Implementing Sustainability

Opportunities for sustainable rural regeneration through quarry restoration

By P.A. Ellis[1], N. Healy[2] and C.C. Leake[1]

In the light of recent global agreement and subsequent national policy drivers, there is a need for organizations, institutions and individuals to better understand how planned changes to the environment, such as quarry extraction and restoration, can contribute to the sustainability agenda – in particular, the harmonization and balance of social, environmental and economic needs. Hafren Water have undertaken, through the Minerals Industry Research Organisation (MIRO), research into water-based quarry restoration to examine opportunities for sustainable rural regeneration (www.quarry-restoration.com).

The quarry and minerals industry 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 industrialization 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 realizing new opportunities for sustainable development.

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

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

Why quarries?

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

Quarries and mineral sites present interesting locations for exploring sustainability issues

Planning: The minerals 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 permit 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 of environmental issues, eg landscape, ecology, atmospheric pollution etc. This presents an opportunity to evaluate and test the 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 maximize 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 land use.

Environmental resources: Quarries are often located near watercourses with significant hydroelectricity generation potential. Mineral extraction often results in large water bodies 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 offset the operator's 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 utilize the available energy within the proposed restoration schemes, which often include a 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 the creation of sustainable, affordable rural housing.

Table 1: Loads required for site after-use

Site use	Floor area	Power	Space heating*1		Hot water
	(m²)	(MWh/yr)	Peak (kW)	(MWh/yr)	(MWh/yr)
One residential dwelling	211	9	8.4	23	3
200 residential dwellings	42,200	1,800	1,688	4,544	600
Hotel destination – sport/leisure	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-commerical	2,830	297	142	381	19
Scorton Quarry		1,379			

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

Land-use scenarios

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 were considered for a case study site at Tarmac's Scorton Quarry, in North Yorkshire. The purpose of the scenarios was, first, to 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 included;

Commercial: Light commercial and industrial units with a 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 biofuels
- —local recycling stations to reduce environmental impact
- —supply of locally sourced energy to nearby settlements
- —self-sufficient energy supplies within a localized system
- —educational and environmental interpretation opportunities
- —tourism/promotion of exemplar sustainability initiatives.

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

- —encouraging healthy 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 enhanced tourism/leisure opportunities
- —creation of new semi-skilled jobs and training for young people within the 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 initiatives, eg national parks
- —using available local workforce to construct buildings
- —income generation for local farming community
- —new tourism/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 the 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. Potential 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
- —diversification of local employment profile
- —providing a local tourism feature for day visitors.

Sustainable technology employed for the different end uses was sized to ensure that sufficient capacity was available to cope with peak loads and monthly base loads, incorporating temperature variations and including seasonal factors.

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 site, which may then also serve the final end

Table 2: Scorton plant energy use in 2007

Electricity (MWh)	1,379
Diesel fuel (MWh)	2,668
Total production (tonnes)	480,699
Energy use per tonne (kWh/tonnes)	8.4

use. This may be economically attractive, given the potential lifespan of the quarry (>10 years) is often compatible with a higher capital investment, thus benefiting from low operating costs. Resulting carbon emission reductions may also be of importance given the significant emissions associated with mineral extraction, processing and onward transportation.

Energy use data for Scorton Quarry for 2007 was provided by Tarmac. This includes fuel used for mobile plant and pumps, plus electricity used in the site offices and mineral-processing plant.

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. This may provide a driver for looking at capital investments in sustainable energy projects. For example, with an array of 17 small (25m) wind turbines, and an installation cost of £1,000 per kilowatt, the estimated pre-tax rate of return is 10.8% with a 10-year payback.

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 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.

The RETScreen International Clean Energy Project Analysis Software (www.RETScreen.net) is a free tool specifically aimed at facilitating feasibility analysis of clean energy technologies and was used as the basis of the energy assessments in this study.

In addition to power generation, open-loop ground-source heat pumps may be used to extract heat from groundwater or surface water for use in space-heating applications. Typically, assuming a temperature drop of 5°C, a flow of approximately 0.05 litres/s is required for 1kW of heat energy delivered. Ideally, as is the case at Scorton, gravity flow will reduce pumping costs. The available heating potential for the site by open loop was in the order of 50MW peak capacity. This could supply significant future industrial or commercial requirements or potentially some type of district heating scheme distributed to the surrounding locality.

The site power consumption at Scorton was of a similar order of magnitude to many of the site after-uses considered. Therefore, energy generation methods installed to support quarry operations would provide a valuable legacy for subsequent users. The site's operational electricity requirements could potentially be met through the use of a single large wind turbine or multiple smaller ones. A hydroelectric facility on the river Swale could generate some 70% of the site's energy requirements, although potential installation costs would be in the order of £1 million. Sufficient ground-source energy is available via an open loop to supply any of the potential site after-uses considered.

Barriers do exist, however, 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 the use of these technologies is worth assessing and reviewing periodically. The wider benefits to the surrounding communities and potential for carbon offsetting should also be considered.

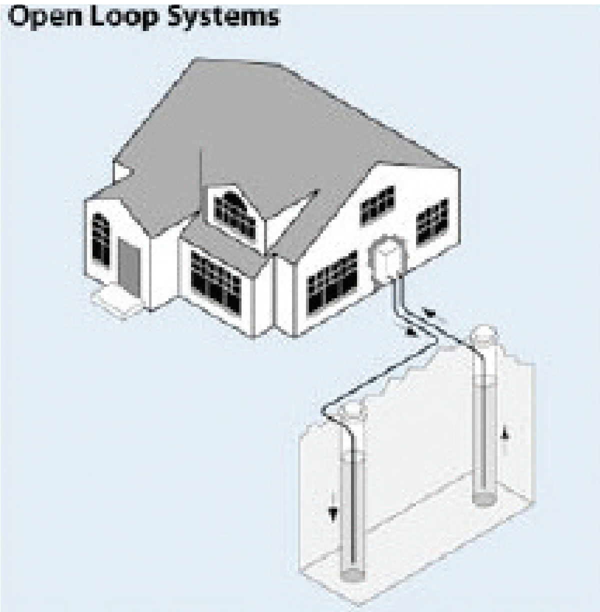
Summary

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. Hafron Water's 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 after-use. 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 ➤

Archimedes Screw: The use of sustainable water resources can add value to the final restoration and benefit the surrounding community

Table 3: Annual power generation potential at Scorton

Type	MWh
Direct solar radiation per $100m^2$	93
Photovoltaic per $100m^2$	13
Wind turbine (50kW, 25m height, 15m diameter)	85
Wind turbine (1MW, 70m height, 54m diameter)	1,783
Hydro-electric – North Stream (mean flow $0.1m^3/s$)	9
Hydro-electric – river Swale (mean flow $12.8m^3/s$)	500-1,000



Open-loop ground-source heat pumps could be used to extract heat from groundwater

indicators are likely to become a feature of future planning applications. Consumers are making increasing demands for low CO_2 emissions associated with both the production and transport of materials. Many aggregates companies have started some form of CO_2 accounting procedure, and offsetting through the implementation of sustainable energy technologies should feed into this.

Barriers still exist to renewable energy and mineral companies may feel that the creation of a hydro-electric facility or the 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 recognized. Planners predict that the proposed construction of the Eastgate renewable-energy village in Co. Durham has the potential to create 150 jobs on site and another 200 in spin-off industries (*The Northern Echo*, p.5, 1 Feb 2008). The site is to be developed on a restored quarry operated by Lafarge and will utilize wind, solar, geothermal, hydroelectric and biomass to be fully self-sufficient in energy. The development is planned to promote opportunities for skilled workers in the renewables sector and will include a geothermally heated public hot spa, homes, businesses, a hotel, a visitor centre, and education and leisure facilities.

Nevertheless, further work remains to be done in reducing barriers to providing new sustainable land-use solutions and exploring how the quarry industry can positively contribute to national sustainability indicators and/or carbon emissions through new end-use/land-use options.

For further information, contact Dr Paul Ellis on tel: (01743) 355770; or email: paul.ellis@hafrenwater.com

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Authors' notes

1. Hafren Water (www.hafrenwater.com)
2. Pleydell Smithyman Ltd (www.pleydellsmithyman.co.uk)