Aggregate Portal Hard Rock Quarry Case Study

Introduction

Hard rock quarrying is an energy intensive industry. Although quarry sites can differ, the main operations are relatively similar with common areas for energy saving opportunities that would be applicable across most sites.

This case study is an introduction to the likely energy saving measures at a hard rock quarry site. The information is an amalgamation of a number of surveys undertaken and reports and guidance produced by the Carbon Trust.

Consider a hard rock quarry site that spends around £600,000 a year on fuel and electricity. The company is looking to reduce energy costs and carbon emissions across its business.

The Site Manager and staff are working together to identify new technologies, processes and behaviours that can be introduced at the site. Unsurprisingly they are particularly interested in low cost options.

The energy saving measures have been grouped, where possible, to follow the quarrying process at a site. Some measures /activities can be applied across a number or all of the activities on a site.

1. Energy Management

The energy team is uncertain exactly how much energy the site uses and how this changes over time. The team has decided to undertake monitoring of fuel and electricity consumption to identify trends, distinguish potential areas of energy reduction, to benchmark themselves against other sites and companies and to demonstrate success over time.

The team has decided to install a number of sub meters across the site to provide a more detailed view of the site activities and energy saving opportunities.

The team has started raising awareness, training and motivating staff in energy management - such as through switch off regimes, efficient use of machinery and vehicles as they have been shown on other sites that this is one of the most important and cost-effective ways to save energy.
Some of their favourite awareness ideas are poster campaigns, energy champions for each team, weekly progress reports and motivational speakers at events.

2. The Quarry Face

2.1 Blasting and Winning Rock

The quarry has employed the same methods for excavating rock since opening. It is looking at other sites that have begun to use Top Hammer drilling as opposed to the Down the Hole (DTH) method for some applications, as the smaller hole diameter and faster drilling rates leads to more efficient drilling, saving up to 50% of the energy consumed.

The research and development team at the site are trialling techniques such as stemming plugs remote controlled blasting and digital imaging to concentrate blasting, improve its effectiveness, optimise output and ultimately reduce crushing required. However the team admits that these are still at the development stage and the costs could outweigh the benefits.

2.2 Water Pumping

Parts of the site are located in low areas prone to the build up of water and flooding. Pumping water to a higher level on the site is required. Large pumps are on continuously to ensure that the rock face is always accessible. Water is often needed at other parts of the site that is taken directly from the mains.

Site engineers initiated a period of pump operation; monitoring and assessing water levels to develop solutions to reduce energy from water pumping as monitoring showed this was a high area of energy consumption at the site.

The engineers found that the pumping operation did not match requirements. Water level rise at the site did not require constant pumping, and could be reduced with adequate control. In some areas more prone to flooding they were able to manually turn pumps off until needed, in other areas they installed level sensors to improve pump control (such as submersible pumps), whilst in areas where water levels were more constant pumps were only used at night to maximise off-peak electricity use.

The assessment identified that pumps were too large for their application, and that the water could be pumped to a lower level and at a lower flow rate. Further energy reductions could be realised by re-sizing pipe-work, adding parallel pipes and excavation for more efficient pipe-work runs.

Engineers are looking at the cost effectiveness of pumping water elsewhere on the site as opposed to purchasing water on the mains.

3. Quarry face to Crusher

3.1 Mobile Plant

Material is currently carried by mobile plant to the primary crusher on the site. Energy data assessment showed that diesel used in the mobile plant formed a significant proportion of total site energy consumption.

A site team has found that in some cases, where there is a suitable haul route, energy and costs could be reduced by replacing some mobile plant with conveyors. The team stressed that a joined up approach to all operations across the site could lead to energy and carbon savings.

Where it is not feasible to replace mobile plant such as earth excavators and dumper trucks, a group of vehicle drivers looked into ways to reduce energy consumption.

They found that driver training led to reduced vehicle idling and fuel savings, they improved the vehicle maintenance regimes (such as tyre pressures), and improved haulage routes for more efficient driving.

They also found that through changes to contracts they were able to influence the behaviour of contractors and their choice of vehicles. The team is also looking at the possibility of replacing the diesel fuel with bio fuel blends.

The team also found that where feasible savings could be realised by locating the primary crusher closer to the quarry face and reducing mobile plant distances.

3.2 Conveyors

Where conveyors are used on the site, they aim to reduce the conveyor distance where feasible. Further actions identified by staff running the conveyors included:

- Improve conveyor operation control with programmable start up and presence sensors.
- Improve motor controls such as variable speed drives (see below).
- Improved plant load management.
- Reduced energy losses through torque adjustment or conversion where possible through the removal of V belts and gearboxes.
- Improved maintenance of the belts and drive system.

3.3 Motors

Motors are used on the site for a variety of applications such as for crushing, pumps, conveyors and fans. Energy monitoring at the quarry has shown that motors are one of the largest consumers of energy on the site. In some cases the annual cost of energy to run a motor can be up to ten times its purchase cost.

Currently there is no inventory of the size, number and application of the use of motors on the site. As a first step site engineers decided to put together a motor management policy to determine management decisions; as motors are most efficient at high loads, monitoring consumption and installing new motors can reduce costs. New motors are also classified by efficiency with higher efficiency motors (HEMs) able to be purchased at similar costs.

Running the correct motor and controls (also known as drives) can lead to significant energy savings. Motors and improvements to their controls need to be understood within the context of the application, load served and the operation pattern.

Variable speed drives (VSDs) are suited to applications with load conditions at continuously variable demand. VSDs can also be useful for constant conveyors and grinders with a fixed output that varies from job to job. The team found from monitoring that installing a VSD to a 30 kW pump could save around £2,000 a year in energy costs.

Other controls include soft starters that reduce the large energy spike when a motor is switched on – but these do not control motor speed in normal operation. Smart motors can reduce energy consumption as they analyse load conditions for themselves, without needing to feed back information to a central control system.

3.4 Compressors

Compressed air is used for power and control for a number of applications within processing on a site.

Monitoring has shown that compressed air is the most expensive utility and around 90% of the energy input is wasted as heat. They have implemented a number measures to reduce the use and improve the efficiency of compressed air at the site.

- They have replaced compressed air in the process where feasible - for example by using suitable electrical actuators or low energy fans.
- Reduced the pressure where high pressure was not required.
- Reduced idling of compressors, which consume 20–70% of their full load power.
- Carried out ultrasonic leak detection surveys and repairs and found that one small leak costs over £500 a year.
- Where possible reduced air intake temperatures, monitoring found that 10% reduction in air inlet temperature improves efficiency by about 3%.
- Installed of Variable Speed Drives on generators with variable loads and fixed duty motors.
- Where feasible, the installation of variable speed drives on idling compressors saved between 20% and 70% of their full load power.
- Recovering and using waste heat was used to compliment heating the office buildings on site.
- The team is currently considering integrating small distribution networks into a more efficient joined up systems approach.

3.5 Crushing and Screening

The quarry currently does not have a crushing operation that matches the delivery of material. A site team looking to reduce energy from crushing found that rationalising the plant operation could eliminate energy waste. The team has estimated that a 10% reduction in secondary crushing electricity consumption can be achieved from a 15% reduction in operating time, based on the same output.

The team also found that stationary crushing opportunities from improved motor controls would reduce energy consumption. And that further opportunities should be investigated for using mobile plant for crushing.

3.6 Distribution

Looking across all their activities it has been calculated that transport accounted for 25% of carbon emissions. Currently 90% aggregate material is transported by road.

Drivers are looking into reducing emissions from distribution from the site. They have realised that training operators, use of articulated trucks, use of lower carbon fuels, optimising delivery routes and, in the longer term, using rail or water as opposed to road transport are potential opportunities to save energy.

They have calculated a possible reduction of around 10-12% of vehicles fuel consumption with the implementation of these opportunities.

3.7 Buildings and Lighting

Energy saving measures for on-site buildings and structures can be overlooked as not directly related to the quarrying process. A range of cost effect opportunities are likely to exist to improve heating systems, fabric, controls, lighting, ventilation and cooling systems within a building.

Lighting around the site is up to 10 years old with limited control and it is noticed that lighting is on for most of the time. Timers and occupancy controls would reduce this lighting load and have a small impact of the site's energy consumption.

3.8 Electricity supply

The electrical engineers are keen to implement savings to lower overall electrical demand. Due to the close proximity of the site transformer to the Plant, along with the fact that many of the newer drives and motors can operate satisfactorily at the European voltage of 380v, then lowering the incoming voltage supply to the optimum voltage for electrical equipment on site will save between 1-3% of the site electricity demand. This involved altering the Site Transformer tap settings to reduce the site voltage from 415v to 380v.

3.9 Low carbon technologies

The energy team is also looking at low carbon and renewable technologies such as wind turbines, and bio diesel fuels to reduce overall energy consumption.

4. Opportunities in the Case Study

Opportunity	Capital Cost	Carbon reduction	Payback
Energy Management and training	£5- 10,000	2-10%	Immediate to 4 yrs
Use of Top Hammer Drill	High capital cost	Up to 50% of drilling	Varies
Blasting – imaging and blast concentration	£5-10,000	1-5% of blasting energy	1-4 years
Water pumping	£<1000	Up to 20% of pumping energy (and 50% of costs if at night)	Quick win
Driver training	£15,000	10% of vehicle fuel emissions	Quick win
Vehicle maintenance	£10,000	1% of site emissions	1-4 yrs
Improve quarry road surface	Medium capital cost	<1%	Varies
Sub-contractor fuel management	Low capital cost	1-4% of site emissions	Quick win
Bio fuel	<£20,000	1%	1-4 years
Use conveyors instead of mobile plant	Medium capital – varies with project	Varies	1-4 yrs
Conveyor improvements – belt and torque adjustment	£12,000	0.5%-1%	1-4yrs
Conveyor controls	£2,000	0.5%	Quick win
Motor controls (VSD, Soft Start)	£20,000	Up to 10% of site electricity	1-4 yrs
Reduced use and losses from compressed air	£2,500	1-2% of site energy	Quick win

Optimise crusher output to reduce operating time	No cost	1-2% of site energy	Quick win
Buildings and lighting	£5,000	<1%	1-4 yrs
Power factor and voltage optimisation	£1,000	1-3% of electricity consumption	Quick win

5. Quick Wins

- Energy management and training
- Driver training and monitoring
- Improve vehicle maintenance
- Manage sub-contractor fuel use
- Motor Control - Survey and install variable speed drives on largest suitable motors (crushing and conveyors)
- Reduce water pumping energy– pump size and controls, height, flow rate, operation times
- Compressed air - reduce use losses, identify and fix leaks and install variable speed drives
- Buildings and lighting around site – ensure sufficient controls
- Electricity control – power factor correction.