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Commentary

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What will Canadian green jobs really look like?

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The phrase "green jobs of the future" immediately evokes powerful images of solar technicians perched on rooftops, wind turbine mechanics suspended from towering windmills, and electricians retrofitting homes with better insulation. Such appealing visions make for eye-catching billboards and evocative political speeches, and there is little doubt that occupations like these will continue growing as the world pursues a low-carbon future.

Yet it is important to broaden this conceptualization of jobs created by the clean technology sector. The clean energy transition is more akin to a new industrial revolution, one that will depend on many sectors of the economy and parts of the workforce that may not, at first glance, seem to align with environmentalism's traditional objectives.

Particularly in Canada, green jobs could ultimately look a little different from the clean tech workforces of other countries. The global push towards net-zero emissions will transform power generation, transportation, industry, agriculture, and more, requiring the mobilization of vast quantities of materials and a large-scale rethinking of how to produce the energy that modern society requires. Considering such needs, Canada's chief contribution to worldwide climate efforts may well take the form of mined critical minerals, processed metals, and innovative clean generation technologies like advanced geothermal power and small nuclear reactors.

For Canada, a country with considerable mineral resources, sizeable industrial energy requirements, and a strong need to guide workers through the transition to a low-carbon economy, investing in such sectors can both accelerate broader climate progress and yield high economic returns. In addition to expected growth in “conventional” sectors of the green economy, areas like critical minerals and nuclear technology not only correspond to Canadian strengths but will likewise experience increasing global demand.

The path to decarbonization will thus benefit from an open-minded approach that recognizes the clean energy transition’s need for miners, aluminum smelters, and nuclear power plant operators – and that will consider those jobs as full-fledged green jobs in their own right.

Responsible mining for clean technologies

The clean energy landscape of the future will fundamentally be built using mined commodities (Tsafos 2022), and it will be better not just for Canada but also arguably for the world if more of those minerals and finished materials are sourced from Canada. From solar modules to wind turbines, batteries to transmission lines, hydrogen electrolyzers to low-carbon aircraft, clean technologies require both basic materials and critical minerals in vast quantities.

Ambitious climate efforts will thus drive expanded global demand for strategic minerals at scales considerably exceeding today’s current rate of usage. This will necessitate not only a continued supply of raw materials but also the development of new mining capacity to avoid potential resource constraints. Projected increases in material demand are virtually unavoidable according to modelling and research by the World Bank (Hund, La Porta, Fabregas, Laing, and Drexhage 2020) and the International Energy Agency (IEA 2021), even assuming different technological pathways or greatly improved techniques for recycling minerals from existing waste streams.

This expectation is driven by the higher material intensity of wind and solar generation infrastructure per unit of electricity produced. A 50 MW solar facility requires 3000 tonnes of steel, 1000 tonnes of aluminum, and 350 tonnes of copper (IRENA 2017). An onshore wind farm with 25 turbines of 2 MW each requires 6500 tonnes of steel, 250 tonnes of aluminum, close to 90 tonnes of copper, and up to 10 tonnes of rare earth metals (Razdan and Garrett 2015). Offshore wind turbines, with large moorings and long transmission cables back to shore, may require several times more steel and copper per unit of capacity (Chipindula, Botlaguduru, Du, Kommalapati, and Huque 2018). While such clean energy technologies provide innumerable benefits in terms of reduced pollution and climate impacts, they nonetheless necessitate greater mineral inputs. Add in the sizeable metal requirements for batteries used in the power and clean vehicle sectors, and the clean energy transition’s dependence upon metals and mining becomes plainly evident.

The World Bank report, *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition*, estimated that the demand for critical minerals such as cobalt and graphite could increase by as much as 500 percent by 2050 (Hund, La Porta, Fabregas, Laing, and Drexhage 2020). Our own research suggests that future demand for copper and aluminum for solar and wind farms could increase to between 10 and 20 percent of current global production (Wang, Hausfather, Davis, et al. 2022). Annual use of neodymium in permanent magnet drives for wind turbines alone could necessitate a tripling of global neodymium production. Meanwhile, neodymium requirements in other clean technologies like electric vehicles will also likely grow. Further, clean technologies are not the only source of future mineral demand with neodymium and other rare earth metals also extensively used in sectors ranging from medical devices to consumer electronics to radar systems.

In the event of limited supply, the price and availability of such mineral inputs could potentially constrain clean energy deployment. Wind farm projects and electric vehicle factories would not grind to a halt due to a shortage of copper or rare earth metals, but commodity cost increases could raise prices for clean technologies or slow the rate at which developers are able to build. On the supply side, mining projects require significant lead times of several years, reinforcing the importance of near-term proactive planning to ensure that mining capacity expands along with growing demand.

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Risks associated with geopolitical events or backlash in the wake of accidents, unsafe labour practices (Searcey, Forsythe, and Lipton 2021), or environmental mismanagement can also threaten to disrupt global supplies. The World Bank (Hund, La Porta, Fabregas, Laing, and Drexhage 2020), IEA (2021), and academic researchers (Sonter, Dade, Watson, and Valenta 2020) have already expressed concern regarding the potential for added global environmental and social impacts caused by expanded mining operations.

In the context of such anxieties, Canada possesses not just large mineral reserves but also favourable characteristics as a geopolitically reliable supply source and as a producer with good environmental, labour, and climate standards. With world governments looking to diversify critical material supply chains and with investors and manufacturers showing increasing interest in responsible sourcing of raw materials, Canada's stable geopolitical relations and high industry standards offer welcome assurances.

Canada is already a key global producer of cobalt (Natural Resources Canada 2022a) and other clean energy inputs such as uranium (Britannica Undated) and will undoubtedly play an influential role in ensuring adequate global flows of mined minerals to support the clean energy transition. Canada is the fifth largest global mine producer of copper (Bokovay 2013) and a top 10 global producer of nickel (Natural Resources Canada 2022b). It also holds sizeable reserves of molybdenum and zinc (Natural Resources Canada 2014) in addition to approximately 40 to 50 percent of the world's known rare earth minerals reserves (Standing Committee on Natural Resources 2014).

Given these considerations, mining sector employment warrants more consideration alongside other green jobs. In 2019, the mining sector directly employed 392,000 people (Natural Resources Canada 2022a) and supported 327,000 additional indirect jobs providing, in total, employment for one in every 50 Canadians. In addition, downstream industrial processes to refine mined ore and produce usable input materials for customers are both substantial and critical. Expansion of the minerals industry can thus also spur the creation of additional jobs at aluminum smelters, nuclear fuel factories, steel plants, and throughout other positions along the materials supply chain from extraction to distribution to construction. As the demand for critical materials increases with the expansion of the clean tech economy, this supply chain workforce has the potential to grow further.

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While the Canadian mining industry demonstrates responsible environmental and labour practices by international standards, mining activities nevertheless produce inherent impacts that highlight the importance of continued improvements and proactive attention to prevent potential harms. Nearby communities should enjoy both ample economic compensation and robust environmental protection from adjacent activities, while having a voice in determining these arrangements. Meaningful engagement with Indigenous communities will be vital for strengthening relationships between the mining industry and First Nations. Pollution control and prevention will also remain crucial as mining activity increases. *The Canadian Minerals and Metals Plan* (Mines Canada 2019) represents a good starting point for efforts in the aforementioned areas. Providing more incentives such as tax deductions for waste reduction practices and stronger policies for abandoned mine reclamation could prove effective for pushing the mining industry towards a smaller environmental footprint.

While environmental activists have often labelled the mining sector as an archnemesis, there is also no escaping the industry's necessity. As the Center for Global Development's Senior Policy Fellow Gyude Moore expressed recently: "Expecting clean energy without externalities is, per Frederick Douglas 'men who want crops without plowing up the ground, they want rain without thunder and lightning, they want the ocean without the awful roar of its many waters'" (2021). No matter one's preferences about the optimal rate of car ownership in a net-zero society or how capable one imagines future recycling techniques will be, the inescapable reality is that the world in 2030 or 2040 will contain many orders of magnitude more windmills, electric vehicles, and battery storage facilities than it does today. That will require more copper, lithium, and cobalt mining, and accepting at least some of the associated tradeoffs of extractive industries.

Negative impacts can and absolutely should be minimized through continual efforts to improve best practices. Canada, already a leader in this regard, can strive further to set a strong example for the world in the decades to come.

Clean energy for the industrial transition

Minerals are far from Canada's only potential contribution to the global clean energy revolution, and Canada's capacity for innovative energy-related research, development, and testing could help produce key clean technologies with sizeable future impacts both domestically and globally. For sectors such as nuclear power, geothermal energy, green hydrogen, or carbon capture and storage, the realization of such research and deployment efforts could create new dedicated green workforces and help secure new employment options for legacy fossil fuel workers.

Canada is a potential leader in future nuclear technology thanks to an active domestic next-generation reactor research and startup community. As a geographically vast nation, rural settlements and far-flung economic sites like mines and lumber mills are currently dependent on expensive diesel generators (Abou-Jaoude, Arafat, Foss, and Dixon 2021), creating a considerable potential domestic market for microreactors and small nuclear reactors. This domestic interest in next-generation reactors may itself pale in comparison to a growing international demand for nuclear power. With substantial experience in exporting designs such as the CANDU reactor abroad, Canada could aim to secure an influential position in the global market with newer technologies.

As the second largest global producer of mined uranium (Natural Resources Canada 2022c), Canada is similarly well-positioned to establish an important role in nuclear fuel manufacturing. The domestic nuclear industry provides a high proportion of well-paying, unionized, and desirable jobs, particularly in regions and communities like northern Saskatchewan where the uranium sector is the largest employer of Indigenous people in Canada (Phillips 2021). All told, the Canadian Nuclear Association (CNA 2012) estimates that Canada's nuclear industry currently employs 60,000 people, generates $7.9 billion in economic activity, and contributes "[US]$1.5 billion in federal and provincial taxes" (World Nuclear Association 2021).

Of course, developing the future of nuclear power in Canada will not be without obstacles, from overcoming political opposition to ensuring a sufficient education and training pipeline of skilled engineers. Canadian policies to promote clean energy research and deployment should adopt a technology-neutral focus to guarantee a level playing field for nuclear projects relative to solar, wind, and hydro. Efforts to promote and grow nuclear engineering programs at both the undergraduate and graduate levels and to attract skilled professionals from abroad could help ensure that Canada meets its workforce needs.

At the same time, there is ample potential for Canada to ensure that its supplies of energy are clean and reliable through other emerging clean energy technologies such as geothermal power, hydrogen, and carbon capture and storage. Canada possesses not only good geothermal and geologic carbon storage resources and a strong record of carbon capture research projects (IEA 2022), but also a large existing oil and gas workforce whose skills will doubtlessly be invaluable (Wang 2020). While the country does not currently host a significant geothermal industry, efforts to develop just 5000 MW of domestic geothermal energy potential could produce nearly 30,000 operations and construction jobs (Canadian Geothermal Energy Association 2022) and offset more than 25 Mt of annual CO2 emissions. The heat from geothermal energy is itself a valuable co-product, such as for heating both residential and commercial spaces.

Canada is already one of the top 10 global hydrogen producers, and possesses the resources and means to push hydrogen into a major alternative domestic energy source. Thanks to the vast array of uses for clean hydrogen, growth of the hydrogen sector can promote decarbonization and growth in areas ranging from energy storage to heavy industry to heating. Under an ambitious scenario for developing an export-based hydrogen sector, the Canadian hydrogen industry could be worth up to $50 billion by 2050 and employ up to hundreds of thousands (Natural Resources Canada 2020).

Definitions of green

The idea that people engaged in mining metals that will be used in batteries or those employed as reactor fuel engineers are also part of the green work-force is not only entirely reasonable, but should be uncontentious. However, it is quite likely that efforts to exclude certain sectors, activities, and forms of labour from being considered part of the green economy will only grow louder in the years ahead. Apart from civilian nuclear energy projects, which have historically been subjected to much hostility, mining is perhaps the only other target to draw the ire of generations of opponents. Opposition to mining is fundamental and ideological, albeit shortsighted and misdirected. Even at a time when the societal need for mined minerals is clearer than ever before, activist intellectuals would rather immerse themselves in delusions that global metal requirements can be "degrown" than concede that new mines ought to be opened (Paulson and Kaden Paulson-Smith 2021).

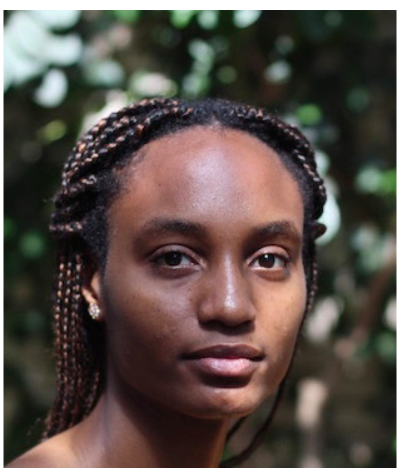
Certainly, objections to mines based on their potential impacts are both understandable and historically well-grounded. But researchers, policy-makers, and industry stakeholders have been, and must continue, to work alongside labour and community members to resolve environmental and safety concerns and uphold high standards and good practices. Similarly, there are valid grounds for strict certification requirements for the clean hydrogen industry or for carbon capture projects to ensure that the carbon intensity of such activities is genuinely comparable to that of other clean technologies. Strong commitments to social responsibility and to continual improvements are basic expectations for any Canadian industry.

Nevertheless, one should recognize that much of the opposition to mining, nuclear power, hydrogen, or carbon capture in addressing climate change is categorical. Some advocacy organizations will echo the call for greater responsibility, but will also retain the strategic intention of setting the goalposts in ways that will make it impossible for any project, anywhere, to ever move forward. Other opponents are committed to stopping such projects even if it means, knowingly or unknowingly to them, undermining labour interests, shifting the impacts of mineral extraction onto communities in poorer, less-regulated parts of the world, or slowing the pace of global climate progress.

The very idea of a "green job" is highly alluring, and therefore sits at the heart of a contentious conflict between aspirational values and the reality of the world in which we live and work. Canada – and the rest of the world – must begin to think more realistically and openly about the kinds of labour it considers "green" if the world is to be successful at addressing our climate challenges effectively and swiftly.

About the authors

Seaver Wang works at the Breakthrough Institute as Associate Director for Asia on the Climate and Energy team, researching topics in energy and broad decarbonization as well as working to link Breakthrough's projects to the latest in earth and climate research. Seaver holds a PhD in Earth and Ocean Sciences from Duke University as well as a BA in Earth Sciences from the University of Pennsylvania. His contributions to researching the links between marine plankton ecology and oceanic cycling of carbon and nitrogen have produced a number of scientific peer-reviewed articles, including publications in the ISME Journal and Nature Communications. He is also a former Chateaubriand STEM Fellow.



Juzel Lloyd is a climate and energy analyst at Breakthrough. Originally from Jamaica, she completed her Bachelor of Science in Mechanical Engineering at Howard University. As a student, she explored various fields through different avenues such as astrophysics research, software development, and machine learning training. She was also a fellow of the 2020 Summer Institute of Sustainability and Energy (SISE) where she finally got a real-world taste of environmental studies by meeting with multiple leaders in the energy industry as well as other students who shared the same drive for making a positive impact in this world.

References

Abou-Jaoude, Abdalla, Yasir Arafat, Andrew Foss, and Brent Dixon. 2021. *An Economics-by-Design Approach Applied to a Heat Pipe Microreactor Concept*. United States, Department of Energy, Office of Scientific and Technical Information. Available at https://www.osti.gov/biblio/1811894-economics-design-approach-applied-heat-pipe-microreactor-concept.

Bokovay, G. 2013. "Copper." *The Canadian Encyclopedia* (December 16). Available at https://www.thecanadianencyclopedia.ca/en/article/copper.

Britannica. Undated. "Resources and Power: Minerals." *Canada: Introduction and Quick Facts*. Britannica. Available at https://www.britannica.com/place/Canada/Resources-and-power.

Canadian Geothermal Energy Association. 2022. "Where Are Geothermal Resources Located in Canada?" Canadian Geothermal Energy Association. Available at https://www.cangea.ca/location.html.

Canadian Nuclear Association [CNA]. 2012. "Economic Impact Study Launch: A Canadian Strategy for Energy, Jobs and Innovation." News Release. Canadian Nuclear Association. Available at https://cna.ca/2012/10/19/economic-impact-study-launch-a-canadian-strategy-for-energy-jobs-and-innovation-2/.

Chipindula, Jesuina, Venkata Botlaguduru, Hongbo Du, Raghava Rao Kommalapati, and Ziaul Huque. 2018. "Life Cycle Environmental Impact of Onshore and Offshore Wind Farms in Texas." Sustainability 10, 6. Available at https://tethys.pnnl.gov/publications/life-cycle-environmental-impact-onshore-offshore-wind-farms-texas.

Hund, Kirsten, Daniele La Porta, Thao P. Fabregas, Tim Laing, and John Drexhage. 2020. *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition*. World Bank Group. Available at https://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf.

International Energy Agency [IEA]. 2021. *The Role of Critical Minerals in Clean Energy Transitions*. World Energy Outlook. IEA. Available at https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

International Energy Agency [IEA]. 2022. *Canada 2022: Energy Policy Review*. IEA. Available at https://www.iea.org/reports/canada-2022

International Renewable Energy Agency [IRENA]. 2017. Renewable Energy Benefits: Leveraging Local

Capacity for Solar PV. IRENA. Available at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jun/IRENA_Leveraging_for_Solar_PV_2017.pdf.

Mines Canada. 2019. *The Canadian Minerals and Metals Plan*. Natural Resources Canada. Available at https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/CMMP/CMMP_The_Plan-EN.pdf.

Moore, W. Gyude (@gyude_moore). "There are costs to the transition to net zero - Expecting clean energy without externalities is, per Frederick Douglas 'men who want crops without plowing up the ground, they want rain without thunder and lightning, they want the ocean without the awful roar of its many waters.'" October 7, 2021. [Twitter Post]. Available at https://twitter.com/gyude_moore/status/1446118658367909895?s=20.

Natural Resources Canada. 2014. *Canadian Reserves*. Information Bulletin. Government of Canada. Available at https://www.nrcan.gc.ca/science-data/science-research/earth-sciences/earth-sciences-resources/earth-sciences-federal-programs/canadian-reserves/15745.

Natural Resources Canada. 2020. *Hydrogen Strategy for Canada: Seizing the Opportunities for Hydrogen*. Government of Canada. Available at https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf.

Natural Resources Canada. 2022a. "Mineral Production." *Minerals and the Economy*. Government of Canada. Available at https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/minerals-and-the-economy/20529#production.

Natural Resources Canada. 2022b. "Nickel Facts." *Minerals and Metals Facts*. Government of Canada. Available at https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/nickel-facts/20519.

Natural Resources Canada. 2022c. "Uranium and Nuclear Power Facts." *Minerals and Metals Facts*. Government of Canada. Available at https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/uranium-and-nuclear-power-facts/20070.

Paulson, Susan, and Kaden Paulson-Smith. 2021. "Degrowth: Less Resource Use for More Wellbeing and Resilience." *Georgetown Journal of International Affairs* (May 9). Available at https://gjia.georgetown.edu/2021/05/09/degrowth-less-resource-use-for-more-wellbeing-and-resilience/ .

Phillips, Leigh. 2021. “Nuclear Power and the Land.” *Canadian Dimension* (August 1). Available at https://canadiandimension.com/articles/view/nuclear-power-and-the-land.

Razdan, Priyanka and Peter Garrett. 2015. L*ife Cycle Assessment of Electricity Production from an Onshore V110-2.0 MW Wind Plant*. Vestas Wind Systems. Available at https://www.vestas.com/content/dam/vestas-com/global/en/sustainability/reports-and-ratings/lcas/LCAV11020MW181215.pdf.coredownload.inline.pdf.

Searcey, Dionne, Michael Forsythe, and Eric Lipton. 2021. *A Power Struggle Over Cobalt Rattles the Clean Energy Revolution*. New York Times (December 7). Available at https://www.nytimes.com/2021/11/20/world/china-congo-cobalt.html.

Seaver Wang, Zeke Hausfather, Steven Davis, et al. 2022. “Materials Demand for Electricity in Climate Mitigation Scenarios.” Research Square. Available through https://www.researchsquare.com/article/rs-1229622/v1.

Sonter, Laura, Marie Dade, James Watson, and Rick Valenta. 2020. “Renewable Energy Production Will Exacerbate Mining Threats to Biodiversity.” *Nature Communications* 11, 4174. Available at https://www.nature.com/articles/s41467-020-17928-5.

Standing Committee on Natural Resources. 2014. *The Rare Earth Elements Industry in Canada – Summary of Evidence*. Canada, House of Commons, 41st Parliament, Second Session. Available at https://www.ourcommons.ca/Content/Committee/412/RNNR/WebDoc/WD6669744/412_RNNR_reldoc_PDF/RareEarthElements-Summary-e.pdf.

Tsafos, Nikos. 2022. *Safeguarding the Global Market for Critical Minerals. Statement before the Standing Committee on Industry and Technology*. Center for Strategic and International Studies. Available at https://csis-website-prod.s3.amazonaws.com/s3fs-public/congressional_testimony/ts220126_Tsafos_Critical_Minerals.pdf?qSj_fpQjOfjcCSDMn0mmxP7AeNgQr.dq.

Wang, Seaver. 2020. “How the Fossil Fuel Industry Could Help Drive Decarbonization.” The Breakthrough Institute (February 25). Available at https://thebreakthrough.org/issues/energy/fossil-fuel-decarbonization.

World Nuclear Association. 2021. *Nuclear Power in Canada*. World Nuclear Association. Available at www.world-nuclear.org/information-library/country-profiles/countries-a-f/canada-nuclear-power.aspx.

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