TRACKING THE ENERGY REVOLUTION 2017

Mining for Clean Energy

How the global rise of solar power will drive demand for Canadian metals and minerals

CLEAN ENERGY CANADA

THE RAPID GROWTH OF CLEAN ENERGY in countries around the world has garnered significant media attention, driven by record-breaking investment and deployment. Less discussed is the associated growth in demand for the metals and minerals used to manufacture clean energy technologies—and the opportunities and challenges this creates for mining companies and communities. This report explores the rise of solar power in particular, the associated metal and mineral requirements, the resulting opportunity for Canadian mines to serve as clean energy enablers, and the imperative of responsible mining.

The Rise of Solar Power

Give someone a pen and ask them to draw the global clean energy transition, and there's a good chance they'll doodle row after row of solar panels. Solar power has become the symbol of the energy transition, and with good reason.

In 2016, the solar industry set a new record, with 73 gigawatts (GW) of new capacity coming online. For context, that's more than half the capacity of Canada's entire electricity grid.[1]

If these numbers seem impressive, they pale in comparison to projections for further growth in the coming decades, as solar photovoltaic (PV) systems become the cheapest source of new power in more and more jurisdictions around the world.[2]

> "The next great technological marvel may be conceived in a glittering San Francisco high-rise, but the raw materials needed to build it will emerge from the murky depths of the grittiest mines."
>
> —Jeremy Deaton, *Popular Science*[3]

Growth in solar PV capacity is creating a boom in demand for solar panels, which in turn is driving demand for the metals and mineral products used to manufacture them. Take Canadian mining firm Ivanhoe Mines: it recently announced plans to develop a major copper discovery in the Democratic Republic of the Congo, citing copper's ubiquity in renewable energy as a motivating factor.[4]

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Thanks to technology improvements and economies of scale, **solar costs fell 58%** between 2010 and 2015.[5]

Over 3 million jobs

GLOBAL EMPLOYMENT IN SOLAR ENERGY

PHOTO: DAVID DODGE

Sunny Outlook

Recent modelling[6] by the International Energy Agency (IEA) found that, to reduce the risk of drastic climate change,[7] the global power sector would need to be transformed—with solar PV playing a dominant role. In this scenario, **solar PV capacity would increase more than 17-fold between 2015 and 2050**.[7] That rapid growth is already underway, with the IEA projecting a rise to 547 GW by 2021—nearly doubling capacity relative to 2015.[8]

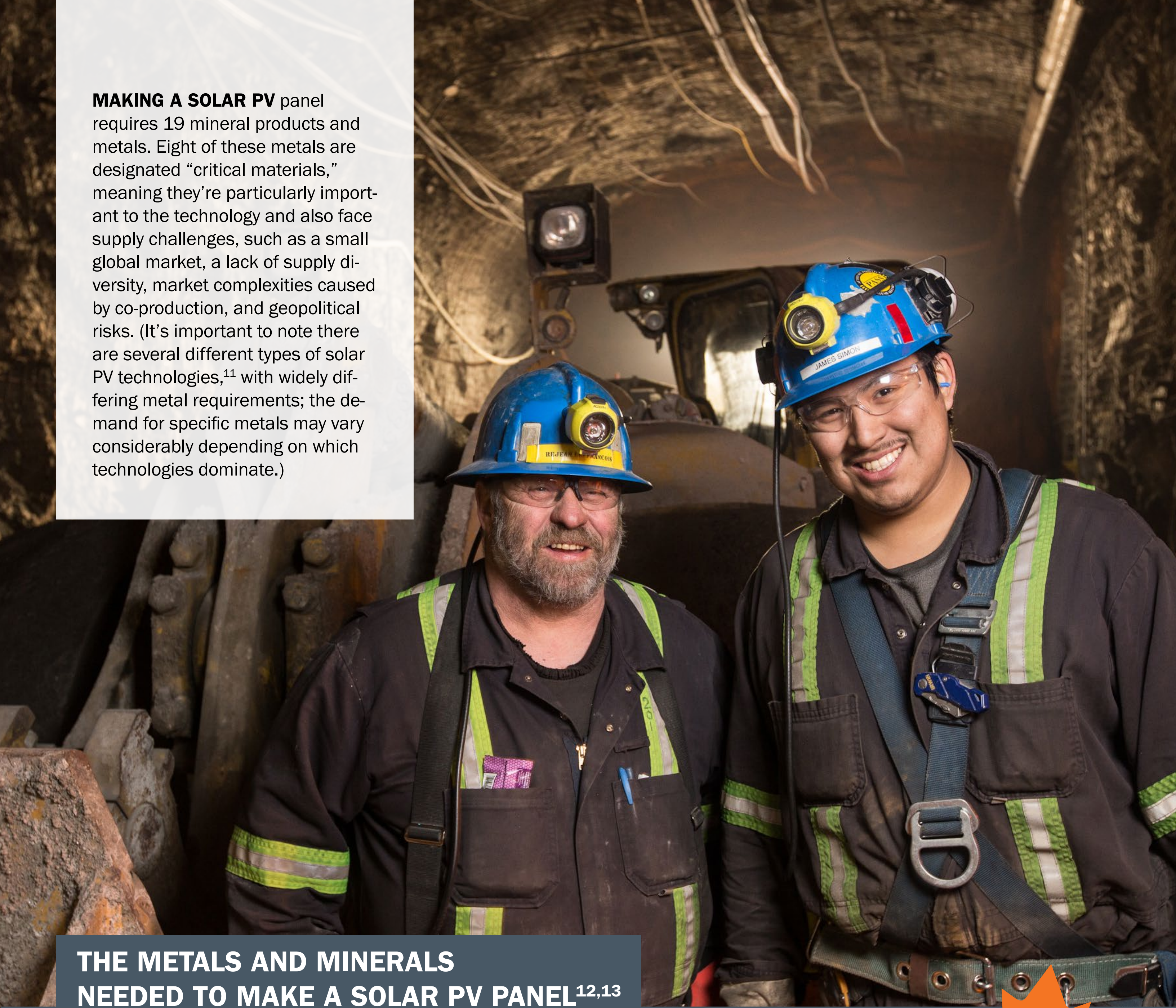
CHINA
In China alone, 30 GW was added in 2016—enough solar panels to cover roughly three soccer fields every hour.

U.S.
In the U.S., solar led all other sources of new electricity last year, with new installations nearly doubling over 2015.

INDIA
In India, new solar capacity more than doubled last year compared to 2015.[9]

IN 2016 INDIA BUILT THE WORLD'S LARGEST SOLAR PROJECT[10]

Generating capacity	Size	Time to build	Cost
648 MW → **150,000 homes**	**2.5 million panels** (10km × 10km)	**8 months**	**C$900 million**



MAKING A SOLAR PV panel requires 19 mineral products and metals. Eight of these metals are designated "critical materials," meaning they're particularly important to the technology and also face supply challenges, such as a small global market, a lack of supply diversity, market complexities caused by co-production, and geopolitical risks. (It's important to note there are several different types of solar PV technologies,[11] with widely differing metal requirements; the demand for specific metals may vary considerably depending on which technologies dominate.)

THE METALS AND MINERALS NEEDED TO MAKE A SOLAR PV PANEL[12,13]

- ○ ● Copper (wiring; thin film solar cells)
- ○ ● Indium (solar cells)
- ● Lead (batteries)
- ● Phosphate rock (phosphorous)
- ● Silica (solar cells)
- ○ ● Selenium (solar cells)
- ● Iron ore (steel)
- ● Molybdenum (photovoltaic cells)
- ● Cadmium (thin film solar cells)
- ○ ● Tellurium (solar cells)
- ● Titanium dioxide (solar panels)
- ○ ● Gallium (solar cells)[14]
- ● Metallurgical coal (used to make steel)
- ○ ● Silver
- ○ Germanium
- ○ Tin
- Arsenic (gallium-arsenide semiconductor chips)
- Bauxite (aluminum)
- Boron minerals (semiconductor chips)

● Found and/or produced in Canada

○ Critical material

Some of these metals and minerals are co-produced with zinc and gold

PHOTO: COPYRIGHT © 2017 RIO TINTO

Will Canadian Mines Emerge as Clean Energy Enablers?

Home to 14 of the 19 metals and minerals needed for PV panels—including six critical materials—**Canada could emerge as a key supplier of resources for the buildout of solar power.**

Canada is known for its mining production and can claim some of the world's largest mining companies, such as Barrick Gold, Teck Resources and Goldcorp. For firms such as these, growth in clean energy technologies—not just solar but also wind turbines, LED lights, and electric vehicle components and batteries—represents a significant opportunity.

Natural Resources Canada has also highlighted the opportunity that clean energy offers to Canada's mining sector. The federal department produced a brief, *Enabling Clean Energy Applications with Canadian Minerals and Metals*,[15] that explores Canada's potential to contribute minerals and metals used for wind turbines, solar cells and high-density batteries. The brief finds that—as a producer, processor and refiner of lead, zinc, copper and gold—Canada is poised to benefit from continued growth in solar PV around the world.

Is solar PV really a clean source of energy?

Given the material requirements of solar PV—as well as the impacts of solar farms—people sometimes wonder whether solar PV is in fact a clean, sustainable source of energy. Environment Canada and Natural Resources Canada have explored this question using lifecycle analysis. They looked at impacts from greenhouse gases, other air pollutants, heavy metals and other chemicals, and how water use and quality are affected; they also considered impacts to landscape and ecology from the manufacturing, operation, maintenance and decommissioning of solar panels.

Their conclusion? While all forms of electricity generation have environmental impacts, **solar PV technologies "have fewer negative environmental impacts" than traditional fossil-fuel-based electricity production.**[16]

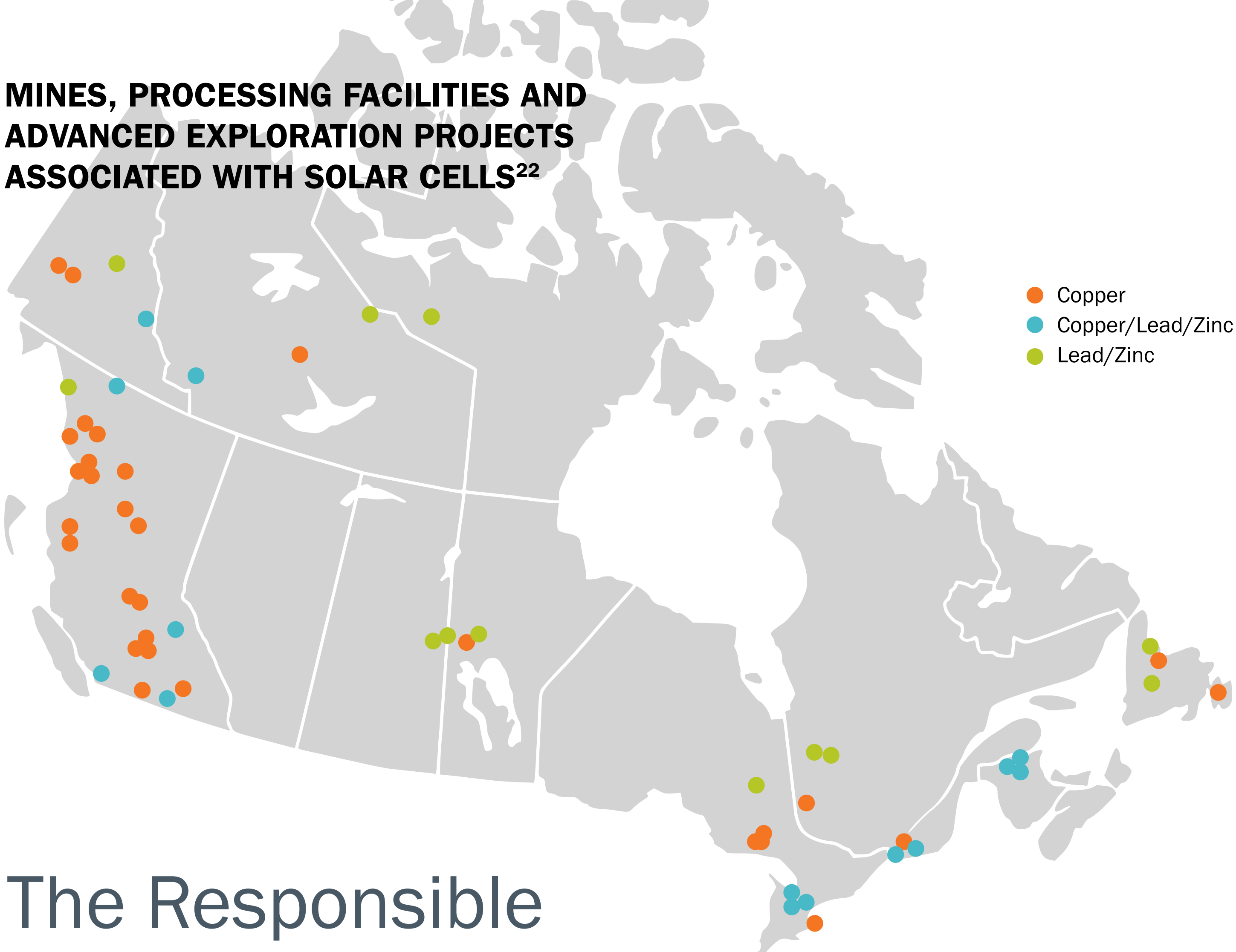
"Copper is the king of metals.... Every single solution drives you to copper—solar power, wind power, electric cars, you name it."

—Robert Friedland, Ivanhoe Mines[17]

COPPER HAS EMERGED AS AN ESSENTIAL MATERIAL IN THE CLEAN ENERGY TRANSITION, not because it is critical for any one technology but because it is critical to the whole clean energy system.[18] From its use in wind and solar technologies, to power transmission lines, to wiring in electric vehicles (electric vehicles require four times as much copper as internal combustion engines),[19] copper is an essential ingredient. The McKinsey Global Institute estimates that primary copper demand could potentially grow by nearly 2% annually, reaching 31 million tonnes by 2035—a 43% increase over current demand of 22 million tonnes.[20] **Canada has the world's 10th-largest copper reserves**, at 11-million tonnes, and was the world's eighth-largest producer in 2016, producing a total of 720,000 tonnes.[21]

PHOTO: JONATHAN ZANDER

MINES, PROCESSING FACILITIES AND ADVANCED EXPLORATION PROJECTS ASSOCIATED WITH SOLAR CELLS[22]



The Responsible Mining Imperative

The global transition to clean energy will create new and growing demand for many of the metals and minerals found in Canada. **But if we are to capitalize on this opportunity, a more responsible approach to mining will be required.** Recent mining accidents—like B.C.'s Mount Polley copper mine disaster, which saw 24 million cubic metres of mine waste and contaminated water spill into nearby lakes in 2014[23]—are fresh in Canadians' memories.

The Mining Association of Canada has the Towards Sustainable Mining program (TSM),[24] a set of tools and indicators adopted by its members to drive performance and responsibly manage mining risks—but it needs wider adoption across Canada and beyond. In another approach to standardizing what "responsible mining" looks like on a global basis, the Initiative for Responsible Mining Assurance (IRMA) has brought together a group of major mining, electronics, jewellery and steel companies, NGOs, affected communities and labour unions to establish a multi-stakeholder and independently verifiable responsible mining assurance system, focused on improving both social and environmental performance.[25]

But TSM only applies to members of the Mining Association of Canada (which are required to apply the program as a condition of membership) while IRMA is voluntary. This means there is no guarantee Canadian mining operations will deliver this standard of performance. Should Canada wish to be a growing contributor of clean-energy-enabling metals and minerals, the federal and provincial governments will need to ensure their regulations are sufficiently stringent to maintain the confidence of Canadians. By adopting a high bar for sustainability performance, Canadian mines would not only achieve greater community and public support, they would also be well-positioned to sell their products to an increasingly discerning clean energy marketplace.

Improving operations

Because many mines are located far from cities, they often produce their own power, traditionally with diesel

generators. But increasingly, these off-grid mines are integrating renewable energy sources. Africa and Australia have emerged as hotspots for integrating solar into mining operations, while Canada and South America are at the forefront of wind-diesel hybrids,[26] such as Diavik Diamond Mines' system in the Northwest Territories and Glencore's wind power and energy storage facility at its Raglan mine.[27,28] Looking abroad, Canadian mining company Iamgold recently announced an agreement to use solar power as a source of electricity for its Burkina Faso gold mine, after its successful deployment of solar power at its mine in Surinam.[29] Thanks to hydro-dominated electricity grids and the rise of off-grid renewable energy, Canada is home to some of the least carbon-intensive mining companies in the world.[30]

Some mines are also exploring electrification—switching from fossil fuels to clean power—for their operations. At Goldcorp's Borden gold mine in Ontario, electricity and battery-powered equipment will eliminate virtually all greenhouse gas emissions associated with the movement of ore and waste rock—or about 50% of the mine's total potential emissions.[31]

Add to all that experience operating in provinces with carbon pricing, and Canada's mining industry is positioned to be competitive in global markets that increasingly factor in climate change performance.

IN THE FUTURE, recycling could become the new mining. Recognizing how many materials go into building solar panels, the solar industry has been making plans to re-use components as solar panels reach the end of their lives. This is not only to cut down on waste but also to recycle metals and minerals, unlocking a large stock of materials and other valuable components.[32] It has been estimated that by 2030, the materials technically recoverable from recycled PV panels could produce approximately 60 million new panels. (To put that in perspective, though, 180 million new panels were produced in 2015.)[33]

Researchers at the University of British Columbia have successfully "mined" copper and silver from LED lights, and they believe electronic waste will prove to be a richer source of metals than mined ores.[34] (Here, Canada may benefit as well: the world's largest processor of electronic scrap containing copper and precious metals is the Horne Smelter in Quebec.)[35] In the future, **recycling solar PV panels and other electronic waste, such as LED light bulbs, will increasingly contribute to the supply of minerals and metals needed for their construction.** For now, there will be an ongoing need for the extraction of raw minerals and metals to support the clean energy transition.

A Clean Growth Opportunity

For many Canadians, a clean energy job probably conjures up images of working in an engineering lab, manufacturing solar panels, or assembling a wind turbine. But the economic opportunity associated with the clean energy transition is much broader. It will support job creation and economic growth in sectors like mining that often aren't top-of-mind in conversations about clean growth.

For mining workers and communities across Canada, the clean energy transition will create opportunities for economic development and revitalization. Metals and minerals are essential to increasing the global supply of renewable energy, not to mention smart grids, LED light bulbs and electric cars.

While it may be surprising to some, Canada's mining sector can play an essential role in enabling the technologies that will help the world address climate change and achieve clean growth, both through its own environmental performance and by producing the metals and minerals required for clean energy technologies. It's an opportunity not to be missed.

PHOTO: GOLDCORP

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