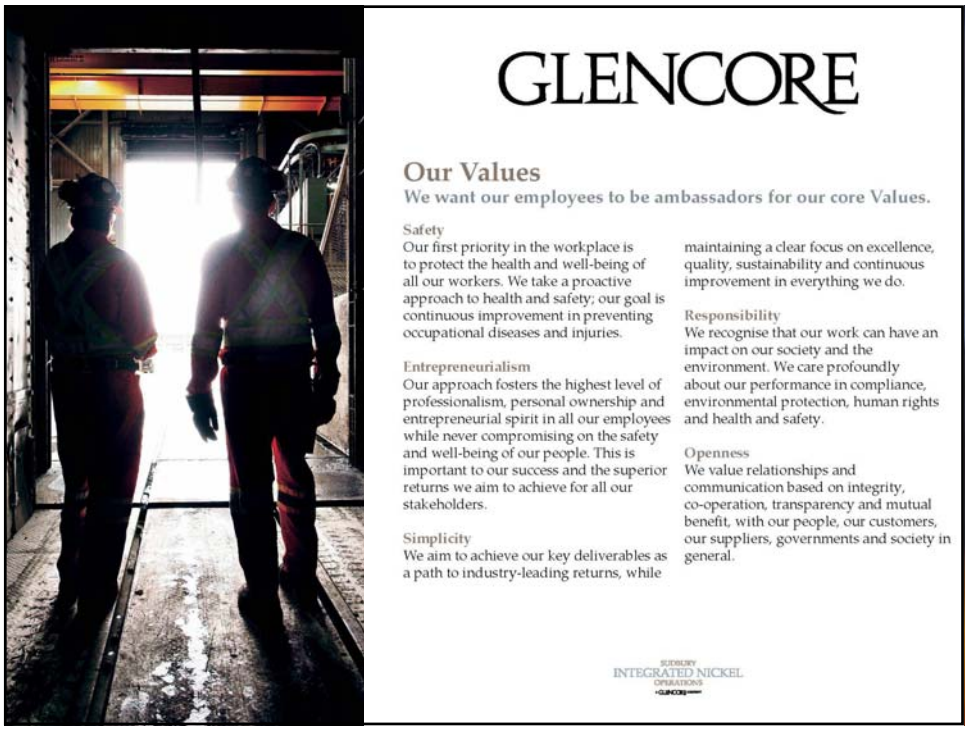

SUDBURY
INTEGRATED NICKEL
OPERATIONS
GLENCORE
MDEC Conference
October 5th, 2016


GLENCORE
Our Values
We want our employees to be ambassadors for our core Values.
Safety
Our first priority in the workplace is to protect the health and well-being of all our workers. We take a proactive approach to health and safety; our goal is continuous improvement in preventing occupational diseases and injuries.
Entrepreneurialism
Our approach fosters the highest level of professionalism, personal ownership and entrepreneurial spirit in all our employees while never compromising on the safety and well-being of our people. This is important to our success and the superior returns we aim to achieve for all our stakeholders.
Simplicity
We aim to achieve our key deliverables as a path to industry-leading returns, while maintaining a clear focus on excellence, quality, sustainability and continuous improvement in everything we do.
Responsibility
We recognise that our work can have an impact on our society and the environment. We care profoundly about our performance in compliance, environmental protection, human rights and health and safety.
Openness
We value relationships and communication based on integrity, co-operation, transparency and mutual benefit, with our people, our customers, our suppliers, governments and society in general.
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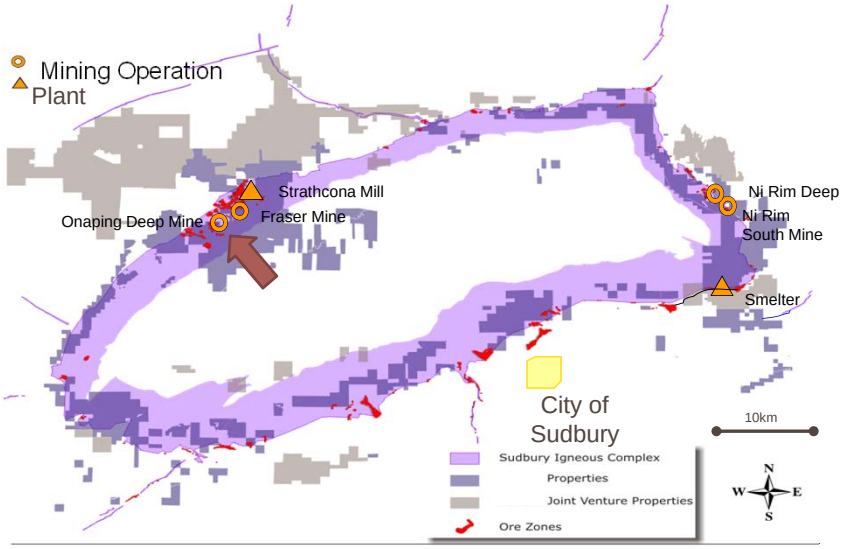
Sudbury Operations



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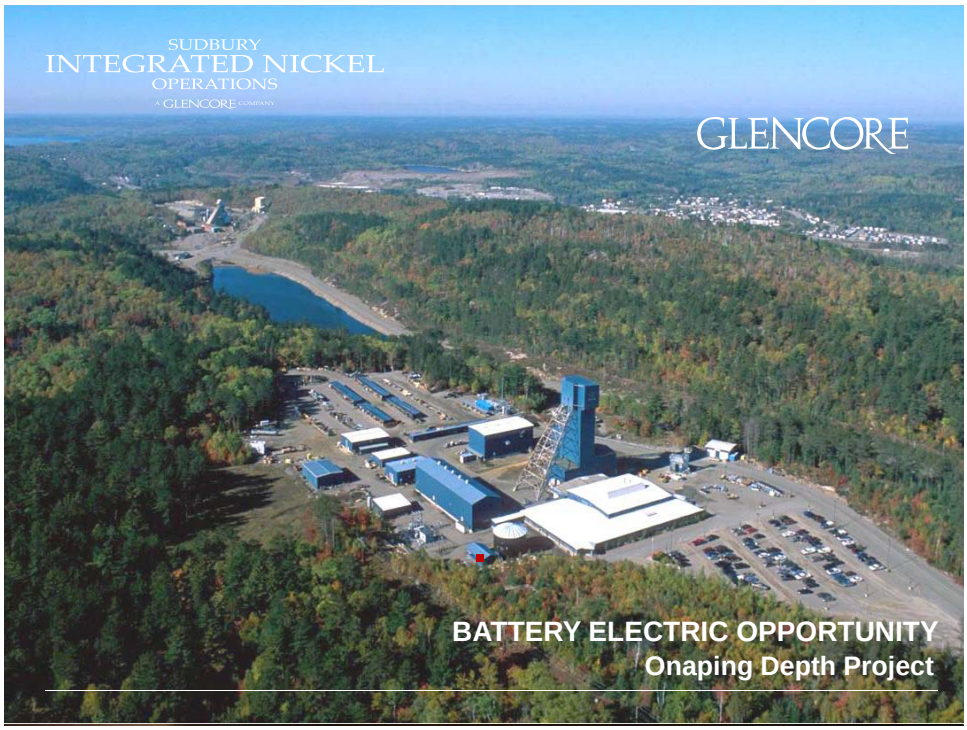
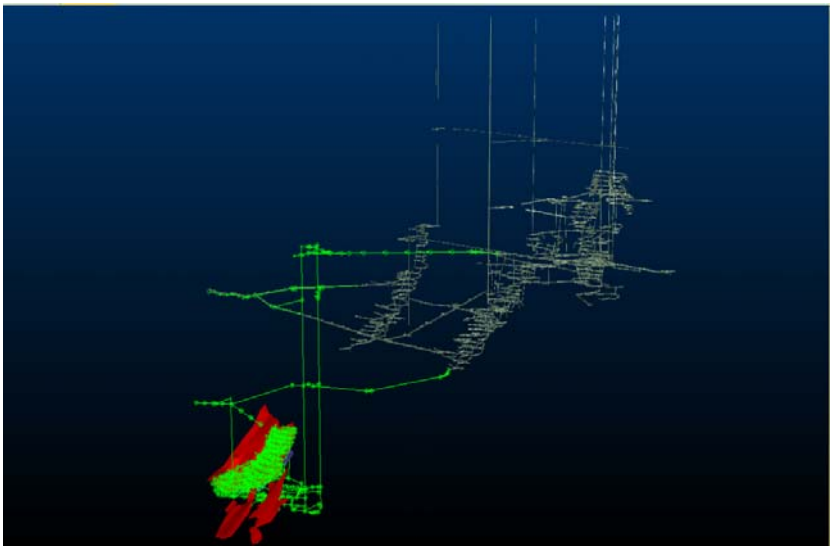


Isometric View



Ventilation Requirements

In general ventilation is required in order to provide workers and diesel engines a source of fresh air to dilute and clear away contaminants in the mining process.

These include the following:

- **Toxic equipment exhaust gases (CO, CO2, NOx, Hydrocarbons etc.)**
- **Diesel Particulate matter (DPM)**
- Heat
- Dust (silica)
- Blasting fumes (CO, NO2 etc.)
- Other gases (SO2, ammonia, Radon)

Current legislation in Ontario is 0.06 m3/s for each kw of power of the diesel engine in underground mines.

Ventilation Requirements

What would ventilation requirements look like if there was no diesel equipment?

We would need to ventilate for air quality.

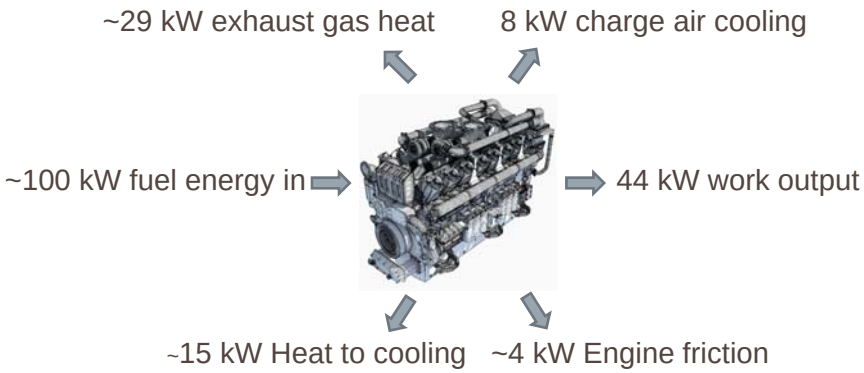
These would include the following:

- Heat
- Dust (silica)
- Blasting fumes (CO, NO2 etc.)
- Other gases (SO2, ammonia, Radon)

In deeper mines like Onaping Depth the driver for ventilation will become heat.

Efficiency of Diesel Engines

- Diesel engines are typically 44% efficient (producing work) and the other ~56% of diesel fuel is converted to heat



Efficiency of Electric Motors

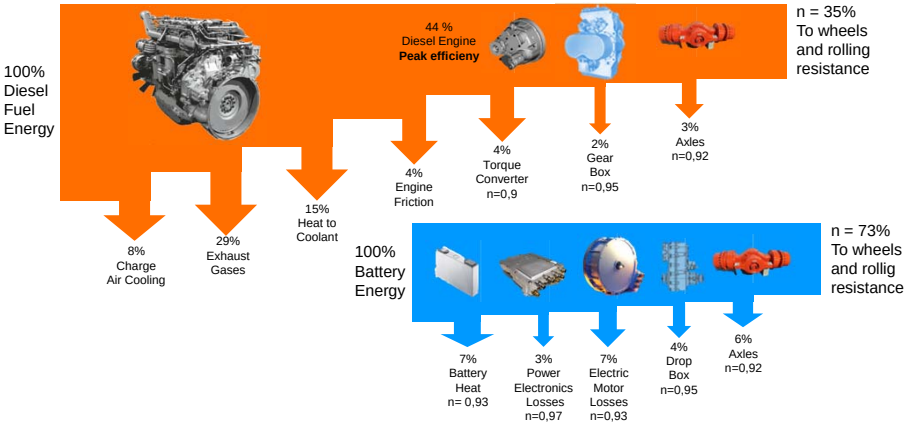
- Electric motors are typically ~93% efficient.

~100 kW Elec energy in →  → 93 kW work output

↓

~7 kW Heat

HEAT LOSSES FROM DIESEL AND BATTERY LOADERS:



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Power Regeneration

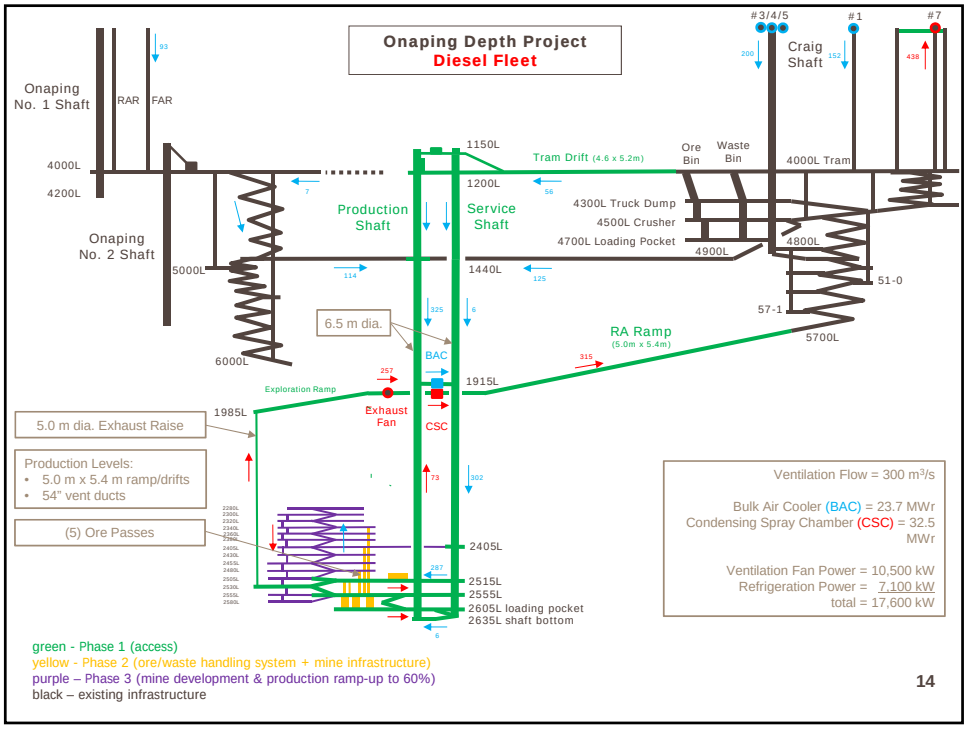
- The battery electric systems offers the ability of the electrical motors to be used for regenerative braking especially when going down ramp.
- Regenerative braking converts the kinetic energy from braking back into the batteries rather that dissipating it off as heat.
- This makes battery significantly more efficient than diesel especially when hauling in a down ramp application.

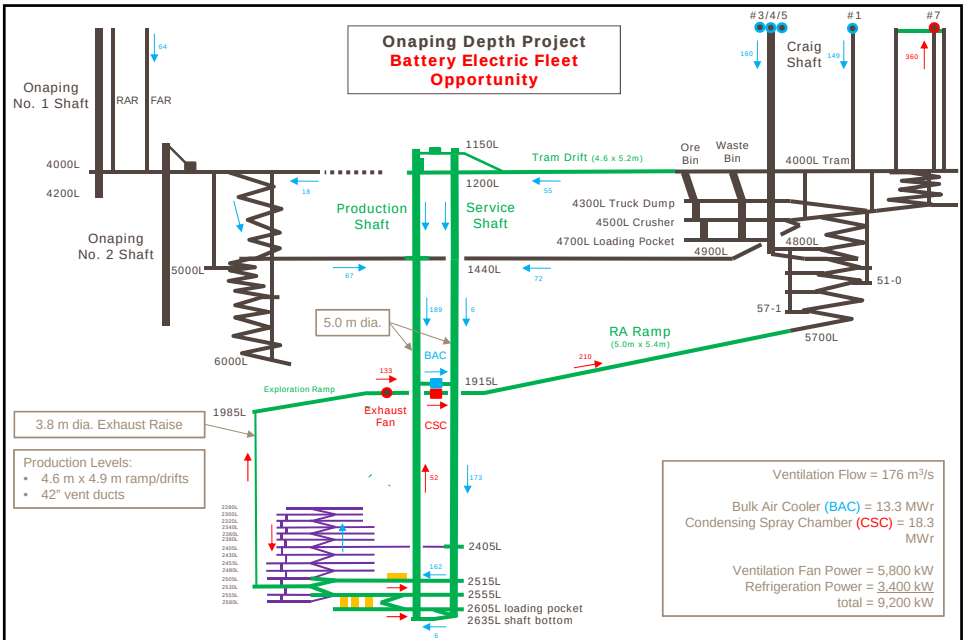
Reduced Ventilation Cost

There is some reduction in ventilation cost to consider

- **Reduction in number and/or size of ventilation raises**
- **Reduction in number of fans**
- **Reduction in heat generation due to auto-compression of ventilation air forced underground**
- **Smaller drift size**
- **Reduction in size of air cooling plant required on surface**
- **Increased humidity due to burning of diesel fuel**
- **For the same amount of work done you generate approximately 6-7 times less heat using battery electric over diesel**

Onaping Depth Project
Prefeasibility Study 2016





Why Battery Electric Mining Vehicles?

Improved Vehicle Characteristics

- **No emissions**
- **Improved Performance**
- **Less Noise**
- **Simpler Machinery**
- **Less Wear and Tear**
- **Less Maintenance**

Benefit to Mining

- **Health Benefits**
  - Less pollutants / particulates
  - Quieter
- **Less Ventilation**
  - Reduce Size & Number of Ventilation Openings
  - Reduce size of refrigeration plant
  - Less heating of mine air in winter (if required)
- **Overall Lower Energy Usage and Cost**
- **Improved Productivity**
  - Subjective at present – but mostly due to health benefits

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Why Battery Electric Mining Vehicles?

Estimated CAPEX savings:

Vent & Cooling Infrastructure	$24M
Shaft Size	$ 5M
Drift Size	$12M
	$41M

CAPEX additions:

Mobile Equipment Premium	$21M (current assumption 140% of diesel fleet)
Charging Infrastructure	$ 5M ?
	$26M

Estimated OPEX savings:

Fan & Refrigeration Power Cost	$7.3M / year
Natural Gas Cost	$0.3M / year
Operating/Maintenance Cost	$0.3M / year
	$7.9M / year

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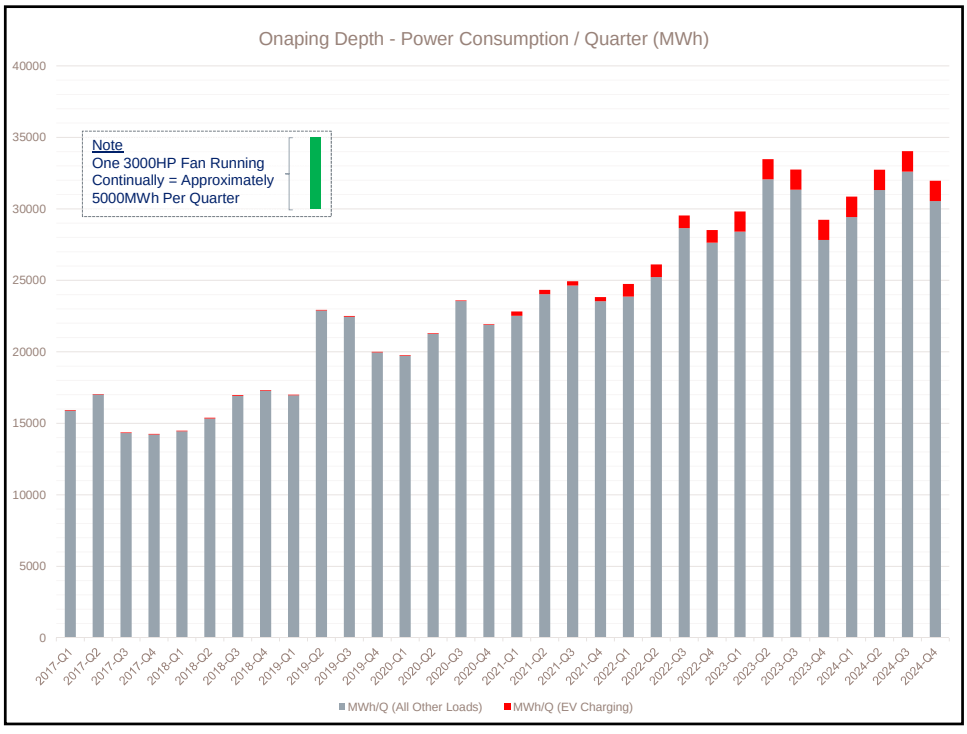

Concerns and Challenges

Vehicles

- **Lower Energy Density**
- **Slower Refueling Time**
- **Capital Cost of Equipment**
- **Availability of Equipment**

Challenges to Mining

- **Duty vs Battery Charge Cycle.**
  - Shift Design around Equipment Capabilities and Limitations
  - Cultural change. Need to break "addiction" to convenience of fossil fuels.
- **Infrastructure and Logistics**
  - Parking
  - Charging

Path Forward and Challenges:

- Confirmation of vent flow and heat load requirements at Feasibility Study Level
- **OEM technology development roadmap**
- **Equipment Cost**
- Hauling up ramp still has challenges at this time
- **Mine infrastructure to support full mine battery electric fleet**
  - o*Charging stations for battery change out?*
  - o Quick change
  - o Large scale infrastructure to support 80+ units
  - o*On-board battery charging?*
  - o Flexibility, reduced infrastructure
  - o Charge time


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Thank you