INTEGRATING RENEWABLE ENERGY IN POST-MINING LAND USES

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Abstract

Renewable energy development is a worthy consideration for mining companies planning for mine closure and post-mine land use in Canada. In this paper, we provide information on integrating renewable energy generation into mine closure planning, show examples from around the world where alternative use of mined and disturbed sites has been advanced, and demonstrate a basic cashflow model illustrating the socio-economic benefits of integrating a wind energy facility into a mining project.

This paper will be of interest to mine operators and owners who are planning for closure and looking for a beneficial post-mine land use. We argue that renewable energy development is a superior choice when compared to traditional approaches like ecological rehabilitation because it is faster to mature, has greater certainty of success, provides revenue following mine closure, and offers additional value in achieving net zero targets. We believe that industrially-compromised mine sites play an important part of the world's non-carbon energy transition.

Introduction

Mine closure and decommissioning of heavily impacted brownfield sites encourage or includes high expectations for rehabilitation success and beneficial uses—often focusing on a return to pre-disturbance ecosystems to support wildlife. The challenges to achieving rehabilitation success that meets high expectations of beneficial use are many and varied: site contamination, substrate amelioration, gradient and landform repair, revegetation, loss of ecological connectivity, and erosion control. Reclamation to a pre-disturbance or wildlife-useful state is difficult to realize, costly, and may not be the best use of the land.

In this paper, we present an opinion that the generation of renewable energy is a more beneficial use of post-closure mine and decommissioned brownfield sites than the often promised and rarely realized rehabilitations for wildlife in many cases. Historically, there are only a few examples where reclamation challenges have been overcome and beneficial use for wildlife has been realized, and these have taken many years to achieve.

Background and Context

End land use planning is a requirement in the mine permitting process in British Columbia and many other jurisdictions worldwide. In British Columbia, the end land uses for major dumps, tailings facilities, and other mining project lands to be reclaimed need to be specified in closure plans, and approved by the chief permitting officer. The following excerpts from the British Columbia Ministry of Energy, Mines and Low Carbon Innovation (BC EMLI) Health, Safety and Reclamation Code for Mines in British Columbia (HSRC) states the following with respect to end land use:

Land Use

10.7.4 *The land surface shall be reclaimed to an end land use approved by the chief permitting officer that considers previous and potential uses.*

Capability

10.7.5 *Excluding lands that are not to be reclaimed, the average land capability to be achieved on the remaining lands shall not be less than the average that existed prior to mining, unless the land capability is not consistent with the approved end land use or compromises long-term physical and/or geochemical stability.*

Where, "land capability" means the capability of achieving a specified land use estimated by limitations as a result of climate, topography and soils (BC EMLI, 2022).

The prescriptions for land use selection in the HSRC indicate that the average land capability to be achieved on reclaimed mine lands should either meet or improve upon the capability of the pre-mining land use. Despite these prescriptions, there are exemptions, notably where long-term physical and/or geochemical stability must be ensured.

Historically Accepted Post-Mining Land Uses

Ausenco completed two high-level reviews of accepted end land uses for mines:

I. Random sample of British Columbia Major Mines Projects
II. Literature review of publicly available information

BC Major Mines Post-Mining Land Uses

The random sample method (Method I) used publicly available information from the British Columbia Major Mines portal to develop a complete list of mine projects, assign a project number to each mine, and randomly select 21 of the 74 operations in the BC Major Mines portal. Mining permit and reclamation reports for the selected mines were reviewed to identify the end land use objectives, which were recorded.

The land uses identified using the two methods described above are:

- Traditional Uses (11)
- Wildlife and Plant Habitat (16)
- Livestock and Grazing (4)
- Forestry (3)

- Industrial Uses (1, log dump)
- Recreation and Tourism (8)

Using the random sample method, we found a range of post-mining land uses, but did not identify renewable energy as a common land use. In the literature review (below), we describe one example of a renewable energy facility on a decommissioned mine site in British Columbia.

International Post-Mining Land Uses from Literature Review

The literature review method (Method II) consisted of a high-level literature review using publicly available documents, news articles, technical publications, and other sources to identify mining projects which have implemented alternative end land uses. The following sections highlight notable examples of post-mining land uses across various jurisdictions which incorporate renewable electricity generation, organized by the type of renewable energy generation.

Solar Electricity Generation:

Teck Resources Limited's SunMine Solar Energy Facility in Kimberley, British Columbia is a 1 MW solar installation which has been operational since 2016 and was the first grid-connected solar facility in British Columbia. The SunMine is located on lands reclaimed after closure of the former Sullivan Mine; the land was released from the Sullivan Mine Permit (Permit M-79) in 2014 for the development of the solar facility (BC EMLI, 2014).

Solar power generating facilities including 175 photovoltaic panels installed on 8 hectares of a Molycorp, Inc. mine site near the village of Questa, New Mexico. This was done as part of a project to evaluate various soil cover scenarios in preparation for closure of the tailings area. The site is registered as a U.S. EPA Superfund site where over 328 million tons of potentially acid-generating waste rock were originally placed in nine piles surrounding an open pit, and where seepage resulted in groundwater and soil contamination (U.S. EPA, 2011).

Former lignite mining operations in Espenhain Germany have converted ash settling grounds at the former Espenhain mine into solar power facilities known as the Leipziger Land Solar Power Plant (LLSPP). The LLSPP was constructed in 2004, initially covering approximately 20 hectares of mine impacted lands, and was comprised of 33,500 solar modules producing 5 MW of electricity. The plant was expanded in 2005 through the addition of the Borna Solar Plant built on the site of a former briquette factory; the Borna Solar Plant created an additional 3.4 MW of electrical generating capacity (U.S. EPA, 2011).

Wind Electricity Generation:

We found two former coal mines using wind turbines for post-mining electricity generation. The Klettwitz Wind Farm, located on the site of a former coal mining pit in Germany, uses 38 wind turbines to generate 100 GWh of electricity annually. A wind energy facility in Kilronan Ireland was identified which generates 14 GWh of electricity on an annual basis (U.S. NRC, 2003).

The Dave Johnston Coal Mine in Wyoming started operations in 1958, and final reclamation on a portion of mine-affected land began in 1999. The mine was owned by PacifiCorp, who operated as Rocky Mountain Power. The company determined that the area had excellent wind resources and access to existing transmission facilities and chose to construct the Glenrock Wind Farm on company lands, which included the former mine land. The Glenrock Wind Farm was established on the former Dave Johnston Coal Mine in Wyoming's Powder River Basin. Reclamation work was completed in 2005, and the

Glenrock Wind Farm was completed in 2009. The facility has an energy generating capability of 237 megawatts with 158 turbines capable of producing 1.5 MW each. The addition of wind turbines required a change to the approved post-mining land use from grazing/wildlife to commercial/industrial pursuant to jurisdictional mining regulations (U.S. EPA, 2012).

The NedPower Mount Storm Wind Project is a 132-turbine wind farm located in part on coal and hard rock mine affected lands in West Virginia. The facility generates up to 264 MW of electricity for the mid-Atlantic power grid (TETHYS, 2023). Ninety-nine percent of the land will continue to be usable for other activities, including farming (U.S. EPA, 2012)

Hydroelectric Electricity Generation

A hydroelectric plant was constructed at the former Summitville Mine site in Rio Grande County, Colorado to power on-site water treatment operations. The 560-hectare Summitville Mine, registered as a U.S. EPA Superfund site, is an abandoned former heap leach gold and silver operation that has process-affected surface water both on and offsite (U.S. EPA, 2009).

Renewable Energy Storage

The Australian Renewable Energy Agency (ARENA) has conditionally approved up to $47 M in funding for construction of a 250 MW capacity 2000 MWh pumped hydro storage project at the former Kidston Gold Mine. The project will use two former mine pits as reservoirs for pumped energy storage. The site includes an existing and operating 50 MW solar farm, with a 150 MW wind farm under construction. (ARENA, 2021)

A compressed air energy storage facility was constructed on former salt mine lands in Goderich, Ontario in 2019, and provides 10 MWh of storage capacity (Butler, 2019).

Geothermal Energy

Case studies have reported the economic and environmental benefits of using geothermal energy reservoirs created from flooded mine workings to provide heating and cooling for buildings. Former coal mines in Springhill, Nova Scotia provide approximately 4M m^3 of 18°C water used to heat the Ropak Can-Am building which the company estimated saved $160,000 per year compared to an equivalent oil-fired furnace system, with a payback period under one year (Jessop, 1995). Other historical studies examined the use of geothermal heating from the Riondel Mine in Quebec (Desroches, 1992), the Sullivan Mine in British Columbia (Evans, 2017), and the Con Mine in the Northwest Territories (Ghomesei, 2007).

Biofuels

A program led by Emissions Reduction Alberta on reclaimed mine land at the Paintearth Mine near Forestburg, Alberta is investigating the use of municipal biosolids and other organic residuals to amend existing topsoil and establish fast-growing willow biomass crops for biofuel and bioproduct development (Emissions Reduction Alberta, 2020).

Other projects combining mine reclamation with the use of municipal biosolids and organic amendments for bioenergy production include Natural Resource Canada’s Green Mines Green Energy project at the Copper Cliff Central Tailings Facility in Sudbury, Ontario (Hargreaves, et al., 2012).

Reclaimed mine soils in the Appalachian coal mining regions have been studied to assess improvement to soil conditions, carbon sequestration, and the protection of cropland for food supply. Reclaimed coal mining lands near Zanesville, Ohio demonstrated successful biomass growth and harvest of corn and miscanthus for energy production (Ussiri, Guzman, Lal, & Somireddy, 2019).

Examples of Active Mining Operations Using Renewable Energy in Canada

There are many examples of renewable electricity being integrated in mining projects to reduce operating GHG emissions and dependency on fossil fuels. A few recent examples include:

- Glencore's Raglan Mine in northern Quebec installed a 3 MW wind turbine in 2014, which offset over 10 ML of diesel fuel and 28,000 tons of GHG emissions (The Mining Association of Canada, 2021). The study wind turbine development at Raglan mine demonstrates the reliable, economic, low carbon fuel source for electricity generation at remote mines (Simard, Fytas, Paraszczak, Laflamme, & Agbossou, 2017)
- Voisey's Bay is planning to commission a 21 MW wind power facility with 6 MW of battery storage in 2024 to reduce the mine's diesel consumption by 10 ML per year and GHG emissions by an estimated 28,000 tonnes (Envest, 2022).
- The Diavik Wind Farm has a capacity of 9.2 MW and provides approximately 10% of the mine's electricity requirements. In it's first year of operation, it reduced diesel requirements by 3.8 ML, equivalent to approximately $5 M. The project is estimated to take eight years to provide economic payback and will have an estimated reduction in GHG emissions of 12,000 tons (Arctic Council Working Group, 2023).

Large scale hydro-electric facilities have provided power to mining operations in Canada (Vale, 2018) and mining operations worldwide for decades, meanwhile mines are beginning to incorporate giga-watt scale solar power generation their energy supply (Riot Tinto, 2022) in, while some companies are planning to move to 100% renewable energy supply by 2030 (Fortescue Metals Group, 2022).

Similar Requirements for Mining Projects and Renewable Energy Projects

Mining projects and renewable energy projects have several similarities with respect to key infrastructure and the need for consultation, baseline studies, and permitting.

When assessing the development prospects for mineral exploration projects, some key infrastructure elements include proximity to major transportation corridors, electrical transmission lines, and available local workforce. These same elements are beneficial to the siting of renewable energy projects, with the most notable difference being that renewable energy projects seek to deliver electricity to the electrical grid instead of use for operations as is the case in mining.

Another similarity between mining and energy projects is the necessity for consultation with Indigenous Peoples, local communities, and stakeholders. The determination of end land use and post-mining land uses requires input from these groups who need to be consulted when assessing the construction of renewable energy projects. It is therefore possible that synergies and efficiencies could be achieved in these consultations by introducing renewable energy as an end land use for mining projects.

A notable similarity between mining and renewable energy projects is the variation in permit requirements by jurisdiction. Mining projects typically require detailed environmental, geotechnical, and socio-economic baseline studies, all of which are require time and expenses as part of planning and development. Renewable energy projects require a similar suite of studies and investigations to support permitting and design. There are substantial overlaps in the required information gathering activities which support design and permitting of mining and renewable energy projects. In most jurisdictions, both mining and renewable energy projects require plans for reclamation and end land use.

While there are many benefits to integrating renewable energy projects with mining projects and as an end land use, it is understood that there are limitations to the acceptance, practicality, and viability of such integrations. In some cases, there may be a greater desire to return land for traditional use by Indigenous Peoples or to establish other land uses such as wildlife habitat. However, the possibility of transitioning mining impacted land to renewable energy projects should be raised with all potentially affected parties. Furthermore, it is understood that while many mining projects in the province are connected to British Columbia's Provincial Electrical Grid, many operations require either partial or full use of fossil fuel electricity generation to power mine facilities, and the economic and environmental trade-offs for each case requires careful assessment.

Benefits of Integrating Renewable Energy Projects in Mining Projects and as Post-Mining Land Use

The increased prevalence of mine fleet electrification is anticipated to increase electrical demand during mining operations where sufficient electrical grid connections or generating facilities exist. The decarbonisation of the mining industry and electricity production presents substantial opportunity for reductions in air pollution and greenhouse gas (GHG) emissions.

The BC EMLI HSRC requires that "*the average land capability to be achieved on the remaining lands shall not be less than the average that existed prior to mining"*. While it may vary on a case-by-case basis, the potential land capability of renewable energy projects is assumed to be relatively high due to the possible economic and environmental benefits.

In addition to providing a high-capacity use for mine impacted lands, the incorporation of renewable energy infrastructure on land which has already been affected by mining reduces the use of other high capability land for construction of renewable projects. Recent news articles have described concerns with the use of high capability lands (such as farmland), are being degraded through the installation of wind and solar projects (Cowley, 2023). Furthermore, academic research indicates that the environmental impacts of solar installations can lead to the degradation of soils, and increases in the net release of CO_2 arising from terrestrial carbon losses (van de Ven, et al., 2021). Siting renewable energy facilities on mine impacted lands both provides a high-capacity land use for the mine impacted land and reduces the need to disturb additional lands.

The economic benefits of including renewable energy installations in a mining project, whether to provide electricity to operations or as a post-mining land use, includes the creation of additional direct and indirect jobs. The construction and maintenance of renewable energy installations present opportunities for workforce transition as mining operations wind down; it can even provide additional employment over and above the labour force demanded by mining operations. Renewable electricity can be used to reduce dependence on fossil fuels supply for mines and local communities, and as a source of revenue and taxation.

As renewable energy projects also require a reclamation plan, it can be understood that the inclusion of renewable energy projects as an end land use for mine impacted lands does not necessarily mean that the site will be host to mining structures or wind turbines in perpetuity. The eventual return of land to traditional uses, wildlife areas, or other uses can be incorporated in the overall site transition plan.

The United States Environmental Protection Agency (U.S. EPA) suggests that the benefits of developing renewable energy installations on mine affected lands include (U.S. EPA, 2011):

Ecological Impacts

- Facilitating Site Cleanup
- Reduced Emissions
- Reduced Fossil Fuel Use
- Water Quality
- Large Land Footprint

Economic Impacts

- Job Creation
- Increased Revenues
- Revitalization of Contaminated Property
- Local Energy Security
- Economic Development

Basic Economic Model of Renewable Energy Integration

The authors have developed a simple mining operation cashflow model to illustrate the potential economic benefits of integrating renewable energy projects into mining projects.

Assumptions:

Land Use	Mine	Wind Energy Facility (200 MW capacity)
Capital Expenditure (CAPEX) ($M)	500	300
Operating Life Span (Years)	10	25
Closure Period (Years)	25	1
Discount Rate	7%	7%

Three scenarios were modelled to evaluate the overall project undiscounted and discounted net present value (NPV). The wind energy facility in this case is based on the 2021 average land-based wind site characteristics reported by the National Renewable Energy Laboratory (Stehly & Duffy, 2022), with electricity costs sourced from the author's home province of Alberta (16.7 cents per kWh at time of writing). The wind energy facility has the following characteristics:

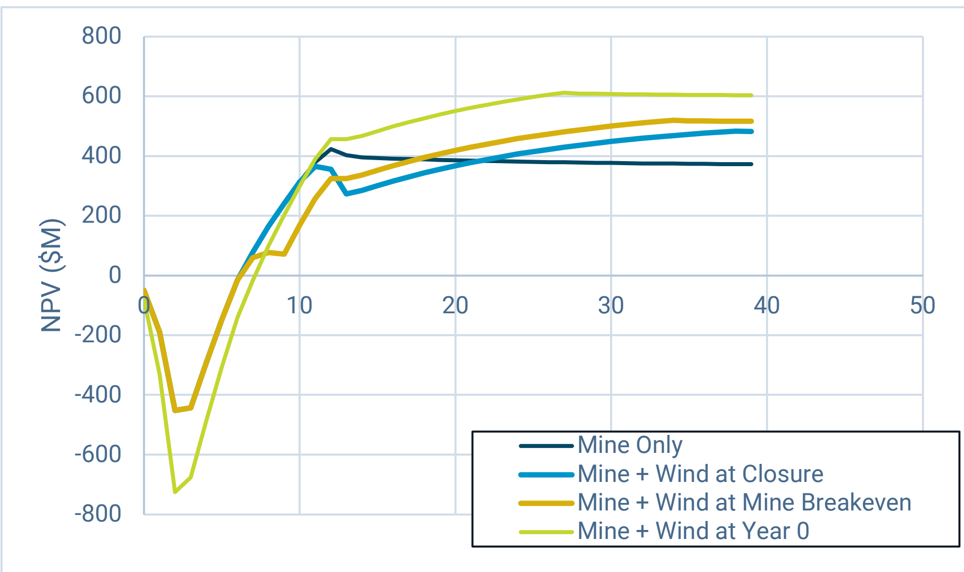
Scenario 1: No renewable energy project developed

Scenario 2: Wind turbines operational at year of mine closure

Scenario 3: Wind turbine project CAPEX initiated in first year after mining operation achieves positive discounted NPV (breakeven)

The simplified cashflow model gives the following project NPVs over the total life of the mine (operations + closure):

Scenario	**Net Present Value (NPV) (Millions) at Year 39**
Scenario 1: No Wind	$372
Scenario 2: Wind at Closure	$481
Scenario 3: Wind at Mine Breakeven	$516
Scenario 4: Wind at Year 0	$603



The socio-economic benefits of wind power projects are estimated to be approximately 130 construction jobs at peak for a 100 MW project with approximately 7-11 long term full-time equivalent (FTE) employees per 100 MW of installed capacity (Adelman, 2020). It is therefore estimated that greater than 100 jobs would be created during the construction process, with approximately 14 to 22 long-term jobs throughout the duration of the project in addition to those jobs created from the mining operation.

The model did not account for savings in mitigated environmental damages from the disturbance of two sites (one for the mine site, and one for the wind energy facility). It is suggested that future works examine the benefits of minimizing the environmental disturbances by co-siting mining and renewable projects. Opportunities for co-siting can include innovations such as the installation of photovoltaic solar panels over surface water conveyances (McKuin, et al., 2021).

The financial model also does not include any reductions in closure bonding or financial assurance. There may be regulatory mechanisms facilitating the return of financial assurance (e.g., bond return) for mine closure which could further offset the capital costs for renewable energy construction.

The capital cost required to develop mining projects is already a challenge faced by mining operators; it is likely that increasing capital expenditure requirements by adding in renewable energy infrastructure would be unpalatable to financial decision makers and shareholders. One solution to the challenges posed by the capital expenditures required to develop renewable energy generation in these scenarios is the model of Renewable Energy as a Service (REaaS), wherein a third-party develops the renewable energy infrastructure, and sells the electricity generated to the mining company. This marginally increases power costs over the life of mine compared to if the mining company owned the infrastructure outright, but alleviates the burden of capital expenditure.

Conclusions and Forward-looking Statements - Where Next?

The successful installation of renewable energy capacity on mine affected lands across the globe indicates that renewable energy is a viable, sustainable post-mining land use which should be considered for projects in the Canadian context.

The recently passed Inflation Reduction Act in the United States of America includes provisions for "Energy Communities" which are defined as "*areas… that have been economically reliant on the extraction, processing, transport, or storage of coal, oil, or natural gas but now face higher-than-average unemployment*." (The White House, 2023). With the introduction of financial incentives for developing renewable energy projects in areas which have been reliant on extractive fossil fuel industries, it is not unreasonable to suggest that similar measures may be developed to support socio-economic transitions from mining economies to renewable energy economies.

The social benefits associated with renewable energy land use at mined sites can be substantial. Continued revenue generation from the renewable energy facility supports good-paying jobs and training opportunities for mine workers.

Finally, Canada has a wealth of renewable electricity generation options, from wind to water to solar to geothermal. To achieve pledges in the 2015 Paris Agreement, the need for low-carbon electricity generation is anticipated to double in the next twenty years, which means a tripling of electricity capacity for renewable and variable sources of electricity. Substantial investments in renewable energy are expected in the next decades and the mining industry could play an important role in meeting these targets in Canada.

References

Adelman, L. (2020, April). *Wind Turbine Economic Impact: Local Employment.* Retrieved from University of Michigan: https://graham.umich.edu/media/pubs/Wind-Turbine-Economic-Impact-Local-Employment-46932.pdf

Arctic Council Working Group. (2023, 04 12). *Diavik Wind Farm Yellowknife Canada*. Retrieved from Arctic Council Working Group: https://arctic-council.org/about/working-groups/acap/home/projects/arctic-black-carbon-case-studies-platform/diavik-wind-farm-yellow-knife-canada/

ARENA. (2021, March 24). *Kidston gold mine lives on as pumped hydro plant*. Retrieved from ARENAWIRE - Australian Renewable Energy Agency: https://arena.gov.au/blog/queensland-gold-mine-lives-on-as-pumped-hydro-plant/#

Australian Renewable Energy Agency. (2019, February). *South Australian zinc mine to be converted into Australia's first compressed air facility for renewable energy storage*.

BC EMLI. (2014, June 25). Release of "Lease Area" and "SRW Access Road" from Reclamation Permit M-74. Victoria, British Columbia, Canada: British Columbia Ministry of Energy and Mines.

BC EMLI. (2022, November). Health, Safety and Reclamation Code for Mines in British Columbia. Victoria, British Columbia, Canada: Government of British Columbia. Retrieved from https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/mineral-exploration-mining/documents/health-and-safety/code-review/health_safety_and_reclamation_code_nov2022.pdf

Butler, C. (2019, November 24). *How an old Goderich salt mine could one day save you money on your hydro bill.* Retrieved from CBC News: https://www.cbc.ca/news/canada/london/goderich-ontario-compressed-air-energy-storage-1.5369478

Chowdhury, D., & Sircar, A. (2023, 01 20). *Fortescue sees renewables overtaking iron ore business*. Retrieved from Mining.com: https://www.mining.com/web/fortescue-sees-renewables-overtaking-iron-ore-business/

Cowley, P. (2023, January 12). Use of agricultural land for solar farms a growing concern for rural residents. *Red Deer Advocate*. Red Deer, Alberta, Canada.

Desroches, D. (1992). *Geothermal feasibility study for the use of hot water near Riondel, British Columbia.* Vancovuer: Geological Survey of Canada.

Emissions Reduction Alberta. (2020). *Biosalix: Mine Reclamation and Biomass Production*. Retrieved April 12, 2023, from https://eralberta.ca/projects/details/biosalix-mine-reclamation-and-biomass-production/

Envest. (2022, 04 12). *Voisey's Bay Wind*. Retrieved from Envest: https://envestcorp.com/voiseys-bay-wind/

Evans, H. (2017). Harnessing the Heat of the Earth: Using an Old Mine for New Energy. Victoria: University of Victoria.

Fortescue Metals Group. (2022, September 20). *Fortescue Announces Execution Plan for Industry Leading Decarbonisation.* Retrieved from FMG ASX Release: https://www.fmgl.com.au/docs/default-source/announcements/fortescue-announces-execution-plan-for-industry-leading-decarbonisation.pdf?sfvrsn=7b20d3db_2

Ghomesei, M. (2007, July 01). *Geothermal energy from Con Mine for Heating the City of Yellowknife, NWT: A concept study.* Retrieved from U.S. Department of Energy: https://www.osti.gov/etdeweb/biblio/21036526

Hargreaves, J., Lock, A., Beckett, P., Spiers, G., Tisch, B., Lanteigne, L., . . . Soenens, M. (2012). Suitability of an organic residual cover on tailings for bioenergy crop production: A preliminary assessment. *Canadian Journal of Soil Science, 92*, 203-211. doi:https://doi.org/10.4141/cjss2010-056

Jessop, A. (1995). Geothermal Energy from Old Mines at Springhill, Nova Scotia, Canada. *World Geothermal Congress.* International Geothermal Association.

Riot Tinto. (2022, 11 30). *Rio Tinto plans further investment in renewable energy in the Pilbara*. Retrieved from RioTinto: https://www.riotinto.com/en/news/releases/2022/rio-tinto-plans-further-investment-in-renewable-energy-in-the-pilbara

Simard, S., Fytas, K., Paraszczak, J., Laflamme, M., & Agbossou, K. (2017). Wind power opportunities for remote mine sites in the Canadian North. *Renewable Energy and Power Quality Journal*, 173-178. doi:10.24084/repqj15.262

Stehly, T., & Duffy, P. (2022, December). *2021 Cost of Wind Energy Review.* Retrieved from https://www.nrel.gov/docs/fy23osti/84774.pdf

TETHYS. (2023, April 14). *NedPower Mount Storm LLC*. Retrieved from TETHYS: https://tethys.pnnl.gov/organization/nedpower-mount-storm-llc

The MIning Association of Canada. (2021, 07 30). *Glencore's Focus on Wind Power*. Retrieved from The Mining Association of Canada: https://mining.ca/resources/canadian-mining-stories/glencore-wind-power/

The White House. (2023, January 9). *Building A Clean Energy Economy: A Guidebok to the Inflation Reduction Act's Investments in Clearn Energy and Climate Action.* Retrieved from https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf

U.S. EPA. (2009, January). *Re-Powering America's Land: Siting Renewable Energy on Potentially Contaminated Land and Mine Sites - Summitville Mine, Rio Grande County, Colorado Success Story Hydroeleftric Plant Powers Contaminated Water Treatment at Former Gold Mine.* Retrieved from United States Environmental Protection Agency: https://www.epa.gov/sites/default/files/2015-04/documents/success_summitvillemine_co.pdf

U.S. EPA. (2011). *Celebrating Success: Molycorp, Inc. Questa, New Mexico.* Retrieved from doi:107.7748/en.16.6.11.s14

U.S. EPA. (2011). *Shining Light on a Bright Opportunity Developing Solar Energy on Abandoned Mine Lands.* Retrieved from United States Environmental Protection Agency: https://semspub.epa.gov/work/11/176032.pdf

U.S. EPA. (2012, March 010). *A Breath of Fresh Air for America's Abandoned Mine Lands Alternative Energy Provides a Second Wind.* Retrieved from United States Environmental Protection Agency: https://semspub.epa.gov/work/11/176038.pdf

U.S. NRC. (2003, July 29). *A Breath of Fresh Air for America's Abandoned Mine Lands Alternative Energy Provides a Second Wind*. Retrieved April 14, 2023, from Nuclear Regulatory Commission Library: https://www.nrc.gov/docs/ML0532/ML053210103.pdf

Ussiri, D. A., Guzman, J. G., Lal, R., & Somireddy, U. (2019, June). Bioenergy crop production on reclaimed mine land in the North Appalachian region, USA. *Biomass and Bioenergy, 125*, 188-195. doi:https://doi.org/10.1016/j.biombioe.2019.04.024

Vale. (2018, 08 14). *Waterpower Management*. Retrieved from Vale: http://www.vale.com/canada/EN/aboutvale/communities/health-safety-environment/our-environment/water/water-sudbury/waterpower-management/Pages/default.aspx

van de Ven, D.-J., Capellan-Peréz, I., Arto, I., Cazcarro, I., de Castro, C., Patel, P., & Gonzalez-Eguino, M. (2021). The potential land requirements and related land use change emissions from solar energy. *Nature*, 12. doi:https://doi.org/10.1038/s41598-021-82042-5