



BBA

MEADOWBANK GOLD MINE COGENERATION PLANT OPTIMIZATION

CANADIAN CONSULTING ENGINEERING AWARDS – 2016
Natural Resources, Mining, Industry & Energy Category

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Summary

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As energy management is critical to the profitability and sustainability of any remote mine operated off-grid, Agnico Eagle partnered with BBA to optimize its Meadowbank mine cogeneration power plant.

Rather than focus on capital investments, BBA fostered technical expertise and implemented innovative solutions to improve plant reliability and efficiency.

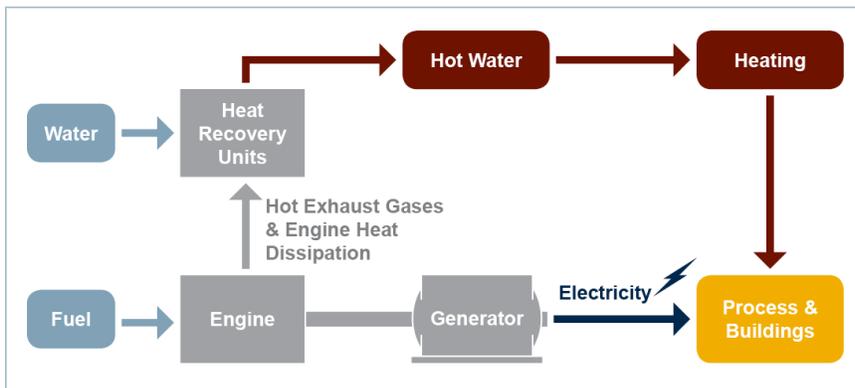
The results speak for themselves: investments under \$400,000, total annual savings of \$2,500,000, a 5,500-ton-per-year drop in greenhouse gas emissions, and higher worker safety and comfort.



The Meadowbank open-pit gold mine in the Nunavut Territory of Canada

Context

Canada is known for its natural resources, which are often found in remote and vulnerable environments. Given the lack of electricity in these locations, especially in the North, certain mines must meet their energy requirements by building and operating their own cogeneration plants, which entails simultaneously producing two types of energy. Cogeneration is an efficient way of using fossil energy by recovering the heat that is usually exhausted into the environment.



Typical cogeneration plant

This stand-alone power plant must be reliable, as all site activities depend on its power. Such a plant must also be efficient, since it consumes a significant amount of fossil fuels. For example, the Meadowbank gold mine's cogeneration plant consumes 4,000 litres of diesel per hour or 35 million dollars per year, which corresponds to the average yearly consumption of 35,000 cars! As energy management is critical to the profitability and sustainability of any remote mine operated off-grid, Agnico Eagle continuously seeks innovative ways to reduce its energy consumption.

The main Meadowbank power plant consists of six 4,400 kW generators and a heat recovery system used to heat mine buildings through a heating network that runs over 3 km and feeds eight multi-use buildings. After its start-up in 2010, plant operators were severely tested. In the first three years of operation, generators suffered major failures, in addition to recurring minor breakdowns. The plant's low reliability caused numerous equipment shutdowns in the ore processing plant, resulting in many hours of production losses every year. On top of that, the heat recovery system was performing poorly, resulting in millions of dollars of additional operating costs and low comfort levels for workers in certain buildings.

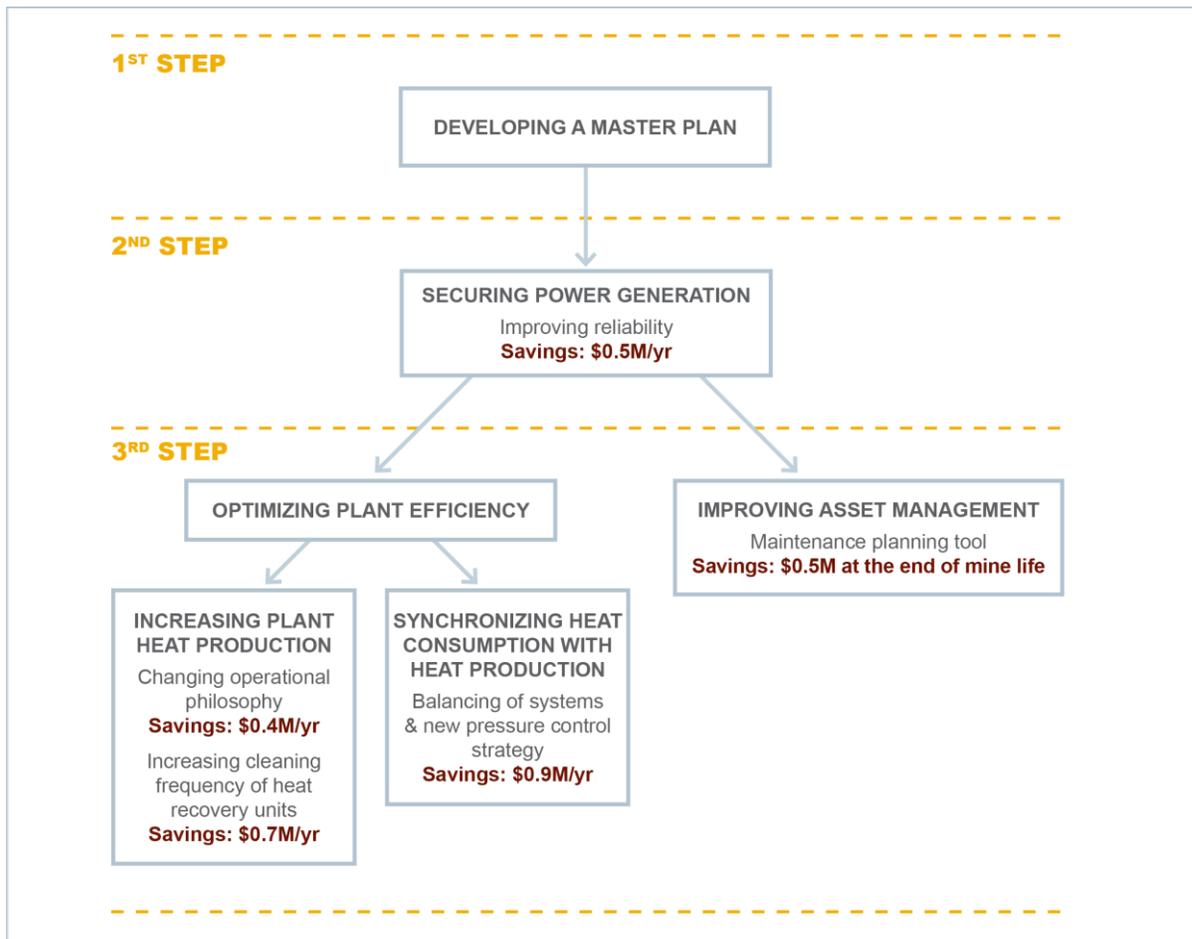
Given BBA's cutting-edge expertise in stand-alone power plants, Agnico Eagle allied with the consulting engineering firm, confident it would come up with innovative, creative and efficient solutions.

Innovation



BBA's mandate was delivered in three major steps, with many phases, over a period of two years:

1. **Developing a master plan** to prioritize critical activities and plan future actions. This was the cornerstone of all subsequent steps.
2. **Securing power generation**, making plant assets more reliable. The completion of this important milestone allowed for a major gain in the cogeneration plant's stability, thus making Agnico Eagle more confident in its installation and providing the ability to balance risk management with plant efficiency.
3. **Optimizing plant efficiency** in two phases:
 - Increasing cogeneration plant heat production through recovery
 - Synchronizing heat consumption with heat production



BBA's mandate resulted in a total recurrent savings of \$2.5 million/year and a \$0.5 million savings at the end of mine life

Given the difficult economic context and minimal investments requirement by the client, BBA focused on optimizing existing equipment, rather than modifying or adding equipment.

Innovation

BBA's innovation and overall vision was reflected in its methodical approach and ability to offer simple and efficient solutions to complex problems, resulting in significant cost savings. The following innovative solutions are the most striking in their simplicity, efficiency and generated savings:

Changing operational philosophy

Typically, stand-alone power plants, including the Meadowbank plant, are operated conservatively (i.e., lower capacity) in case of sudden generator shutdown. Given the state of the Meadowbank plant, this was an appropriate strategy in preventing plant production losses, but it impaired overall efficiency, maintenance costs and fuel consumption.

To improve electrical efficiency and heat production through recovery, BBA implemented an entirely new and innovative plant operational philosophy, allowing generators to operate at higher capacity with greater efficiency. As a result, gains in plant efficiency and maintenance outweighed anticipated production loss expenses.

To apply this philosophy to daily operations, BBA developed a simple-to-use operating matrix, which relies on an in-house simulation software based on:

- thermal and electrical loads
- cogeneration efficiency
- failure probability and associated mill production losses

Operating the plant using the new matrix helped recover a significant amount of high-quality heat and provides savings of \$400,000 in diesel per year.

Improving asset management

At Meadowbank, using typical generator maintenance planning would have resulted in completing all major maintenance sessions prior to mine shutdown, at which point, the generators would have been like new!

A unique planning tool was created jointly with the plant's supervisory personnel to prioritize the operation of four generators, thus preventing the two others from reaching their planned major maintenance before the end of mine life, which will save \$500,000.



Inside view of Meadowbank cogeneration plant

Complexity

Complexity

Throughout the various project phases, from the master plan to final optimization, BBA surmounted many complex challenges with solutions, such as:

Improving reliability

Due to recurring generator failures, the top priority was to solve generator reliability issues. These are just a few of the problems encountered and fixed:

- Broken engine crankshafts
- Sticking and braking of intake and exhaust valves
- Cracked cylinder heads
- Low fuel injector service life

All reoccurring failures, that started many years before, required substantial data analysis, which involved experts from various fields. BBA managed the team work among experts, operators, mechanics and suppliers, and the sources of failures were located and solved. Shutdown time for the ore processing plant went from 15 to under 2 hours per year, leading to more than \$500,000 in additional gold production at the process plant.



Broken intake and exhaust valves



Workers replacing broken engine crankshaft

Synchronizing heat consumption with heat production

Complexity

The buildings' heating system was synchronized with the recovered heat, further increasing heat production efficiency of the cogeneration plant through heat recovery. This integration was no small feat considering the complexity of the heating system that runs over 3 km and feeds 8 multi-use buildings. BBA implemented corrective measures for efficient synchronization, including:

- Programming a new system pressure control strategy
- Balancing 310 heating systems

The average recovered heat increased by over 50%, replacing the need for auxiliary electric heating and resulting in an additional savings in diesel costs of \$900,000 per year.



Meadowbank heating system runs over 3 km and feeds 8 multi-use buildings

- | | |
|-------------------------|------------------------|
| 1. Laboratory | 5. Indoor storage area |
| 2. Process plant | 6. Gymnasium |
| 3. Power plant | 7. Maintenance shop |
| 4. Workers camp complex | 8. Crusher |

Social and/or economic benefits

Social and/or economic benefits

Improving health and safety

Typically, heat recovery units for exhaust gases are cleaned using a rotating brush. At Meadowbank, employees wore a full ventilation mask when cleaning the units, which lasted an entire day and produced hazardous dust throughout the plant.

After testing various cleaning methods, BBA found a new approach that is simple, powerful, and above all, safe. Employees now clean the equipment by spraying pipes with low-pressure water, while wearing their regular work clothes.

The method takes only a few hours. Knowing that this equipment is critical for heat recovery and quickly gets dirty, plans were developed to clean it two to three times a month rather than once a year. This significantly increased heat recovery— a measured savings of \$700,000 per year in diesel costs.

Increasing worker comfort

Gymnasiums in remote mine housing complexes are vital as they provide employees in isolated areas with a meeting place for social activities. The one at Meadowbank was uncomfortable because of a poorly designed heat recovery system. Following modifications, the temperature in the gymnasium increased from 11°C to 16°C. Workers also greatly appreciated the temperature increase in the indoor storage area.



Camp recreational facilities (gym)



Job creation in local community

Economic benefits

Given operating costs that have a significant impact on the survival of remote mines as well as the creation of related jobs, along with community benefits, cogeneration plants must be optimal. One of the biggest attractions of this project is that it can be reproduced at other cogeneration plants and requires little investment.

Environmental benefits



Diesel savings and lower emissions

The planet's arctic regions are and will be the most affected by global warming. Changes are already being felt. It is admirable that Agnico Eagle is proactive in reducing its greenhouse gas emissions.

The optimization project for the cogeneration plant generated an annual reduction of 2 million litres of diesel per year and lowered greenhouse gas emissions by 5,500 tons a year. This is equivalent to removing 2,000 cars from our roads annually!

Reduction in annual diesel delivery

Given its remote and isolated location, delivery of materials to the Meadowbank site is a huge undertaking. Usually, material is delivered by boat to Nunavut, and then transferred to barges to Baker Lake. After that, materials are transferred again by truck and driven over 100 km on a remote road to the mine. In an emergency, materials can be delivered by plane. This energy-consuming supply chain comes with its own environmental risks.



Trucking to Meadowbank

Given the reduction in major works and the slight maintenance incurred by this optimization project, fewer pieces of equipment will need to be delivered to the site, which in turn will reduce the yearly supply volume and, at the same time, lower the number of trucks on the road and the resulting environmental footprint. But above all, it's most certainly the savings of 2 million litres in diesel that won't need to go through the road system, lowering inherent environmental risks.



Caribou near Meadowbank Gold Mine

Meeting client's needs

Meeting
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The cornerstone of this optimization project was the production of a clear master plan that identified objectives, the stages in which to attain these objectives as well as priorities. The following objectives from the master plan were delivered successfully and went above and beyond client expectations:

- 1. Secure the plant's power generation:** The shutdown time for the ore processing plant went from 15 to less than 2 hours per year, and the client now has more confidence in the power plant.
- 2. Increase heat recovery from generating sets:** The average heat recovery increased by more than 50%, from 5.3 to 8.3 MW.
- 3. Reduce the plant's diesel consumption:** The plant now consumes 2 million fewer litres per year than planned.
- 4. Limit required investments:** Most required investments were for consulting engineering services from BBA, totalling under \$400,000.
- 5. Use an integrated approach to carry out the mandate and facilitate knowledge-sharing:** By being on-site for a significant period of time, and witnessing day-to-day operations through personnel secondment, BBA fully understood stakeholder concerns and coached every member of the Agnico Eagle Operations team by involving them in each mandate phase. Thus, throughout the project, particular focus was placed on sharing knowledge and improving understanding for operators, supervisors and managers. As a result, Agnico Eagle staff are now much more autonomous, confident and in control of their equipment.



Control room



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About BBA

For over 35 years, BBA has been offering a wide range of consulting engineering and project management services, from project definition to commissioning. The firm's expertise is recognized in the fields of energy, mining and metals, and oil, gas and biofuels. BBA relies on a team of seasoned experts to transform complex problems into practical, innovative and sustainable solutions.

BBA is supported by a network of offices across Canada to better serve its clients and carry out mandates at the local, national and international levels.

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