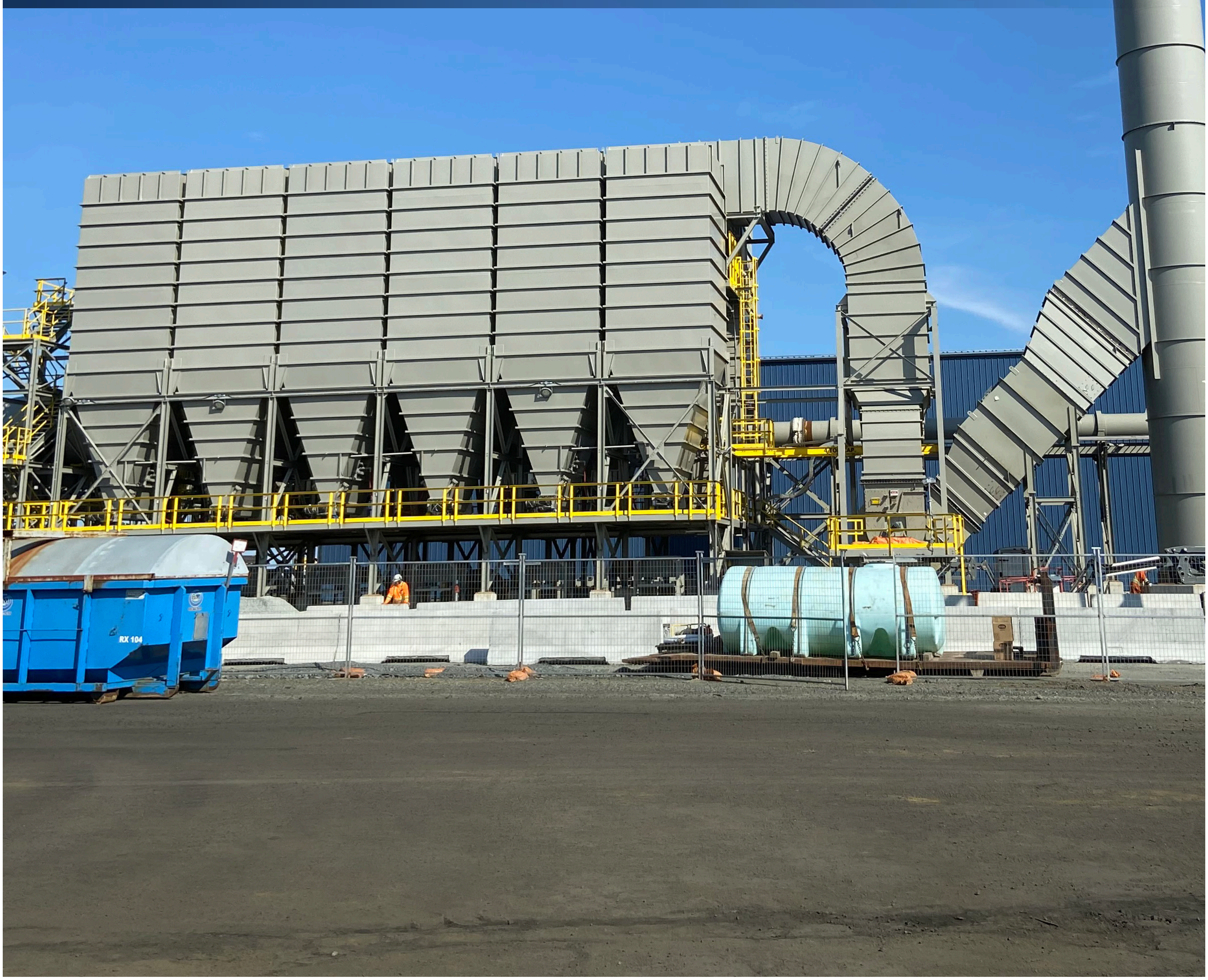
Executive Summary

The Process Gas Project (PGP) and the Particulate Emissions Project (PEP)

2022 Canadian Consulting Engineering Awards

HATCH

The Process Gas Project (PGP) and the Particulate Emissions Project (PEP) comprise a CAD$288 million investment by Glencore to reduce sulfur dioxide (SO2) and particulate emissions and improve productivity at the Sudbury Smelter. The projects are critical to the long-term viability of their Sudbury Integrated Nickel Operation in Ontario, Canada. Hatch was engaged to respond to the government-mandated SO2 and emissions-reduction requirements, providing full engineering, procurement, and construction management (EPCM) services for process upgrades.



Project highlights

Over the past 30 years, Glencore Sudbury Integrated Nickel Operations (Sudbury INO) has reduced sulfur dioxide (SO_2) gas emissions at their Sudbury Smelter in Ontario, Canada by over 90 percent through investments in technology and process improvements to meet government-mandated ambient air-quality standards. The Process Gas Project (PGP) Phase 1, PGP Phase 2, and Particulate Emissions Project (PEP)—a three-phase program—comprise a CAD$288 million investment by Glencore to reduce SO_2 and particulate emissions and improve productivity at the Sudbury Smelter.

In 2010, Hatch was retained by Sudbury INO to support Glencore's response to the more stringent government-mandated SO2 and emissions-reduction requirements. Since then, Hatch has provided full engineering, procurement, and construction management (EPCM) services for the process upgrades. The safe and successful execution of these services will help ensure that Smelter operations remain in compliance with the new federal and provincial regulations by reducing allowable emissions of SO_2 and heavy metals (nickel, cadmium, lead, cobalt).

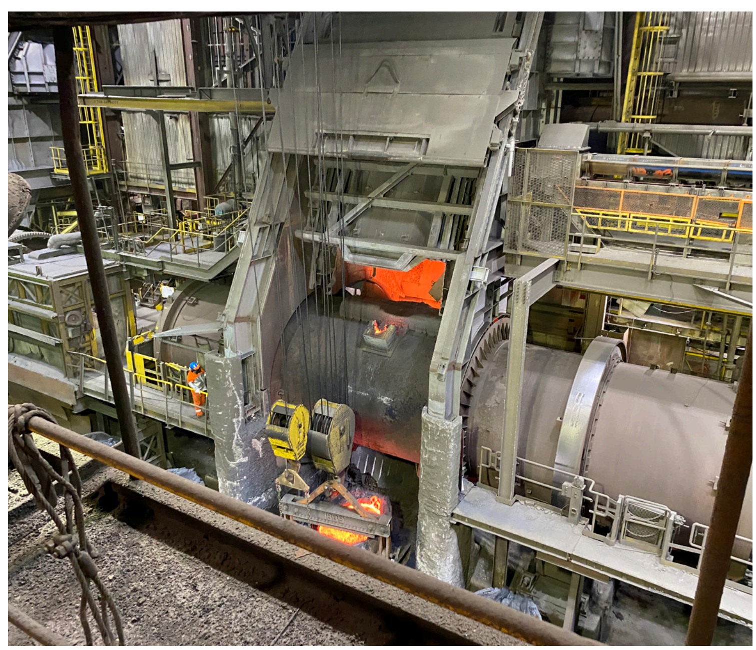
The PGP and PEP projects comprise a CAD$288 million investment by Glencore to reduce SO_2 and particulate emissions and improve productivity at their Sudbury Smelter.

The overall project was split into three phases: PGP Phase 1 was completed in late 2015 and Phase 2 was completed in February 2021. In 2019, Glencore approved the last phase of the project, PEP, and it was completed in October 2021. The combined program was executed over an 11-year period, employing over 40 different local construction contracting companies and hundreds of vendors, and resulted in over 1.2 million hours on-site over the course of the projects. The projects were completed safely, with zero Lost-Time Injuries (LTIs), and under budget.

Complexity and project challenges

Overall, the projects were complex, brownfield executions that involved modifying virtually every major process in the smelter while maintaining 24-hour-per-day operations. The major upgrades to the smelter included the following:

- Expanded nickel concentrate receiving and handling facilities. Operations were brought indoors and ventilated to dust control systems to eliminate particulate emissions to the environment.
- Upgraded concentrate thawing facility.
- Improved feed slurry preparation facilities to allow uniform feed profile, reducing spikes in sulfur that cause spikes in emissions. The feed slurry preparation facilities included new blending tanks and a slurry mixing facility.
- Upgraded capacity of fluid bed roaster off-gas systems, enabling increased sulfur removal from the calcine.
- Debottlenecking the acid plant to allow processing of the increased sulfur dioxide in the roaster off-gas.
- Implementation of a Controlled Furnace Atmosphere (CFA)—a new innovative process—in the electric furnace to control oxygen levels in the furnace freeboard by injecting low-oxygen acid plant tail gas to reduce SO_2 formation.
- New hybrid converter vessel along with associated feed infrastructure, allowing increased efficiency of the converter aisle as well as further emissions reductions generated from ladle transfer operations.
- New system to continuously inject combustion air into the furnace uptakes to improve safety during occasional furnace events in which high CO concentrations are experienced.
- New secondary ventilation system in the converter aisle, including complex fume capture hoods with moving doors to collect emissions from converter charging and pouring operations.



The integrated project team was required to overcome several challenges throughout the project. These challenges, as well as the solutions employed to solve them, include the following:

- **Maintaining 24-hour operations while modifying nearly every core process in the plant:** Meticulous implementation planning ensured that critical tie-ins could be made during short, planned shutdown windows. This approach required close coordination between the Hatch construction team and the Glencore operators who depended on Hatch to keep to promised shutdown duration timelines—sometimes of only a few hours.
- **Achieving complex process modifications:** Hatch leveraged and coordinated global expertise to support the local Sudbury execution team, including specialized material handling flow modeling, acid plant design, electric furnace design, computational fluid dynamic modeling, noise abatement, process gas handling design, and machine design.
- **Ensuring reliable project governance and documentation:** The project complexity necessitated hundreds of equipment and contract packages, and tens of thousands of deliverables. Hatch's management systems facilitated effective and efficient review, record keeping, and problem resolution.
- **Overcoming challenging ground conditions on-site:** Ground conditions were frequently poor due to historical site use. Thorough geotechnical investigations, appropriate cost estimates, and robust foundation design were needed to ensure success.
- **Working in a brownfield environment:** Equipment layout was significantly complicated by the brownfield environment. Successful execution required a high degree of field presence, including a full-time team reporting to site daily, which facilitated quick resolution of field-encountered issues.

Meeting Glencore's needs: objectives, solutions, and achievements

Glencore's goals for the combined projects included achieving:

- The prescribed environmental performance targets for SO_2 and metals;
- A target Total Recordable Injury Frequency (TRIF) rate of less than 3.7;
- Project completion within budget and on schedule;
- Project completion without impacting production; and
- A retrofitted facility that is reliable, safe, and energy efficient.

To achieve these goals, Hatch personnel worked within an integrated team with key Glencore personnel that remained focused on continuous scope reductions, cost optimization, and improving execution. The integrated project team made ongoing efforts to align project and safety objectives to drive desired behaviors and project outcomes. This strong, collaborative relationship was paramount to achieving cost reductions and ultimately, project success. The Hatch and Glencore team worked together for about five years on front-end studies, developing simplified, elegant flow sheets that achieved government mandates and reduced project costs significantly. The team's efforts reduced the required capital expenditure by approximately 15%.

As an integrated team, Hatch and Glencore remained focused on continuous scope reductions, cost optimization, and improving execution.

The scope of this brownfield project touched virtually every part of the operating plant, yet its execution was not permitted to impact ongoing operations. Through rigorous project management and scheduling practices, the project did not have any impact on production at the Smelter. In fact, the Smelter has managed to increase production since the commencement of PGP1.

Factors that contributed to the projects' success included:

- Safety practices were rigorously enforced from the start of the project.
- Design development and execution were carefully staged over 11 years, between 2010 and 2021, in three implementation phases.
- An integrated team was formed between Glencore and Hatch with effective teamwork, clear responsibility for package execution and costs, and strong relationships to coordinate construction in an operating plant. Continuity of the integrated team model was maintained throughout with top priority on safety on all related efforts (planning, execution).
- Continuous improvement, lessons-learned, and value improvement practices were implemented through all phases, which reduced cost and achieved a better outcome. These practices contributed to bringing the project 16% under budget without any spent contingency.
- Equipment and material selection was based primarily on quality, not lowest price.
- A thorough Feasibility Study was completed, upon which realistic budgets and schedules were derived.
- Work was carefully planned so short outages—even a few hours—could be efficiently used for critical tie-ins in the operating plant.
- Contract bid packages were well defined and issued with construction-ready drawings and final documentation, minimizing cost adders.
- Shop inspections of equipment packages were completed before delivery to ensure quality.
- Regular CAD model reviews with stakeholders were completed to ensure technical alignment.

Environmental benefits

The PGP project significantly reduced SO_2 and metals impacts to the local community. Furthermore, reducing sulfur dioxide emissions represents another step forward in the battle to stop acid rain. The impressive results include:

- A reduction of 65% in the SO_2 measured in the community
- A drop in the total SO_2 emitted to approximately 26,000 t/annum (from 40,000 t/annum);
- A reduction in SO_2 emission intensity to achieve 0.3 t SO2 per t Ni + Cu (from 0.45);
- A reduction of 62% in the cadmium measured in the community;
- A reduction of 50% in the nickel measured in the community; and
- A reduction of 65% in the cobalt measured in the community.

Additionally, the project made extraordinary efforts to minimize noise impacts to the community from the equipment. For example, one of the largest fans Hatch has ever incorporated on a project needed to be installed close to the property line with the community. The project incorporated special noise control measures including a specially designed building to mitigate noise impacts below nighttime limits.

The projects reduced $S0_2$ measured in the community by 65%—from 40,000 t/annum total $S0_2$ emitted to 26,000 t/annum.

To address energy efficiency and contribute to sustainability, the project invested in Variable Frequency Drives (VFDs) on the new process ventilation systems and some existing process systems. The control strategy for these VFDs is designed to minimize electrical energy consumption by controlling the speed of these major fans to the minimum necessary to meet process requirements at that moment. Investment in this technology benefits the environment and will also pay for itself through lower power costs.

Innovation

The Controlled Furnace Atmosphere (CFA) system used to further reduce SO_2 emissions was an industry first, whereby no other engineering consultant had attempted to tie tail gas from an acid plant into an electric furnace before. Careful test work and design was needed to make this system successful. The concept was first proven by injecting nitrogen gas into the operating furnace as a full-scale test.

The design required:

- Improved freeboard pressure control;
- Fast isolation dampers to shutoff tail gas flow in an emergency;
- Twelve injection points around the furnace to ensure uniform coverage, designed using Computational Fluid Dynamic (CFD) modeling;
- Dampers at injection points to allow flow distribution to be modified during operation;
- Stainless steel sloped ductwork to prevent corrosion and drain tail gas sludge;
- Precise duct construction to contain positive pressure tail gas near personnel areas; and
- Accurate and verifiable instrumentation to ensure proper monitoring.

The system successfully reduced furnace SO_2 formation. Consequently, it also significantly improved furnace temperature control.

The converter secondary system flow control required an innovative approach. The system includes five users with independent, rapidly changing flow demands, and a variable speed fan to minimize power consumption. The required fast response time (< 10-15 seconds) and competing demands would challenge a set of Proportional-Integral-Derivative (PID) control loops.

A control matrix specifying damper and fan parameters for all 214 possible flow demand scenarios was developed using a theoretical model of the system. The Smelter's Distributed Control System (DCS) was programmed to recognize the demand scenario and set the fan speed and damper positions as required. This approach was successful on the converter secondary system and on the concentrate handling ventilation system.

Social and economic benefits

Community engagement was critical to the success of the projects, particularly given the project's goal to reduce environmental impacts. Further, Sudbury INO is a major employer in the Sudbury region and complying with environmental regulations was essential to keeping this facility viable for the community. The improved emission abatement has resulted in fewer periods during which the facility needs to curtail production due to specific weather conditions that would otherwise contribute to elevated contaminant concentrations and impact to the community. Overall, the project has significantly improved the economic performance of the facility.

The project was executed through a 10-year period employing over 40 different local construction contracting companies, hundreds of vendors, over 1.2 million hours on site over the course of the project.

The local community in Falconbridge was engaged quarterly throughout the project at town-hall-style updates. In addition to thoughtful engagement, regular project updates were provided on billboards, as well as to the local contracting community.

Other benefits include:

- PGP achieved significant reductions of contaminant concentrations for SO_2 and metals as measured in the nearby community, which contributes to the wellbeing of the community.
- Reduction in annual SO_2 emissions contributes to Ontario's continued efforts to stop acid rain.
- As a part of PGP, some processes were upgraded to be more efficient and reliable, this contributes to making the facility viable in the long term.
- The project was executed through a 10-year period employing over 40 different local construction contracting companies, hundreds of vendors, over 1.2 million hours on site over the course of the project.

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