IMPROVING THE SUSTAINABILITY PERFORMANCE OF ABANDONED MINE SITE REMEDIATION PROJECTS THROUGH ENERGY USE AND GHG EMISSIONS REDUCTIONS

Tracy Ma, Indian and Northern Affairs Canada, Gatineau, Quebec
Stefan Reinecke, Stratos Inc., Ottawa, Ontario
Michael Nahir, Indian and Northern Affairs Canada, Gatineau, Quebec

ABSTRACT

The Northern Contaminated Sites Program (CSP) for the Northern Affairs Program of department Indian and Northern Affairs Canada is responsible for the management of a number of contaminated properties that originated from private sector mining activities, oil and gas exploration, and government military activity. The CSP is looking to maximize the environmental sustainability of its remediation activities, with a focus on energy use and associated emissions of greenhouse gases (GHGs).

Stratos Inc. was retained to conduct a study to improve the environmental sustainability of Faro and Giant Mine by conducting a greenhouse gas (GHG) and energy assessment of two major remediation projects being undertaken by the Northern Contaminated Sites Program. The two projects, the Giant Mine Remediation project (Giant Mine) and the Faro Mine Closure project (Faro Mine), are two of the largest contaminated sites projects in Canada and potentially present a number of opportunities for sustainable remediation.
The objective of the assessment were to 1) identify opportunities to improve the environmental sustainability of these two projects by reducing energy use and greenhouse gas emissions, and 2) to identify sustainable technologies, such as renewable energy technologies, that could be incorporated into the projects and be successfully implemented in Northern climates.

This paper will provide a high level overview on an approach and methodology for a GHG and Energy Assessment for two major remediation projects. The focus will be on considerations for maximizing the use of suitable energy sources and other sustainable technologies, and presenting management and technical approaches for incorporating GHG and energy reductions in large-scale remediation projects in the North.

INTRODUCTION

Indian and Northern Affairs Canada (INAC) and Stratos Inc. conducted a greenhouse gas (GHG) and energy assessment of two major remediation projects being undertaken by its Northern Contaminated Sites Program. The two projects, the Giant Mine Remediation Project (Giant) and the Faro Mine Closure Project (Faro), involve the remediation two of the largest contaminated sites in Canada. Stratos retained Hatch Ltd. as a subcontractor to provide technical expertise on energy management for this project.

The objectives of the assessment were to identify opportunities to incorporate environmental sustainability, specifically increasing energy efficiency, utilizing renewable and alternative energy sources, which lead to reducing green house gas emissions. To be successful in the context of the Faro and Giant projects, recommended approaches and technologies to reduce energy use and GHG emissions must be implementable (technically and economically) in Northern regions.

Context

As the custodian of most federal lands in the North, INAC has responsibility, through the Northern Contaminated Sites Program (CSP), to manage a number of contaminated properties that are no longer maintained by the original occupant. The contamination at these sites originated from private sector mining activities, oil and gas exploration, and government military activity.

Giant and Faro are unique projects within the INAC contaminated sites program and within the federal contaminated sites inventory due to their nature and size. Most INAC NCSP abandoned mine sites, especially in NWT, are remote sites accessible only by aircraft, barge, or winter road. Giant and Faro are accessible by road, attached to the electrical grid, and located close to populated areas and services (Giant more that Faro). Remediation plans for both sites focus on containment of contaminants rather than contaminant destruction or removal and neither offers a walk-away solution.

The energy-intensive care and maintenance programs and the perpetual water treatment and monitoring aspects of these projects make them ideal candidates for an assessment of opportunities to reduce energy use and GHG emissions. However, due to their uniqueness, learnings from these sites will not all be applicable to many 'typical' contaminated sites across Canada.

Drivers for Sustainable Remediation

The CSP is looking to maximize the environmental sustainability of its remediation activities, with a focus on energy use and associated emissions of greenhouse gases (GHGs). This objective is consistent with the Treasury Board Secretariat of Canada's Policy on Management of Real Property, and with INAC's 2007-2010 Sustainable Development Strategy (SD), which recognizes unique challenges faced by First Nation, Inuit and northern communities in building their capacity to respond to climate change. The strategy has two areas of focus, on internal and one external. The first set of SD commitments address the cornerstones of supporting sustainability at the community level, and the second set of commitments focus on the more subtle operational and behavioural changes required from within the INAC.

It is anticipated that in the long-term petroleum costs will increase due to scarcity and the monetization of carbon emissions associated with regulations and policies (i.e. cap & trade, carbon tax) to address climate change. As a large civil works projects with long-term post-closure treatment components, both the Giant and Faro projects will be affected by long-term trends in energy and carbon costs. Energy and GHG management activities that reduce absolute energy use and/or shift energy use to non-carbon based forms will help control the costs of these projects and protect them from price fluctuations.

Background

Giant Mine

Giant Mine is a former gold mine located within the city of Yellowknife, NWT. It produced more than seven million ounces of gold during its more than 50 years of operation. The processing of gold at Giant Mine created a by-product known as arsenic trioxide. This highly toxic dust is currently stored in 15 underground chambers and stopes at the mine site.

In 2005, the Government of Canada entered into a Cooperation Agreement with the Government of the Northwest Territories (GNWT) to remediate the site. The plan was submitted to the Mackenzie Valley Land and Water Board (MVLWB) and is currently under regulatory review.

The Remediation Plan calls for the long-term storage and maintenance of the 237,000 tonnes of arsenic trioxide dust stored in sealed chambers and stopes underground using the Frozen Block Method. The Remediation Plan also outlines activities to demolish the more than 100 buildings and facilities on the surface of Giant Mine, and to cover the tailings ponds.

It is anticipated that regulatory approval of the remediation plan will take approximately two years. The major construction phase, expected to take about 10 years to complete, will be followed by a verification and monitoring phase of approximately 7-15 years. Monitoring and long-term water treatment are expected to continue into perpetuity.

Faro Mine

In 1969, full-scale mining of the Faro lead-zinc deposit began at the newly developed Faro Mine in the Yukon Territory. In 1988, a second mining area called the Vangorda Plateau was developed. The two deposits Vangorda and Grum went into production in 1990. Mining continued intermittently until 1998 when the last operator declared bankruptcy and sought protection under the Companies' Creditors Arrangement Act. After an assessment of remaining mineral reserves in 2003, governments agreed that the Faro Mine Complex would not reopen and that a permanent long-term closure plan would be needed. A closure plan for the Faro Mine Complex has recently been recommended by the Faro Mine Oversight Committee, made up of senior level representatives from the Government of Canada, Government of Yukon, Selkirk First Nation and Ross River Dena Council.

The recommended closure plan involves a stabilize-in-place approach, including the following measures:

- Upgrading of dams to ensure tailings stay in place during natural events such as earthquakes and floods
- Re-sloping of waste rock to improve long-term stability
- Installing of engineered soil covers over approximately 370 million tonnes of tailings and waste rock;
- Installing state-of-the-art collection and treatment systems for contaminated water
- Upgrading stream diversions

It is anticipated that regulatory approval of the closure plan will take approximately two to three years. The major construction phase, expected to take about 15 years to complete, will be followed by an adaptation phase of approximately 20-25 years in which all on-site elements will be tested, monitored and improved as required. Monitoring and maintenance of engineered soil covers and structures is expected to continue into perpetuity.

ASSESSMENT APPROACH

General Approach

Stratos and INAC conducted a site tour of Giant Mine in January 2009 for independent observation of the energy infrastructure and practices. During this visit, the team received a full briefing on the Remediation Plan, with a focus on energy requirements, and participated in a site tour that included tours of surface and underground workings. An on-site workshop with the Giant project team was also conducted in order to share and validate preliminary assessment findings and opportunities for energy savings and associated GHG emission reductions. Stratos also reviewed site specific documentation provided by the project teams and interviewed project team members.

Energy use estimates were based on:

- electricity and fuel bills for the site in combination with technical/power specifications and fuel consumption measurements for individual pieces of equipment and systems (current use); and
- estimates and specifications in remediation plans.

Interviews were held with INAC staff at program and project level, with the project team, and with project consultants and contractors.

No site visit was conducted at Faro Mine due to the low level of activity at the site during winter months (no water collection or treatment occurs) and minimal site infrastructure due to the nature of the operation. All site information was obtained through correspondence with the Faro project team and their independent consultant.

Additional research, including internet research and personal communication with individuals from external organizations, was conducted to obtain information on sustainable remediation, renewable and sustainable technologies, and resources and incentives to support the energy and GHG management at Faro and Giant.

GHG Inventory

The GHG inventory approach was consistent with the WRI/WBCSD GHG Protocol (World Resources Institute/World Business Council for Sustainable Development). The operational boundary of the GHG inventory was limited to scope 1 emissions (direct emissions from on-site sources) and scope 2 emissions (indirect emissions from purchased electricity. Other indirect (scope 3) emissions, such as those associated with purchased materials (e.g. lime at Faro), were not included. Within these boundaries, the inventory focused on the primary known sources of emissions for each project.

The calculation of GHG emissions for both projects was based on estimates of fuel quantities and electricity consumption, emission factors from Environment Canada sources, and emission intensities based on information on the electricity utilities supplying the Giant and Faro sites. Calculations were conducted using the Mining Association of Canada’s 2008 *Energy Use and GHG Emissions Worksheet* (Microsoft Excel worksheet).

Estimates of cost savings provided in the assessment report (not provided in this paper) were based energy and fuel prices at the time of writing. These estimates are based on ‘rules-of-thumb’ and reasonable estimates of certain parameters (e.g. # of fluorescent bulbs at site, compressed air leakage rate, steam heat efficiency) and are considered to be order-of-magnitude estimates. Detailed quantitative analysis was beyond the scope of this assessment.

ENERGY USE AND GHG EMISSIONS RESULTS – GIANT MINE

Energy Use and GHG Emissions Profile

The assessment addressed the major phases of the project, which include the following: 1) Care & Maintenance 2) Freeze Plant and Underground Work, 3) Surface Remediation and Water Treatment. For the Care & Maintenance phase, the energy use and GHG emissions for Giant were characterized and estimated based on the current site infrastructure. For all phases after Care & Maintenance, the energy use and GHG emissions were estimated with a focus on the major components of energy use. The energy use and GHG emissions profiles are shown in Figure 1 below.

Based on the above profiles and assessment findings, key observations include the following:

- Diesel fuel, used primarily for heating purposes, accounts for close to half of the site's current energy use, and almost three quarters of the site's current GHG emissions
- Electricity use account for over half o the site's current use, however, as the supply mix for the grid is mainly hydro power (95%), electricity use is not a major contributor to GHG emissions

Based on the major components of energy use at Giant, the following key observations were made:

- Mine air heating is currently one of the single largest uses of energy and sources of GHG emissions
- During remediation, heavy equipment will be the major contributor to GHG emissions, together with any existing fossil fuel-based system still in use (e.g. steam boiler for C-Dry).
- Operation of the freeze plant will be the major use of electricity, but will not result in significant GHG emissions based on the current supply mix for the grid.

Opportunities to Reduce Energy Use and GHG Emissions

Based on the assessment findings, a number of opportunities were identified and are presented below separated into the major phases of the project.

Care & Maintenance:

For the care & maintenance phase, a number of opportunities are presented with no or short payback periods separated into two categories of opportunities: 1) opportunities that are ready to implement, 2) opportunities requiring further investigation. The following specific opportunities and recommendations were identified:

Ready to Implement

- Reduce electricity use in underground emergency refuge stations (and other infrequently occupied buildings) by installing timers to limit heating and lighting to periods when work is being performed underground.
- Reduce air leaks in compressed air system by checking for and repairing leaks, using pre-lubricated T-type gasket, and adopting best practices in gasket installation.
- Optimize lighting, inside and outside, by installing timers, photocells, or occupancy sensors.

Opportunities Requiring Further Investigation

- Decommission steam heating for the headframe and hoist room, through interim replacement of steam heating with targeted electric heat, or by accelerating full decommissioning of headframe and hoist room.
- Implement a night and weekend temperature setback for all heated buildings.
- Optimize mine air heating under cold weather conditions – namely modifying alternative methods to avoiding ice formation in C-shaft to avoid excessive propane use.

Freeze Plant and Underground Work:

The project is currently undertaking a freeze optimization study to inform the final design of the frozen block method. After the program is complete and implementation issues have been resolved, there are opportunities to optimize the design and operation of the freeze plant. It is anticipated that the freeze plant will require over 350,000 GJ over its 8 years of operation, therefore the energy requirements will be significant. The following specific opportunities and recommendations were identified:

- A peak demand control strategy to address both the site's and the grid's (city's) peak demand

- The location of the freeze plant relative to other site infrastructure and non-project infrastructure that might benefit from waste heat from the plant
- The use of one large plant vs. multiple smaller plants to minimize energy losses
- Well-scheduled and tracked ventilation and compressed air use as well as controlled peak demand during the work below the arsenic chambers in preparing for freezing.

Aside from the hydro-based power currently supplied through the grid to the site, the use of electricity from other renewable energy sources is likely not economical given the natural attributes of the sites (solar radiation, wind speed, geothermal heat) and the short timescale for active freezing relative to expected pay back periods for a large scale renewable energy investments. It is recommended that the project work closely with the City of Yellowknife and NTPC to achieve the most mutually beneficial and energy efficient design possible.

Surface Remediation and Water Treatment

For the remediation phase, there is an opportunity to optimize the final design of new systems and activities to reduce energy use and GHG emissions. Opportunities to minimize energy consumption and GHG emissions for the surface remediation include the following general best practices:

- Selecting suitably sized and typed equipment
- Minimizing quantities of materials to be excavated and moved by sourcing materials (e.g. gravel) within the property boundary or as close to site as possible and using innovative materials or designs that minimize material requirements
- Optimizing sequencing of activities to minimize hauling distances
- Implementing state of the art operating, fuel, and equipment strategies to reduce emissions from construction equipment, such as those presented the US EPA's report Cleaner Diesels: Low Cost Ways to Reduce Emissions from Construction Equipment
- Using biodiesel, if available, which has a lower carbon footprint than conventional diesel (Currently, biodiesel does not appear to be a viable fuel due to lack of local distributors, cost, and cold weather performance considerations.)

Due to the potentially long-term requirement for water treatment, there is a business case for investing in best available technology and renewable energy infrastructure for these systems. Strategies for reducing energy use and GHG emissions for the water treatment system include minimizing the volume of water requiring treatment, building the pumping system and treatment plant with best available technology, operating these systems as efficiently as possible, and maximizing the use of renewable or low-carbon power sources.

ENERGY USE AND GHG EMISSIONS RESULTS – FARO MINE

The assessment addressed the two major phases of the project, which include the Care & Maintenance and Remediation phases. For the Care & Maintenance phase, the energy use and GHG emissions for Faro were characterized and estimated based on the current site infrastructure. For all phases after Care & Maintenance, the energy use and GHG emissions were estimated with a focus on the major components of energy use. The energy use and GHG emissions profiles are shown in Figure 1 below.

Energy Use and GHG Emissions Profile

The energy use and GHG emissions profile for Faro Mine is shown in Figure 2.

Based on the above profiles and assessment findings, key observations include the following:

- Half of the site's current energy use is in the form of electricity. General electricity requirements for the mine complex (including heating and lighting) represent a baseline electricity demand. There is a seasonal demand for electricity due to the operation of pumping and treatment systems from April to September, with a spike in July and August.
- Currently most (82%) of the site's GHG emissions are associated with diesel fuel for heavy equipment used in care and maintenance activities (C&M), to support engineering activities, and for early reclamation activities.
- Remediation activities, which consist primarily of earth moving by heavy equipment, will result in a significant

increase in diesel fuel requirements and associated GHG emissions.
- There will be an ongoing electricity requirement during remediation for the basic site infrastructure and eventually for a new water collection and treatment system that will continue operation many years after the surface remediation is complete.
- As with Giant, future electricity use will not result in significant GHG emissions assuming the current supply for the grid remains hydro-based. There is currently a surplus of hydro power for the grid, though Yukon Energy is looking to reconfigure its grid to supply hydro-based power to areas served by diesel generators and new industrial users will affect total demand in the future.

Opportunities to Reduce Energy Use and GHG Emissions

Based on the assessment findings, a number of opportunities were identified and are presented below separated into the major phases of the project.

Care & Maintenance:

For the current site infrastructure, two key opportunities requiring some further investigation were identified:

- Implementing night and weekend temperature setback for all heated buildings to reduce electrical energy consumption.
- Switching one of pumping systems that is still run on diesel to electrical power to reduce greenhouse gas emissions.

In comparison with Giant, Faro has more modern infrastructure and fewer energy-consuming systems due to the lack underground infrastructure.

Remediation

Measures to minimize energy consumption and GHG emissions during remediation are similar to those recommended for Giant. Since the scale of surface remediation at Faro is larger, measures to optimize the earth moving activities and equipment could have a significant impact on energy and GHG reductions. By the same token, the lack of viable alternatives to the diesel engine for heavy equipment (hybrid and electric motor are still the early stages of implementation) will limit how much the project can reduce its GHG footprint.

Alternative and potentially more efficient methods of moving granular material at the site, such as using conveyors or slurry pipelines were considered, however, it was concluded that they were neither appropriate for the site nor economical for the project.

APPLICATION OF RENEWABLE AND OTHER SUSTAINABLE TECHNOLOGIES

The greatest potential at both sites for using on-site renewable energy resources is for building heating, for small low-energy equipment, and for long-term systems and installations.

To maximize the use of suitable renewable energy sources and other sustainable technologies, it is recommended that the projects focus on the areas described below.

Renewable Energy Investment for Long-Term Infrastructure

The current and projected energy use at both sites suggests that the use of site-based renewable energy is best suited for long-term/permanent installations, such as water collection and treatment infrastructure. The timescale for these systems and the lead-up time for their implementation provides an opportunity to benefit from evolving market, technological, and regulatory conditions for renewable energy; to conduct more detailed analysis of the feasibility of the various forms of renewable energy; and to consider options with longer payback periods even where the resource's availability is considered marginal.

Heating with Biomass

Biomass in the form of wood pellets is available as a heating fuel for both sites and has been successfully implemented at commercial/institutional facilities in Yellowknife (e.g. YK Community Arena). Burning biomass is considered carbon neutral. Energy performance contractors are available that set up and operating systems on fee basis.

Heating with Passive Solar Methods

Heating and lighting requirements for new buildings (e.g. treatment buildings) can be reduced through buildings design (engineered panels, Trombe walls) and solar water heaters to provide low-temperature heat.

Electricity for Low-Energy Systems

Low-energy systems such as monitoring equipment (small pumps, samplers, data-loggers), especially those located in isolated locations of the site can be powered by batteries that are periodically recharged using small wind turbines or solar panels. For these systems the availability and variability of solar radiation and wind speed or not as limiting as for high-energy systems with more continuous operation and that are more critical to maintain compliance.

Monitoring and Periodically Re-assessing Renewable Potential

Due to their northern location, neither site is naturally endowed with sufficiently high levels of solar, wind, or geothermal energy to economically or reliably power the high-energy systems required during the remediation phase. In terms of hydro power, both sites currently use electricity from the grid from hydro plants located further away, but local water courses flowing through the sites appear to have limited potential for micro-hydro installations due to low flows, the challenges of winter operation, or fisheries considerations.

However, market and regulatory conditions pertaining to renewable and non-renewable energy sources will change significantly over the course of both projects. Most notably petroleum costs will increase, and conditions favouring the implementation of renewable technologies will improve. Therefore, fuel prices, the cost of energy from renewable sources, incentives, and technological advances should be monitored and the feasibility (economic and technical) of using renewable energy for different aspects of the project should be re-evaluated periodically.

Conducting periodic detailed site-specific analyses of renewable energy potential using recognized analysis tools such as RETScreen (NRCan, 2009) focusing on long-term remediation activities and infrastructure could identify future viable options.

MANAGEMENT STEPS TO IMPROVE ENERGY AND GHG PERFORMANCE

A baseline estimate of energy use and GHG emissions for the Faro and Giant projects and an initial list of opportunities to improve energy performance were provided as a basis to begin integrating sustainable technologies and best practices into remediation planning. To sustain these technologies and practices during the execution of these projects, leadership, management system elements and the establishment of a culture that embraces energy and GHG management are needed.

Establish Principles and Goals

A first step is to adopt a set of clear principles or goals for sustainable remediation, and for energy use and GHG emissions management. These goals must be cognizant of the range of challenges and constraints.

Adopt Energy and GHG Management System Elements

Management system elements for achieving reductions in energy use and GHG emissions include: monitoring infrastructure for measurement and tracking of energy and GHGs, establishment of energy and GHG reduction targets, and reporting systems. Senior management commitment and establishing specific roles and responsibilities for energy and GHG management are crucial first steps.

Integrating energy and GHG management into corporate procedures and implementing these through existing planning and reporting tools and procedures, such as annual detailed work plans (DWP), and project and program reports. Technical solutions and on-site management systems that respond to these requirements can be developed by contracted technical experts and other project stakeholders.

Green Procurement and Contracting

Incorporating energy and GHG emissions into the criteria, particularly energy efficiency as a criterion in the procurement for products and services is a key strategy for integrating preferred technologies and best practices into remediation planning and execution.

Community Partnerships and Integration with Community Goals

Ongoing communication with the host community (city or territorial government) and viewing the project's and community's energy assets and use in an integrated way may present additional opportunities for energy use and GHG emission reductions. Examples include sharing waste heat from facilities, managing peak demand, and achieving economies of scale for renewable energy installations. Opportunities can be pursued through formal agreements, including partnership arrangements.

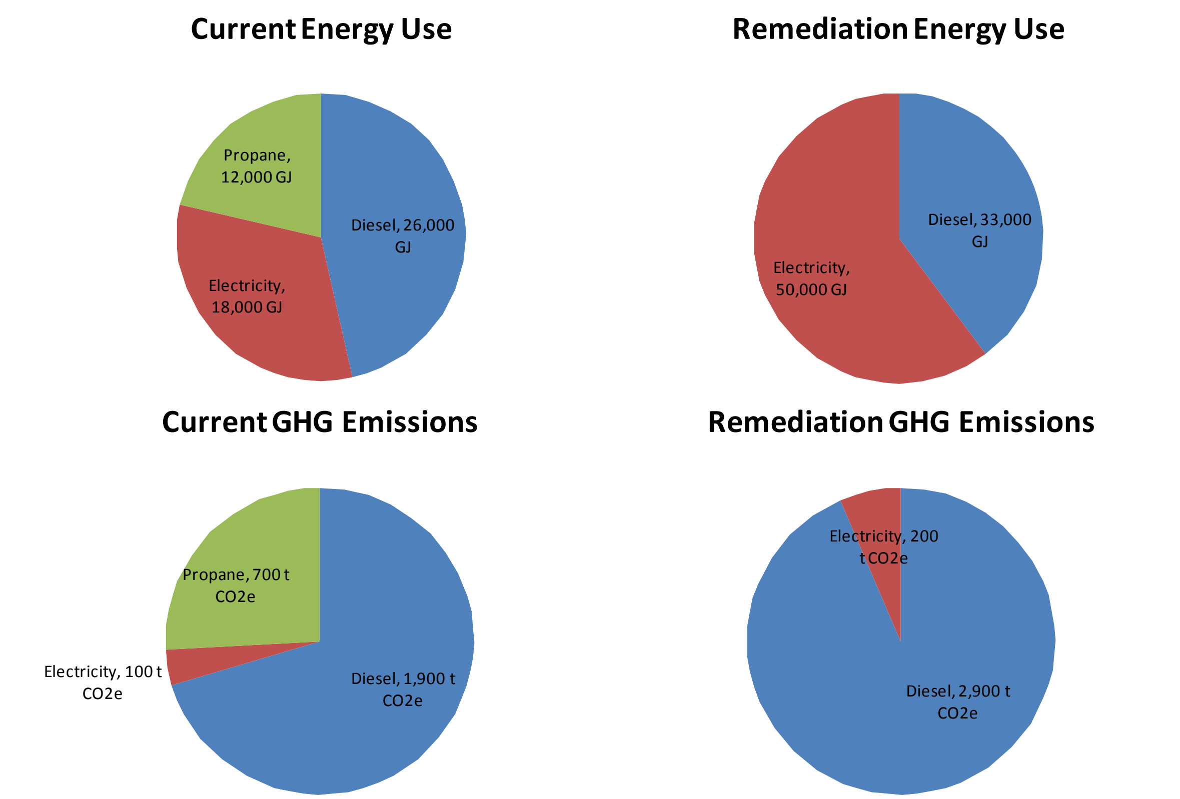
CONCLUSIONS

In this assessment, the current energy use and GHG emissions of the Giant and Faro projects were characterized and estimated. The anticipated energy use during the remediation phase was also estimated, with a focus on the major components of energy use for each project: the operation of the freeze plant and heavy equipment use for surface remediation at Giant, and heavy equipment use for surface remediation at Faro.

Short-term opportunities for reducing energy use and GHG emissions were identified for existing equipment, infrastructure, and practices. Medium- and long-term opportunities were identified for planned activities and systems, involving both existing and new infrastructure and equipment.

The greatest potential currently for incorporating on-site renewable energy resources for both projects is for space heating in buildings, small low-energy equipment (e.g. monitoring stations), and for long-term water treatment and collection systems. However, as market and regulatory conditions pertaining to renewable and non-renewable energy sources change significantly over the course of both projects, fuel prices, the cost of energy from renewable sources, incentives, and technological advances should be monitored and the feasibility (economic and technical) of using renewable energy should be re-evaluated periodically. Renewable energy sources that are currently uneconomic or unfeasible may become viable for future project phases.

Senior management support, setting goals, assigning roles and responsibilities and creating an energy management culture are necessary to initiate and sustain technological and practice improvements that lead to energy use and GHG emission reductions.



Major Components of Energy Use - Current

Diesel	Low-pressure steam heating
	Heavy equipment
Propane	Mine air heating
Electricity*	Mine ventilation
	Mine water collection and treatment
	Compressed air
	Building light and power

* Supply mix from grid: 95% hydro, 5% diesel

Estimated Annual Total

Energy	56,000 GJ
GHG Emissions	2,700 t CO2e

Selected Components of Energy Use - Remediation

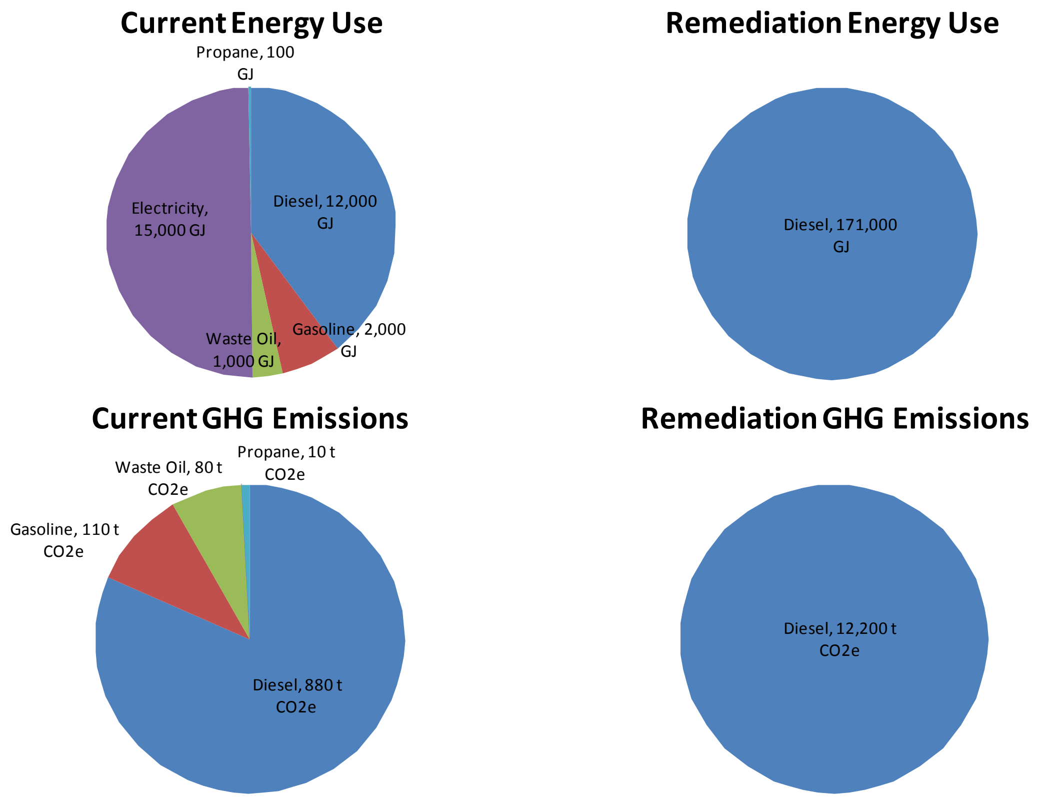
Diesel	Heavy equipment surface remediation
Electricity*	Freeze plant and water treatment

* Supply mix from grid: 95% hydro, 5% diesel

Estimated Annual Total (active remediation phase, ~ 10 years)

Energy	83,000 GJ
GHG Emissions	3,100 t CO2e

Figure 1: Energy Use and GHG Emissions Profile – Giant Mine



Major Components of Energy Use - Current	
Diesel	Heavy Equipment
	Down valley pump
Gasoline	Site vehicles
Propane	Space heating
Waste Oil	Space heating
Electricity*	Water collection and treatment
	Building light and power
	Space heating (office building)

Estimated Annual Total	
Energy	30,100 GJ
GHG Emissions	1,080 t CO2e

Selected Components of Energy Use - Remediation	
Diesel	Heavy equipment for surface remediation
Electricity*	Water treatment *(#s not available at this time)*

* Supply mix from grid: 100% hydro

Estimated Annual Total (active remediation phase, ~ 7 years)	
Energy	171,000 GJ
GHG Emissions	12,200 t CO2e

Figure 2: Annual Energy Use and GHG Emissions Profile – Faro Mine