, they need to supply dwellings which have been built to a minimum density of at least 30 dwellings or 100 people per hectare. A quarter of the UK population lives in such densities, while current government planning policy stipulates densities of between 30 and 50 dwellings per hectare for new housing.

At the early stages of a development the fluctuations in demand for energy (that is, the 'demand profile') for heat, cooling and power is unlikely to match supply capacity. This will mean significant initial capital costs with little return. Options include obtaining bridging finance or securing a grant.

The UK government's Community Energy programme (jointly managed by the Energy Saving Trust and the Carbon Trust) offers advice and support for Community Heating schemes across the UK (www.est.org.uk/communityenergy).

5.7.2 Community heating system design

Heat distribution system

The heat distribution system transports heat from the heating plant to the locations where it is required. This may be within the same building as the heat source, in a nearby building or in a cluster of buildings located in the vicinity of the plant in the case of a district heating system. In most systems, a network of insulated piping conveys water at temperatures up to 90ºC (eg for a biomass system) away from the plant and returns the cooled water back to the plant for reheating; in some industrial systems, heat is distributed by steam or thermal oil.

Within a building, heat is typically distributed by baseboard hot water radiators, under-floor or in-floor hot water piping, or hot air ducting. Between buildings, a network of insulated underground piping transports heat. Small distribution networks utilise low cost coils of plastic pipe. In larger networks, a pipe-within-a-pipe arrangement is common: the inner carrier pipe is generally steel, the outer casing is polyethylene, and the cavity between the carrier pipe and the casing is filled with polyurethane foam. Piping is usually buried 60 to 80 cm below ground surface.

A district heating piping distribution system consists of an underground hot water distribution network with supply and return pipelines in a closed circuit. Each building is connected to the network via a building heat transfer station that regulates and measures the energy taken from the distribution system. The network consists of a *main distribution line* which connects several buildings, or clusters of buildings, to the heating plan, and *secondary distribution lines* which connect individual buildings to the main distribution line. The pipe network is usually oversized to allow a future expansion of the system.

In a district heating system, a central plant provides heat to a number of consumers located around the area near the central plant. The consumers will often be grouped in clusters of public, commercial, and residential buildings located within a few hundred meters of each other. District heating systems offer a number of advantages over the use of individual heating plants in each building. A single, large plant will have a level of sophistication, efficiency, and automation that would not be possible in the smaller plants. In addition, individual consumers will not need the equipment or expertise needed to successfully operate their individual biomass combustion system, further encouraging the substitution of biomass over fossil fuels. Additionally, fuel consumption, labour requirements, and emissions will be reduced, waste heat may be used more effectively, and the system will be operated more safely, all because the plant is centralised.

Heat distribution systems can often be expanded to accommodate new loads if the main distribution piping has sufficient capacity. Additional buildings within a reasonable distance can be connected to the system until its capacity is reached. If sufficient space is allocated in the heating plant building, additional burners can be installed at a later date to increase capacity.

Since the initial costs of a district heating system are high, it is cheaper to be integrated into newly constructed areas. A central biomass combustion or ground source heat pump and district heating system requires a higher level of dedication and organisation than simple fossil fuel-fired systems.

Heating load and system sizing

Heating requirements are considered in terms of the peak load requirement (eg the maximum requirement during short periods at low temperatures) and the annual base load requirement (Mwh) which varies on a monthly basis dependent on outside air temperatures.

Calculation of the heating load for a building depends on many complex factors including dimensions, insulation, aspect, window area, ventilation, occupancy, equipment usage, climate and design temperatures. Therefore accurate calculation of heating requirements is generally specific to each building. As building design and insulation improves, internal heat gains become more significant when calculating the overall building heating requirements.

Typical first estimates of peak heating load requirements in the UK for modern buildings are generally 40-50 W/m^2, dependent on the floor area and insulation. These values do not account for any internal gains, eg from lighting and appliances within the building. The RETScreen software allows for more detailed analyses of energy requirements within the 'energy efficiency measures' project analyses.

Approaches to heating system sizing are presented in the table below.

TABLE 5.1: Approaches to heating system sizing (RETScreen, 2005)

BASE LOAD DESIGN	PEAK LOAD DESIGN
Description (Design philosophy)	
Maximise cost-effectiveness by 'undersizing' the central heat plant to handle only the major (or base) portion of the heating load. Use a lower capital cost, smaller fossil fuel system to handle peaks.	Determine the peak (or maximum) heating load, then oversize the system by a contingency factor to ensure that unanticipated extreme loads can be satisfied.
Advantages	
The system is running at or near its full (optimum) capacity most of the time, which will provide highest seasonal efficiency; capital costs significantly reduced; and better system control for efficient performance and lower emissions.	Minimises use of fossil fuel; maximises use of biomass; provides the possibility for increased energy use at marginal cost (if biomass fuel cost is low); and provides a built-in capacity surplus for future load expansion.
Disadvantages	
A conventional system is required for peak heating loads; fossil fuel use will be increased; future load expansion will affect base load; and increased energy use must be supplemented by more expensive conventional fuels.	A larger system greatly increases capital cost (and labour operating costs); with variable loads (as in heating applications), the system must be operated at part load much of the time. This reduces operating efficiency, resulting in an increase in biomass fuel consumption; and when operated at low load, BCSs are prone to higher emissions (smoke) and often unstable combustion.

5.7.3 Case study - Southampton district heating

In response to dramatic rises in oil prices in the 1970s, Southampton embarked on one of the UK's first district heating and cooling schemes. Elements of the scheme include:

- a geothermal aquifer providing 15–20% of the system's heat and a CHP engine supplying the remainder 30,000 MWh of heating and 1,200 MWh of cooling each year
- 4,000 MWh of electricity that is generated from CHP and sold to the national grid each year
- a saving of 11,000 tonnes of CO_2 per annum
- an initial cost of £6 million

The council's private sector partner is Utilicom which financed and developed the scheme. It also owns and operates the scheme under a subsidiary ESCo called Southampton Geothermal Heating Company (SGHC). The cornerstone of this partnership is the joint co-operation agreement between Southampton City Council and Utilicom.

Competitively priced heat supply is guaranteed because costs are linked to national fuel prices. Customers can also choose to have air conditioning provided by chilled water circulated via a seperate chilling mains. Since 1987 the network has expanded and now has over 40 commercial and public sector customers including a hospital, academic and civic buildings, offices, a leisure complex, hotels and a shopping centre, as well as housing.

Electricity from the scheme is sold to the energy supplier Scottish and Southern Energy on a long-term contract. Ideally, SGHC would sell directly to those on the CHP grid but to do this it would need to install a PWN.

The profit-share from the scheme generates £10,000–15,000 of income for the council each year.

Key lessons learnt include:

- Ensure agreements with companies and developers are binding so they cannot avoid their obligations
- Watch out for consultants who know nothing about, and may therefore advise against, community heating
- Emphasise the triple bottom line (reduced costs, reduced emissions and improved relations with the community)
- Use planning powers to put pressure on those submitting planning applications to consider linking up to the district heating system (this may need to be through a Section 106 agreement)
- Get political support

5.8 RETScreen software

The RETScreen International Clean Energy Project Analysis Software is a tool specifically aimed at facilitating pre-feasibility and feasibility analysis of clean energy technologies. The software formed the basis of the case study energy assessments and is available free of charge from www.RETScreen.net.

The core of the tool consists of standardised and integrated project analysis software which can be used worldwide to evaluate the energy production, life cycle costs and greenhouse gas emission reductions for various types of proposed energy efficient and renewable energy technologies.

Each model also includes integrated product, cost and weather databases and a detailed online user manual, all of which help to significantly reduce the time and cost associated with preparing pre-feasibility studies. Project case studies and worked-out solutions are also available from the website. Details relating to this project are presented in ***Appendix 7***.

The RETScreen software has been developed to overcome the barriers to clean energy technology implementation at the preliminary feasibility stage. It provides a proven methodology for comparing conventional and clean energy technologies at a significantly lower cost.

6 SCORTON QUARRY - A LOCAL PERSPECTIVE

In developing the theme of sustainable rural regeneration and alternative technologies for heat and power, Scorton Quarry, Yorkshire provides a useful case study to demonstrate local needs and requirements, which reflect national priorities.

6.1 Site context

Currently owned and managed by Tarmac Ltd, the site is situated in North Yorkshire between the settlements of Brompton on Swale to the east, Scorton to the west and Catterick to the south, see ***Appendix 3***. The site extends to approximately 126 hectares and consists of a mixture of agricultural landscapes and operational mineral extraction. Restoration proposals potentially include the creation of a series of linked waterbodies with an outfall to the River Swale immediately to the south of the site.

The area comprises a sequence of relatively coarse glacial sands and gravels with interbedded clay. The base of the workable mineral is predominantly formed by a thick sequence of clay, the depth of which generally increases south-westwards. The underlying bedrock comprises Triassic Sandstone in the east and interbedded mudstone and Dolomite to the west.

6.1.1 Sustainable resources

The site has a range of sustainable resources including wind, water and direct solar energy. In addition the site may be suitable for the growth of biomass crops such as short rotation willow coppice. An assessment of the site has been undertaken based on climatic data obtained from the Environment Agency, NASA and through the RETScreen data. Water resources have been assessed based on site monitoring data and information from the Environment Agency gauging station at the nearby Catterick Bridge. Further details on the site water balance are presented in Ellis et al (2007).

Hydrology

Scorton Lake lies immediately to the north of the current plant site within a previously worked area. The lake is used within the current water management system, receiving discharge from the silt settlement lagoons and the quarry void. Water is abstracted from the lake via a gravity feed to a freshwater lagoon which supplies water to the mineral processing plant.

A stream discharges into Scorton Lake which originally discharged into the River Swale, but was diverted to permit landfilling to take place within its valley. The total stream catchment area is c 400 ha. (The landfill is operated by North Yorkshire County Council (NYCC)). The lake does not have a natural outlet and NYCC currently regulates its level by pumping to a drainage ditch running to the east of the site access road. The ditch is estimated to be carrying 75-100 l/s. Water levels within Scorton Lake are generally much higher than in the adjacent workings. The hydraulic connection between Scorton Lake and the groundwater system is thought to be restricted due to the presence of low permeability silt on its base. Scope exists to incorporate discharge from the lake within the final restoration design.

Significant volumes of water are flowing through or immediately adjacent to the site as indicated in the table below.

TABLE 6.1: Scorton average water resources

	Flow (l/s)
Direct rainfall	17
North Stream	61
Groundwater	32
River Swale	12,810

There are approximately 5.1 x10^5 litres of water in storage within Scorton Lake. Groundwater and surface water heads fall by some 7 m across the site from 58 mAOD in Scorton Lake to 51 mAOD in the River Swale at the southern extent of the quarry. Water levels are maintained at 58 mAOD by North Yorkshire County Council using two 6” electric submersible pumps and up to three temporary diesel pumps to prevent flooding of the landfill installed in the original valley downstream of the lake. The energy cost of pumping is considerable and required in perpetuity unless some more sustainable method is utilised as discussed in Appendix 4.

6.1.2 Operational energy requirements at the quarry

Using an integrated approach to the design of the quarry it may be possible to incorporate sustainable energy usage during the operational life of the quarry, which may then also serve the final end use. This may be economically attractive, given the potential life span of the quarry (>10 years) is often compatible with a higher capital investment and benefiting from low operating costs. Resulting carbon emission reductions may also be of importance given the significant emissions associated with mineral extraction and onward transpiration.

Energy use data for 2007 has been obtained from Tarmac for the Scorton site and is presented below. This includes fuel used for mobile plant and pumps, plus electricity used in the site offices and mineral processing plant.

TABLE 6.2: Scorton Plant 2007 energy use

Electricity (Mwh)	1379
Diesel fuel (Mwh)	2668
Total production (tonnes)	480,699
Energy use per tonne (Kwh/T)	8.4

At current rates of 10p/Kwh this will be an annual electricity cost of £137,900 amounting to some 2% of the sale price of a tonne of mineral (£15.75/tonne). This may provide a driver for looking at capital investments in sustainable energy projects.

Apart from heating the site offices, power is the primary requirement for the Scorton site. However, other sites may have significant heating requirements as part of additional production processes, eg cement works, and Tarmac coating plants. Many of these require high temperatures, which rules out some sustainable technologies, but may benefit from heat recovery and pre-heating applications or combined heat and power production opportunities.

6.2 Social context

The local social context can be summarised as follows:

- The site falls within the boundary of Richmondshire Local Authority which has a population of 50,082 (2004 estimates)
- Richmondshire is one of the most sparsley populated districts in the country with only 0.36 persons per hectare in a total area of 131,687 hectares
- 51.6% of the Richmondshire population is male, 48.4% female
- 14.6% of households do not have a car or van, 49.2% of households have at least 1 car and 36.1% of households have 2 or more cars
- 20.4% of the districts population is over 60, whilst 38.7% is under 30
- Despite low unemployment (1.1%) some of the areas rural communities are among the 10% most deprived for accessibility to service; for education, six of the wards are in the most deprived 30% with four in the worst 10%. Colburn, Richmond West and Hawes and High Abbotside are in the top 50% most deprived wards in the country

6.3 Economic context

Within Richmondshire the local economic context can be summarised as follows:

- Based on 2007 estimates Richmondshire has an unemployment rate of 1.1%, one of the lowest in the country
- There are 0.9 jobs for every resident of working age in the district
- 26% of the district's population work in public administration and defence whilst only 6.3% work in agriculture, hunting and forestry
- The majority of businesses in the area are small to medium sized enterprises that employ less that 250 people

6.4 Community strategy

Richmondshire's 2021 Sustainable Community Strategy states investment should be used to protect and develop *"the environmental aspects of the District to underpin the rural economy, maintaining the quality of life for residents and enhancing Richmondshire's advantage over competing areas."* The strategy includes the following aims:

- Promoting Richmondshire as an attractive area to locate businesses
- Developing workspace and managed workspace units to encourage the types of employment the district wants
- Improving the quality of the tourism product, building on the area's assets and strengths, and promoting 'green tourism'
- Maximising funding opportunities and delivering regeneration projects throughout the district
- Supporting sustainable land management and suitable diversification to assess the viability of farm businesses
- Attracting beneficial ward investment

6.5 Sustainable energy

In direct response to national objectives, local planning guidance has been prepared to deliver sustainable energy. Delivering Sustainable Energy in North Yorkshire – Recommended Planning Guidance (October 2005) states that *"Addressing energy issues is an essential element of good sustainable design….The energy related measures that should be encouraged as part of sustainable design area listed below:*

- *Reduce the need for energy;*
- *Use energy more efficiently;*
- *Use renewable energy; and*
- *Make clean and efficient use of fossil fuels."*

6.6 Local needs assessment

Given the overall site context, national agenda and local aspirations there are a number of potential opportunities for considering alternative sustainable land use options. These can be summarised using a P.E.S.T analysis framework as follows:

Political. National planning guidance and local community planning seek to target opportunities for sustainable development by supporting quality of life issues and rural regeneratrion. There is political will to enable integrated sustainable solutions and therefore potential for alternative land use options. In particular there is local support for farm business and su

Environmental. The availability of a large land mass and nautral resources is a key strength; in particular local water supply, availability of wind energy and connectivity with the local landscape. There is potential to exploit natural resources as sources of alternative power and enhancing local biodiversity through restoration and strenghthen local landscape character.

Techological/economic. Although locally there are relatively low unemployment levels this is restricted to narrow sectors. There is potential for wider diversifaction of the employment profile and opportunities for encouraging tourism and light/engineering. The available infrastructure also allows for potential

Social. The geographical context of the area has a direct impact on access to services. This, coupled with the availabity of affordable housing has a direct coralation with social depreviation and opportunities for education and employment. There is potential therefore to contribute and tackle social exclusion through the development of appropriate housing and creating new opportunities for local communities.

6.7 Scorton energy assessment

6.7.1 Power generation potential

The RETScreen software was used to assess the energy potential of various resources at the site based on climate data and manufacturers' standard technical data. Given the significant potential for the generation of hydro-electricity indicated by the initial RETScreen assessment, a more in-depth feasibility assessment was undertaken by the specialist engineering consultants Mann Power Ltd (***Appendix 4***). A more wide ranging assessment was also undertaken of the opportunities for hydro-electric generation within an extended radius of the site (***Appendix 5***).

The assessment has been made in terms of separate power and heat generation potential. The potentially available energy resource can then be compared with the energy requirements of the site (1,379 Mwh electricity per annum) and the different end use options discussed in the next chapter. The calculations associated with each assessment are presented **in *Appendix 7***. Full details of the methods used in the software are available at www.RETScreen.net. A summary of the results is presented in the table below.

TABLE 6.3: Annual power generation potential at Scorton

Type	Mwh
Direct solar radiation per 100 m^2	93
Photovoltaic per 100 m^2	13
Wind turbine (Atlantic Orient 50 Kw, 25 m height, 15 m dia)	85
Wind turbine (Siemens 1 Mw, 70 m height, 54 m dia)	1,783

Hydro-electric – North Stream	9
Hydro-electric – River Swale	500-1000

6.7.2 Wind

For an array of 17 of the small (25 m) turbines, and an installation cost of £1000 per Kw, the estimated pre-tax rate of return is 10.8% with a 10-year payback. The rate of return increases to 15.5% if a debt ratio of 70% is assumed at 6% over a 15-year period. RETScreen can be used to perform more detailed financial analyses as increased information becomes available.

6.7.3 Scorton Potential for Hydro-electricity generation on the River Swale at Scorton

In order to assess the potential of the Scorton site measurements of both the changing flow and head over the course of several years were obtained in order to determine the average annual energy capture. Data was available from the Environment Agency's Catterick Bridge flow gauging station on the River Swale, almost adjacent to the quarry.

There are a number of different types of machinery that can be used to generate hydroelectricity, each having advantages and disadvantages for a particular location. All systems have some kind of gearing mechanism that drives a generator, but where they differ is in the method used to convert the power of falling water to mechanical rotation. All machinery will require a trash screen, with a wide bar spacing, to keep out large debris that could be potentially damaging and a failsafe means of stopping the equipment. Typically this consists of an inlet sluice gate that can fall by gravity to stop the flow of water.

Full cost / benefit comparisons have previously been carried out for projects of a similar nature, which clearly identify the Archimedean screw system as likely to provide the best return on the investment. Flow and head duration curves were derived and used to estimate a typical annual energy capture curve, for a range of options. Options 1-3 involve direct use of the electricity at the quarry site and options 4-6 were for sale to theREC. The optimum scheme size was determined by analysing the results for a range of flows, and these are summarised below. Detailed quotations and additional measurements are required to produce more accurate figures, but these estimates should be good enough to make a decision to proceed with further design work. The full assessment is provided in **Appendix 4**.

TABLE 6.4: Hydro-electric summary – Scorton main site on the River Swale*

Option	Peak capacity (Kw)	Installation cost (£)	Net income (£)	CO_2 emission reduction	Rate of return %
1	73	1,300,000	53,200	174	4.1
2	140	1,400,000	78,200	257	5.6
3	265	1,600,000	102,000	344	6.2
4	91	1,300,000	44,000	217	3.4
5	176	1,400,000	65,000	325	4.7
6	329	1,900,000	80,000	432	4.3

* Further details of the assessment are provided in ***Appendix 4***

Option 3 provides the most favourable rate of return, but requires a capital investment of some £1,600,000 which is likely to be a barrier to development. However, the majority of this cost (£1,000,000) is for weir construction within the River Swale. Other sites may potentially have lower costs if an existing weir structure is available.

6.7.4 Electricity connection

The electricity generated from sustainable sources would either be sold into the local supply network or to a local user, which would require connection to a 3-phase supply, together with the appropriate metering system. Connection costs would consist of running a 3-phase cable from the generator to the closest connection point, and installing the necessary metering and safety protection equipment.

For small applications if the maximum output is below 3.7kW per phase then the connection can be made under the G83 standard. This means that you have an automatic right to export power, and it is only necessary to inform the local District Network Operator that you intend to connect an approved generator. The connection costs therefore consist simply of supplying and fitting a suitable cable between the generator and a switchboard. A ROC's meter and export meter will also need to be fitted, so total costs are likely to be around £2,000.

For large installations if there is a local electricity user that can accept the complete output from the system (such as an office block, leisure centre etc) then a better price could be obtained by selling the power directly to this customer. Either way, a connection (G59) will need to be established with the Regional Electricity Company (REC), via a suitable transformer, which in this case is NEDL. The connection costs are likely to be between £15,000 - £100,000, depending on the distance to the nearest connection point and the ability of the local network to absorb the likely output. These costs are likely to include, digging a trench for the electric cable, cost of the cable, load testing by the REC and internal costs by the REC. However, it is worth noting that arranging some of the civil works privately can sometimes reduce this price.

6.7.5 Income

Selling renewable electricity to the REC is complicated, because the price obtained is made up of a number of different elements:

- Actual electricity supplied (5.2p/unit)
- Renewable Obligation Certificate sales (ROC) (4p/unit)
- Climate Change Levy Exemption Certificates (0.43p/unit)

The prices quoted were correct at the time of print and there is no guarantee that they will remain at this level. However, the Renewable Obligation set by the government will run until 2026 and this forces suppliers to supply a proportion of their power from renewable energy. The RECs are currently failing to meet their obligations, increasing the value of ROCs, this has opened a niche in the market. It is not possible to realise the full value of all these prices, as a share goes to the company to whom you sell the electricity, and the brokers negotiating the deals. So a contract for a single combined price is usually agreed and would be expected to yield between 8p/unit and 9p/unit (at the time of print). NB: Micro-generation <50kW will be paid double ROCs 8p/unit.

6.7.6 Operational costs

There will be certain ongoing costs that need to be taken into account: insurance, rates, meter reading charges, machine overhaul and servicing costs.

6.7.7 Grant funding

Grant aid was available for community or non-profit organisations through the Low Carbon Buildings Programme (LCBP). However, this programme is currently closed and is no longer receiving applications for funding. It is anticipated that a new scheme will be launched to replace the LCBP, in the near future. Various other forms of grant aid may be available through local authorities, the local National Park and regional development agencies, as well as from most of the utility companies and other private sector organisations. Two examples of the latter are UnLtd - the Foundation for Social Entrepreneurs - that has now linked up with the Guardian and Guardian Unlimited to offer £5,000 awards to people who come up with green ideas, and the Green Living Awards which will hand out around £100,000 in small grants to encourage people to come up with original ways to tackle environmental problems. The Carbon Trust also offers interest free loans for energy efficiency schemes, which could be applicable to this project if the scheme can be seen as directly reducing the energy consumption of an organisation. Finding Grant Funding is often a matter of application, persistence and form-filling. There are 'Fund-Finder' software packages available and information on the Internet. However, it is worth noting that schemes, which are community, based or offer community benefits, will be eligible to apply for funding from a greater variety of sources.

6.7.8 Heating potential

As indicated above, direct annual horizontal solar radiation at Scorton amounts to some 93 Mwh per 100 m^2 area. This energy may be harnessed through solar air heating for building space heating or for processes such as crop drying. Solar hot water heating is also an efficient technology.

Residential solar hot water

A residential house with 3 occupants, requiring 180 l/d of hot water at 60°C, could typically meet 33% of their hot water energy requirement from a single 2.13 m^2 solar hot water unit. Modern thermal storage systems can allow temperatures as high as 85°C in water and 250°C in phase changing materials such as paraffin wax, allowing the extension of coverage by solar heating.

Open loop ground source heat pumps

Open loop ground source heat pumps may be used to extract heat from groundwater or surface water for use in space heating applications. Typically for a drop in water temperature of 1°C, 4200 Joules of energy are released from each litre of water. Assuming a temperature drop of 5°C and a co-efficient of performance for the heat pump of 4, then a flow of approximately 0.05 l/s is required for 1 Kw of heat energy delivered.

Additional energy costs associated with pumping water around an open loop system may be reduced by the use of gravity flow at the Scorton site. Water may be circulated to a heat pump in either a single large plant room or multiple heat pump units connected to a warm (outward – for heating) and cold (return – for heating) circulation pipe. Heat pump technology may be used for both heating and cooling, and is especially attractive when both operations are undertaken on the same site, allowing increases in efficiency via heat transfer/recovery. It is noted that water from a heating system will be, say, 5°C colder than surrounding ambient conditions and it is necessary to ensure that negative environmental impacts are not incurred. However, as an example based on a 5°C temperature drop, the following heat energy is potentially available from water resources passing through the site.

TABLE 6.5: Annual open loop heating potential (@ 5°C drop)

	Kw	Mwh
Groundwater	648	5,678
Rainfall	340	2,978
North Stream	1,219	10,681
River Swale	256,200	2,244,312

In addition to this there are approximately 2,975Mwh of heat energy in storage within the water of Scorton Lake assuming a 5°C temperature drop (Specific heat capacity of water 4200 j/l/°C).

In practice temperature drops of less than one degree are likely to be acceptable for surface waterbodies.

Closed loop ground source heat pumps

Ample opportunity will exist during site operations and restoration for the installation of horizontal closed loop systems, buried in horizontal trenches 1-2 m in depth or sunk within open waterbodies. Although these systems are less efficient and require significantly greater amount of groundworks than an open loop system, they are more straightforward and not subject to the maintenance and water quality/siltation issues associated with open loop. Also installation costs may be absorbed within earthmoving costs already associated with the restoration. Buried closed loop systems should be installed within saturated sand or gravel or finer grained backfill or potentially silt material. Unsaturated sand and gravel with open void spaces will have a low efficiency (bulk thermal conductivity) for the operation of the ground array.

At the Scorton site the meterage of closed loop pipe is estimated to range from 43 m/Kw in a damp clay to 128 m/Kw for dry sand, per kilowatt of peak heating demand. However, it is noted that this assumes a standard distribution of heating base load requirements over the course of the year.

Biomass Potential

For the production of 1,500 Mwh of heating, sufficient for the proposed leisure or retail destinations, there is an estimated requirement for an annual total of 423 OD tonnes of willow. (RETScreen assumes a heating value for willow of 18.5 MJ/kg). At a rate of £42.50 per tonne this equates to £17,997 per annum (8.3 £/Mwh) compared with a gas price of £92,075 (42 £/Mwh). An area of between 42 -127 Ha (10 and 30 ODT ha^{-1} per 3 year cutting cycle) would be required to produce this. These are example calculations only to illustrate the potential of the site and a more detailed feasibility assessment would be required.

7 LAND USE SCENARIOS

7.1 Introduction

In bringing together the elements of sustainable development and alternative technologies combined with the national and local requirements for sustainability, a number of provisional land use scenarios have been proposed for Scorton Quarry. The purpose of the scenarios is to firstly respond to requirements for economic development, affordable housing and diversification (both locally and nationally) and secondly to consider the relative economic and environmental benefits of using specific alternative sustainable technologies.

Details of the potential land use options are provided in ***Appendix 6*** and include:

Commercial: Light commercial and industrial units with focus on recycling and biofuel technology. Potential outcomes for this scenario include:

- diversification of the local employment opportunities to create new jobs;
- creation of new habitats related to the propagation of bio fuels;
- local recycling stations to reduce environmental impact;
- supply of local sourced energy to nearby settlements;
- self sufficient energy supplies within a localised system;
- educational and environmental interpretation opportunities;
- tourism/promotion of exemplar sustainability initiatives.

Destination leisure: Destination leisure venue consisting of a hotel, conference facilites, fitness centre, swimming pool and indoor sports hall.
Potential outcomes for this scenario include:

- encouraging health living and lifestyle choices;
- facilitation of new social welfare frameworks and community initiatives;
- providing access to leisure services and amenities;
- diversifying the local economy and providing enhance tourism/leisure opportunities;
- creation of new semi skilled jobs and training for young people within leisure sector.

Family leisure: Lakeside family orientated leisure facility with camping/log cabins, associated entertainment area and recreational activities.
Potential outcomes for this scenario include:

- long term solutions for local employment;
- links with wider recreational initative e.g. National Parks;
- using available local workforce to construct buildings;
- income generation for local farming community;
- new tourim/day visitor opportunities;
- creation of new customers for local shops, restaurants and services;
- new markets for local food suppliers.

Residential dwellings: Mixed use housing development in semi rural location within close proximity to existing services and small settlements, consisting of 30% affordable housing and 10% housing for elderly/disabled.
Potential outcomes for this scenario include:

- use of local skilled/semi skilled workforce;
- creation of new jobs and training opportunities in construction;
- meeting local demand for affordable housing;
- reduction in car usage;
- creation of new services for local people through planning gain and good design;

- integrated heating/ power technologies.

Retail: Destination retail garden centre with catering franchise, retail units, outdoor plant sales area with a shop.
Pontential outcomes for this scenario include:

- growing of local provenance plants and nursery stock;
- creation of new employment and training opportunities;
- promotion and sale of locally grown produce;
- supporting and providing an outlet for local craft industries;
- diverisifaction of local employment profile;
- providing a local tourism feature for day visitors.

7.2 Energy load calculations

Sustainable heating technology employed for the different end uses must be sized to ensure that sufficient capacity is available to cope with peak loads and monthly base loads incorporating temperature variations and including seasonal factors (as discussed in Section 5.7.2).

For the purposes of this study, conservative estimates have been made for the scoping calculations based on a peak heating load of 40 W/m^2 for residential and 50 W/m^2 for other uses. Further modelling would be required as part of a more detailed feasibility study, however the estimates are useful in estimating the required energy budget for the proposed end uses and comparing these with the resources available at the site.

RETScreen allows for more detailed analyses of energy requirements within the ‘energy efficiency measures’ project analyses. As an example analyses was undertaken for an affordable rural housing end use assuming heat loss u-values based on the 2006 building regulations.

Commercial and industrial buildings have specific features requiring other considerations than those used for residential buildings. Commercial and industrial buildings typically have much higher internal heat gains, higher gains from occupants, potentially higher solar gains and often more complex occupancy schedules. Given all the potential influences upon commercial/ industrial building energy use, prediction of loads and energy demand is a very site-specific endeavour.

As building design and insulation improves, internal heat gains become more significant when calculating the overall building heating requirements. The sources of internal heat gains are varied including lighting and electrical equipment. These internal gains are representative of the buildings electricity demand and typical values used in the scoping calculations are presented in the table below.

TABLE 7.1: Typical values for internal heat gains (RETScreen, 2005)

Equipment and lighting usage	Equipment heat load (W/m^2)	Lighting heat load (W/m^2)
Light	5	5
Moderate	10	15
Heavy	20	25

7.3 Results

The RETScreen software was used to calculate the energy requirements of the different site afteruses and the results are presented below; details of the model are given in ***Appendix 7***. It is noted that this is for preliminary assessment purposes only and a more detailed feasibility assessment would be required with more specific data on building design and usage.

7.3.1 Residential building

TABLE 7.2: Estimated annual energy demand – residential building 211 m^2, to 2006 Building Regulations

Estimation method	Heat energy (Mwh)		Electricity (Mwh)	Population	Water (l)
	Space heating	Hot water	Lighting and appliances	3	600
RETScreen	10[*1]	3	9		
Estimated from TCPA values	8.4	9.5	7.4		

[*1] Note the internal heat gains have been subtracted from the overall heating requirement

The energy demands are subject to considerable variation dependent on changes in the models input parameters, for example a reduction in the natural air infiltration rate from 114 l/s (medium) to 32 l/s (tight) will reduce the total heating requirement from 22 Mwh/yr (table) to 12 Mwh/yr. Changing the occupancy from 24 hr/d to 16 hr/d will reduce the heating load to 16 Mwh/yr. The estimated floor area for the dwelling is considered generous and the energy requirements are therefore conservative (high).

The RETScreen estimate was equivalent to a heat loss of between 20-40 W/m^2 dependent on whether internal heat gains were included or not. RETScreen was used to calculate the peak heating requirements and monthly base load. For an individual dwelling it was assumed there may potentially be a requirement to warm the house up after a period of non-residence in which case a peak load of 8.4 Kw would be required, not including internal gains. For the purposes of estimating the heating requirements for a large number of houses (200) for a community heating scheme, a lower heating load for the building of 20 W/m^2 might be more appropriate, resulting in a peak load requirement per building of 4.2 Kw. However, to ensure adequate capacity and ignoring internal gains, at a building load of 40 W/m^2 the following results were obtained.

TABLE 7.3: Estimated monthly energy demand – residential building 211 m^2, to 2006 Building Regulations

Month	Average space heating load (Kw)	
	Single house	200 houses
Jan	4	1034
Feb	4	871
Mar	3	681
Apr	3	540
May	2	368
Jun	1	218
Jul	0	83
Aug	1	119
Sep	1	250
Oct	2	410
Nov	3	615
Dec	4	826
Peak load Kw	8.4	1688
Annual Mwh	23	4544

7.3.2 Leisure and commercial site afteruse

Preliminary modelling of building heat requirements indicated significant variability in the predicted heating loads dependent on the model input parameters. Without a detailed design it was decided to assume a building heat load of 50 W/m^2 as a conservative estimate. Loads for lighting and electrical appliances were estimated as 10 and 10 W/m^2 respectively for leisure and retail and 10 and 20 W/m^2 for the industrial unit.

TABLE 7.4: Loads required for leisure and commercial site afteruse

Site use	Floor area	Power	Space heating[*1]		Hot water
	(m^2)	(Mwh/yr)	Peak (Kw)	Mwh/yr	Mwh/yr
1 residential dwelling	211	9	8.4	23	3
200 residential dwellings	42,200	1800	1,688	4,544	600
Hotel – sports/leisure destination	11,297	1,166	565	1,520[*2]	380
100 log cabins and leisure venue	5,841	510	292	765	79
Garden centre and retail	11,622	814	581	1,564	156
Industrial-commercial	2,830	297	142	381	19
Scorton Quarry	-	1,379	-	-	-

[*1] Not including internal heat gains
[*2] Not including swimming pool

7.3.3 Pool heating and aquaculture

The RETScreen software solar water heating function was used to calculate the heating requirements of a swimming pool at a leisure destination. An indoor pool area of 1,020 m^2, at 27°C, covered for 8 h/d with 10% make up water required 1,256 Mwh per year. An area of some 1,020 m^2 of solar collector would be required to meet 45% of this demand, with a significant saving in fuel costs.

Aquaculture ponds may also be simulated using this methodology. By keeping water temperatures at optimum levels fish growth can be enhanced and the growth period to market size reduced.

TABLE 7.5: Water temperatures for aquaculture ponds

Species	Tolerable extremes °C	Optimum growth °C	Growth period to market size (months)
Trout	0 – 31.7	17.2	6 – 8
Salmon (Pacific)	4.4 – 25	15	6 – 12
Freshwater prawns	23.9 – 32.2	28.3 – 30.6	6 - 12

The required heating load will depend on the rate of heat loss from the pond which is controlled by such factors as outside air temperature, evaporation, insulation and enclosure.

7.3.4 Horticulture (greenhouse)

Dependent on the crop, greenhouses may require significant energy consumption for optimum growing temperatures. For certain crops the object may be to maintain frost-free conditions with minimum temperatures of ~7°C during winter and spring. Other situations may require warmer temperatures, eg 13-20°C. Current heating systems in the UK are largely dependent on gas boiler systems circulating with outwards temperatures of 90°C and returning at 70°C. The heating system would require some re-configuration with output temperatures of 35-55°C from a lower temperature system such as a heat pump.

Energy consumption during the winter period will be considerable, estimated as around 220 W/m^2 based on a temperature lift of 25°C, dependent on outside air temperatures and greenhouse construction.

It is estimated that for a large greenhouse in Northeast England of some 32,000 m^3 there will be the following resource requirements.

TABLE 7.6: Resource requirements for large greenhouse, NE England

Gas (heating)	peak (7.9 Mw/hr); 300,000 m^3 per year (3,178 Mw/yr)
Water	60,000 m^3/yr (84 m^2/day)
Electricity (for grow lighting etc)	1 to 1.5 Mw

Heating costs could amount to between £95,000 and £127,000 per year (gas 3 – 4 p per KwH). High energy and high value end uses such as this may prove viable if sufficient sustainable resources are available.

8 CARBON EMISSIONS AND OFF-SETTING

Carbon dioxide (CO_2) is a by-product of human activities, which is considered to have a significant role in determining the global climate. The UK Government has committed to reduce CO_2 emissions by 2010 to 20% below what they were in 1990. Overall, energy saving directly results in a reduction of CO_2 emissions, which in turn has a beneficial effect on global warming.

As part of a holistic approach to quarry operation and restoration the operator may seek to minimise the environmental impacts. CO_2 emissions are a bi-product of this industry and, like many others, quarrying currently relies heavily on fossil fuels. Although there are alternative technologies being developed, market forces slow their integration into consumer life. Today the simplest way of reducing emissions is through carbon off-setting.

Our everyday actions consume energy and produce CO_2 emissions, for example driving a car, heating a home or flying. Off-setting is a way of compensating for the emissions produced with an equivalent CO_2 saving. It refers to acts carried out by individuals or companies that are arranged by commercial or not-for-profit carbon-offset providers. This is different to emissions trading, which is regulated by a more strict and legal framework. However, the Government is working on establishing a voluntary code of best practice for the provision of carbon off-setting to consumers. There is a whole array of methods in which carbon off-setting can be carried out. These include:

- Tree planting
- Energy conservation
- Wind power
- Solar power
- Hydro-electric power
- Biofuel
- Methane collection & combustion
- Geothermal energy

Carbon off-setting involves calculating your emissions and then purchasing ‘credits’ from emission reduction projects. These projects have prevented or removed an equivalent amount of CO_2 elsewhere.

Due to the fact that greenhouse gases have a long-life span and tend to mix evenly in the atmosphere it doesn’t matter where in the world gases are emitted. Although, carbon off-setting will not stop climate change, it should help to lessen the overall net effects and raise awareness of the impact of our own actions. Off-setting can provide a mechanism for investment in clean technology in the areas which lack it most. Such investment can lead to the spread of low-carbon development across entire regions, further reducing climate change impact. The first step should always be to avoid and reduce CO_2 emissions - off-setting should only be used for those emissions, which cannot be avoided.

A study was undertaken (***Appendix 5***) seeking to identify the potential for reducing CO_2 production via the use of hydro-electric power whilst involving the local communities and leaving them not just a wildlife reserve, but a lessened reliance on fossil fuels.

8.1 Carbon emission calculation

The RETScreen Software may be used to calculate the green house gas (GHG) emission profile for a Base Case System (Baseline), and for the Proposed Case System (clean energy project). The difference between the two indicates the potential emission reduction by the use of renewable technologies. Methane and nitrous oxide emissions are converted into their equivalent carbon dioxide emission according to their "global warming potential" (GWP).

For comparison with electricity consumption from the national grid a number of variables must be considered including the fuel mix derived from coal and gas power stations and renewables plus the conversion efficiencies. Transmission and distribution (T&D) losses occur electricity is generated in one place but consumed in another, a certain fraction of the electricity is lost as heat. Modern, industrialised grids tend to have losses of around 8 to 10%. All these factors may be combined to derive a green house gas emission factor. This is estimated to vary from approximately 0.974 t CO_2/Mwh for coal 0.485 t CO_2/Mwh for oil and 0.409 t CO_2/Mwh for gas power stations including a transmission loss of 8%. For the purposes of this project a value of 0.43 t CO_2/Mwh has been assumed for power derived from the national grid.

There are also calculators on-line which allow calculation of an individuals or companies CO_2 footprint (eg www.resurgence.org/carboncalculator).

Site use	Power	Electricity cost [*1]	Carbon Emmissions
	(Mwh/yr)	(£/yr)	(Tonnes/yr)
1 residential dwelling	9	900	12
200 residential dwellings	1,800	180,000	506,400
Hotel – sports/leisure destination	1,166	116,600	1,166
100 log cabins and leisure venue	510	51,000	510
Garden centre and retail	814	81,400	814
Industrial-commercial	297	29,700	297
Scorton Quarry (Electricity)	1,379	137,900	1,379

TABLE 8.1: Summary of electricity costs and CO2 emmsions for the different land uses

8.1.1 Estimating the CO_2 footprint/emissions of Scorton Quarry

According to calculations undertaken by Tarmac (presented in **Appendix 5**) on average the quarry has emitted 1239.3 Tonnes of CO_2 emissions per annum (combined diesel and electricity) between 2004-7. For the purpose of the calculation this figure is assumed to be the peak emission for the quarry over a 20 year period. A gradual increase in emissions is assumed to peak values in year 6 year maintained and then falling rapidly in year 18 as the resource is exhausted and the quarry operations are removed. Therefore, the quarry is estimated to emit a total of 20,820 tonnes over its complete lifetime.

The carbon emissions from the quarry may be considered in other terms. RETScreen was used to equate an annual CO_2 emission of 1239.3 tonnes with the following alternative metrics presented in the table below.

1239.3	Tonnes CO_2 emission annually from quarry
252	Cars and light trucks
1239	People reducing energy use by 20%
426	Hectares of forest-absorbing carbon
417	Tonnes of waste recycled

TABLE 8.2: Annual quarry emmssions equivalent to different metrics

8.1.2 Carbon off setting of quarry emissions.

Carbon emissions from the quarry may be offset by the use of sustainable energy such as wind and hydroelectricity, to replace energy produced by fossil fuels for the national grid. A similar reduction in emissions is likely whether the sustainable energy is produced on site or further a-field and sold to the national grid. There are a number of sites within a 15 mile radius of Scorton Quarry, North Yorkshire, which have the potential for the generation of hydro-electric power. A brief assessment of a limited selection of sites has been provided in order to give an indication of the potential capacity for hydro-electric power generation within this area (**Appendix 5**). From this information the likely CO_2 savings can be calculated. There are five major rivers and countless tributaries within the proximity of the quarry. There are a number of existing weirs on these rivers and tributaries, together with various old mill sites that have potential for generation. A radius of 15 miles was selected around the quarry at Scorton. This area was divided into three zones, with the following diameters: 10, 20 and 30 miles. The concept behind this system was that the potential sites that were closer to the quarry would have a higher importance. In fact, a site in Zone 1 may even be close enough to sell power directly to the quarry.

TABLE 8.1: Hydroelectric generation potential within the vicinity of Scorton quarry

Name	Location	Source	NGR	Zone	Max power (kW)	Outline cost	Outline gross revenue (£)	Energy per year (MWh)	Carbon dioxide saved/yr (tonnes)
Mill House	Brompton-on-Swale	Skeeby Beck	SE 212 999	1	38.8	100,000	11,000	77.0	33.1
Abbey Mill	Easby Abbey	Swale	NZ 183 003	1	0				0.0
Richmond Falls	Richmond	Swale	NZ 173 006	1	394.2	340,000	55,000	581.7	250.2
Aiskew Watermill	Bedale	Bedale Beck	SE 269 881	2	29.4	120,000	15,600	120.0	52.0
Broken Scar	Darlington	Tees	NZ 258 137	2	320.4	520,000	63,000	672.6	289.0
South Park	Darlington	Skerne	NZ 284 128	2	44.8	160,000	10,200	108.6	47.0
Fish Lock Mill	Neasham	Tees	NZ 352 097	2	320.5	1,790,000	70,000	730.3	314.0
Crakehall Watermill	Little Crakehall	Bedale Beck	SE 242 901	2	30.0	46,000	5,700	39.5	17.0
Mickley Mill	Mickley	Ure	SE 251 769	3	476.0	950,000	45,000	1790.0	770.0
Brignall Mill	Barnard Castle	Greta	NZ 046 112	3	47.0	250.000	14,100	105.7	45.0
Orton Wells	Reeth	Arkle Beck	SE 039 997	3	48.0	220,000	11,300	84.7	36.0
Rutherford Bridge	Neasham	Tees	NZ 033 122	3	47.9	175,000	14,000	104.9	45.0

Name	Location	Source	NGR	Zone	Max power (kW)	Outline cost	Outline gross revenue (£)	Energy per year (MWh)	Carbon dioxide saved/yr (tonnes)
Whorlton Falls	Whorlton	Tees	NZ 108 144	3	269.4	1,000,000	51,000	533.4	229.0
Alwent Hall	Winston	Langley Beck	NZ 145 184	3	7.9	38,000	1,200	8.7	4.0
Slenningford Watermill	North Stanley	Ure	SE 280 784	3	204.1	1,000,000	75,000	669.3	288.0
Tanfield Weir	West Tanfield	Ure	SE 275 787	3	204.1	1,000,000	39,000	412.8	177.0

8.1.3 Hydropower potential

Of the sites investigated there is potential for a total of over 2.8 MW maximum installed capacity. Some schemes would require a significant investment and it is often possible to only economically develop a proportion of the maximum capacity. It was not possible to visit all the sites identified, so there is likely to be more potential that that listed in this report. Other sites were very small and would require a large investment to develop and so were discounted from this report. If all of these schemes were developed, they would produce a total of 6,563 MWh of electricity per annum, saving approximately 2,822 tonnes of CO_2 from entering the atmosphere every year (Based on 0.43 tonnes per MWh).

Should a quarry operator be interested in the idea of investing in renewable technology to become carbon-neutral, then there is likely to be plenty of potential in local, small scale hydro schemes. Although, some of the smaller schemes only save small amounts of CO_2 per year, once a hydro scheme is set up, it could be expected to last up to 40 years before if would require a major overhaul. There are many potential sites owned privately or by organisations such as the Environment Agency who currently lack the capital to set up such a hydro scheme. An investment by a quarry operator could make the difference to a large number of schemes, UK-wide.

Any potential hydro scheme would need to be independently verified to prove that it would be off-setting the said CO_2 emissions. It would also be worth making sure that any scheme met the Government's "Voluntary Carbon Standard".

9 CONCLUSIONS

A greater emphasis on the optimisation of water-based restoration design is appropriate given the long-term effects of restoration compared with the relatively short operational life of a quarry and the proven potential for schemes to make a major beneficial contribution to the surrounding area. Conclusions on the overall project objectives are presented below.

There is potential for considering alternative land use solutions in relation to quarry sites and the use of alternative technoologes. However the complexity of sustainability issues needs to be considered and evaluated for a number of factors not just energy consumption. True sustainable development operates at a more complex and interdependent level and the presentation of data within this report provides only an indication how this can be achieved. Land use strategies need to be assessed against national, sub regional and local requirements and this can range from straight forward economic agendas to a mixture of social and environmental demands.

There is therefore a need for a more dynamic assessment or audit framework which encompasses these elements and providing quantifiable measures. For example the provision of new housing can have a positive effect on the local economy and social needs but there may be a detrimental impact on local biodiversity. These types of issues are normally considered as part of the planning process and it is here that perhaps that further evidence is required to support the principle of alternative end uses based on sustainable development. This relates especially to landscape planners, developers, land owners and mineral operators all of whom will need to be convinced of the relative commercial, social and environmental gains of using new solutions.

Overcoming existing planning and development control constraints could also be a potential barrier to determining final landuse options. Although much of planning policy guidance is aspirational it does not necessarly translate to planning control at a more localised level. Consideration needs to be given the mechanics of delivering the vision of sustainability and providing flexibility on a case by case basis.

The RETScreen software provides a free and relatively easy method of undertaking a screening assessment of the application of potential renewable energy technologies to the quarry environment. Subject to an initially favourable assessment more detailed feasibility work can be commissioned if required.

The site power consumption at Scorton was of a similar order of magnitude to many of the site afteruses considered. Therefore energy generation methods installed to support quarry operations would provide a valuable legacy for subsequent users.

The use of renewable heat energy from biomass, solar or ground source heat pumps is of limited use for quarry operations, potentially with the exception of pre-heating (and heat reclamation in the case of heat pumps). However, considerable potential exists to employ an open and closed loop ground source heat pump system to heat any proposed developments at the site, and potentially existing buildings in the surrounding community. Biomass production for use in district heating or within a combined heat and power plant is another potential option.

Sufficient ground source energy is available via an open loop to supply any of the potential site afteruses considered. The site operational electricity requirements could potentially be met through the use of a single large wind turbine or multiple smaller ones. A hydro-electric facility on the Swale could generate some 70% of the site energy requirements.

Barriers exist, such as visual objections and the radar shadow associated with wind turbines, and the significant capital costs and flood issues associated with engineering works in the River Swale. However, as energy costs continue to rise the potential for use of these technologies is worth assessing and reviewing periodically. The wider benefits to the surrounding communities and potential for carbon off-setting should also be considered.

Sustainability is becoming increasingly important to corporate investors, on both a local and global scale. As such the promotion of sustainable operations and end use by quarrying companies will become more imperative. Our research indicates the potential for sustainable energy to contribute financially and environmentally to both the quarry company and the surrounding community during quarry operations and during site afteruse. Rising energy costs and carbon taxes will continue to increase the financial incentives to install renewable energy technology. The international drive to reduce carbon emissions will benefit those enlightened companies that invest in low/zero carbon technologies. Sustainability indicators are likely to become a feature of future planning applications. Consumers are making increasing demands for low CO_2 emissions associated with both production and transport of materials. Many aggregates companies have started some form of CO_2 accounting procedure and off-setting through the implementation of sustainable energy technologies should feed into this.

Barriers still exist to renewable energy and mineral companies may feel that creation of a hydro-electric facility or erection of a wind turbine may raise objections from the Environment Agency or Parish Council, potentially reducing the likelihood of obtaining planning permission. However, it may also be seen as a positive step in promoting sustainable rural regeneration if integrated at inception into the overall site master plan.

The potential for the integration of sustainable technologies within quarry restoration has been recognised. Planners predict that the proposed construction of Eastgate renewable energy village in County Durham has the potential to create 150 jobs on-site and another 200 in spin-off industries (The Northern Echo, p5, 1/2/08). The site is to be developed on a restored quarry operated by Lafarge and will utilise wind, solar, geothermal, hydro-electric and biomass to be fully self-sufficient in energy. The development is planned to promote opportunities for skilled workers in the renewable sector and will include geothermally heated public hot spa, homes, businesses, hotel, visitor centre, education and leisure facilities.

10 FURTHER WORK

The research has highlighted several areas warranting further investigation.

- Exploring barriers to providing new sustainable land use solutions. What currently prevents this and how could they be overcome?
- Challenging planning policy. What changes in planning legislation are required to facilitate rural regeneration associated with quarry sites?
- Investigating methodologies for assessing the potential and appropriateness of quarry/ mineral sites for sustainable rural development.
- Exploring how the quarry industry can positively contribute to national sustainability indicators and/ or carbon emissions through new end uses/ land use options.

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APPENDIX 1

Sustainable Technology Figures

APPENDIX 2

District heating – Energyworx2 Ltd

APPENDIX 3

Scorton Quarry - site context

APPENDIX 4

Site hydro-electricity generation potential – Mann Power Ltd

APPENDIX 5

Carbon offset through local micro-hydropower generation, Mann Power Ltd

APPENDIX 6

Site afteruses

APPENDIX 7

RETScreen model