IMII - Applications of Clean Power Generation Technologies to Saskatchewan Minerals Industry

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March Consulting Associates Inc.

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Acknowledgements

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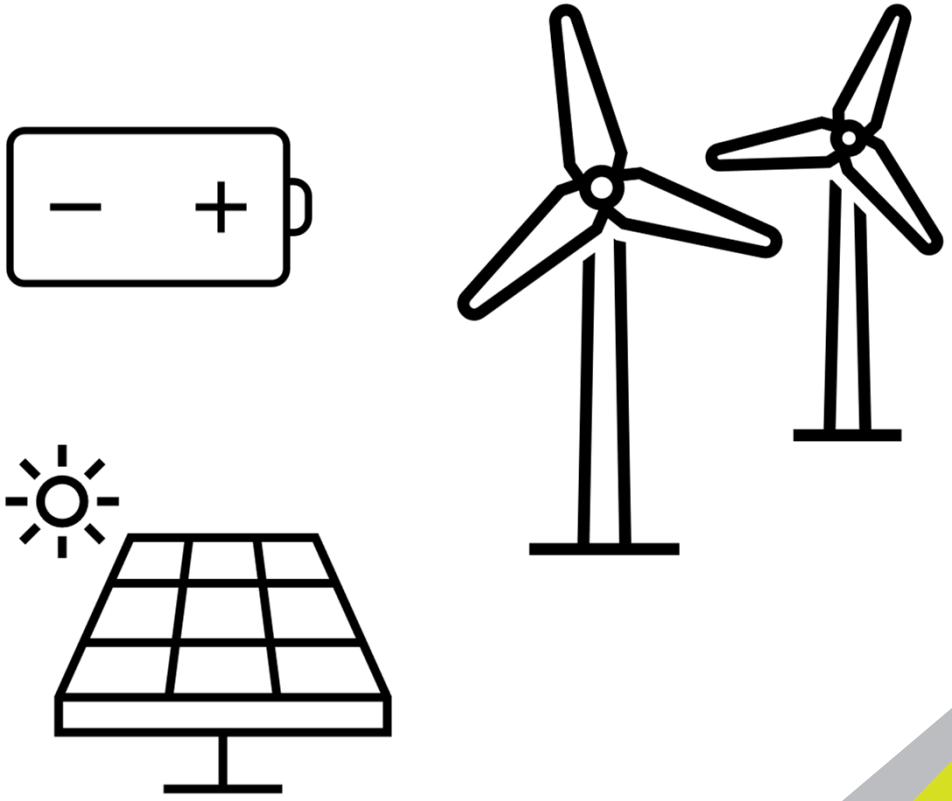
Presentation Outline

- Scope, Context and Basis
- Methodology
- Overview of Technologies Considered
- Key Assessment Criteria
- Evaluation
- Final Assessment and Recommendations

Scope – Review and Assessment of Clean Technologies

Brownfield Mining Operations with existing access to SaskPower grid considered

1. Reliant on electricity and fossil fuels.
2. Access to the SaskPower and natural gas but with significantly higher demand for electricity than natural gas, for process heating.
3. Access to the SaskPower and natural gas but with significantly higher demand for natural gas, for process heating, than electricity.



Context and Basis

- Environmental considerations and clean power production – primary driver for the study
- Consideration to technologies that are feasible within the next 5 years
- Focus on self-generation instead of co-generation
- Independent Power Producers (IPP) who can built and operate the power plant preferred
- Power Purchase Agreements to be between the mining operation and IPP

Methodology

Identifying Applicable Technologies

- Solar
- Wind
- Geothermal
- Nuclear
- Combined Heat and Power (CHP)
- Hydrogen (not considered in the final study)

Assignment of Scores and Weightage

1. Technical compatibility
2. Capital expenditures
3. Environmental impact (GHG)
4. Operating costs
5. Power system reliability
6. Maintenance and skills
7. Land space requirements

Assessment

1. Vendor Outreach/Discussions
2. Collaboration and Feedback from IMII Partners

Overview of Technologies - Nuclear

- Small Modular Reactors (SMRs) were deemed as most relevant to SK minerals industry
- Several designs are in the pre-licensing phase
- Designs use technologies such as molten salt, pressurized water, molten lead, liquid sodium etc.
- For the purpose of this study, consideration was limited to Ultra Safe Nuclear Corporation – micro modular reactor
  - Small size which can be scaled based on the mining needs
  - Pre-Licensing Assessment of Compliance is already complete with CNSC
  - Most advanced and likely operational by 2025

Overview of Technologies

Solar

- Study only focused on Photovoltaic technology
- Single side or dual sided panels
- Modular sizes of 10MW relevant to the SK mining industry

Wind

- Well proven technology
- Southern Saskatchewan can produce reliable wind power
- Modular sizes can be as low as 10MW that can be scaled up for the mining operation

Possibility to partner with First Nations Power Authority (FNPA) to engage with Indigenous organizations as FNPA has existing PPAs with SaskPower

Overview of Technologies

CHP

- Typically consists of a power plant and a heat recovery and distribution system
- Examples include Cory Co-gen, Meridian Co-Gen, Muskeg River Mine, Fort Nelson
- Applicable for base load power

Geothermal

- Mostly applicable to Southern Saskatchewan
- DEEP Energy is the most advanced in Saskatchewan and in Canada
- Applicable for base load power

Key Assessment Criteria

Factor	Weighting
Technical Evaluation	30%
Capital Expenditures	20%
Environmental, Social, and Regulatory	20%
Operating Expenditures	10%
Power System Reliability	10%
Maintenance Cost and Requirements	5%
Physical Footprint Requirements	5%
Total	100%

Evaluation and Assessment

Description	Weightage	Nuclear (SMR)	Geothermal	Combined Heat and Power	Wind	Solar
Technical Evaluation	30.00%	27.36%	14.94%	22.18%	15.28%	13.98%
Capital Expenditures	20.00%	8.67%	7.97%	9.10%	12.85%	16.50%
Environmental, Social, and Regulatory	20.00%	15.33%	17.83%	11.83%	16.50%	16.17%
Operating Expenditures	10.00%	4.27%	7.03%	6.38%	4.81%	6.00%
Power System Reliability	10.00%	10.00%	6.50%	8.25%	4.25%	3.75%
Maintenance Cost and Requirements	5.00%	5.00%	2.54%	3.01%	1.83%	2.58%
Physical Footprint Requirements	5.00%	1.05%	1.13%	5.00%	0.01%	0.00%
Total	**100.00%**	**71.68%**	**57.95%**	**65.76%**	**55.53%**	**58.98%**

Recommendations

Since evaluation for each technology was conducted essentially on a stand-alone basis, any technology can be applicable to any mining operation, with the following considerations:

- Either SMR, Geothermal or a Combined Heat and Power System will be required as a base power option for any operation. Our evaluation rates SMRs and CHP higher than geothermal based on the criteria and information available from IPPs.
- Operations with no significant requirement for process heat and heavy reliance on fossil fuels– recommendation is to use SMRs as base power for the most impact. Geothermal can be used if the site is in southern SK. SMRs can be combined with solar or wind power for peak loads to increase the social acceptability.
- Operations with requirement for process heat – SMRs are recommended over CHP as they are more efficient and environmentally friendly. However, if timelines of development are a constraint i.e. the project needs to be developed and operational before 2025, CHP is the next recommended option.