Integrating Clean Energy into Mining Operations

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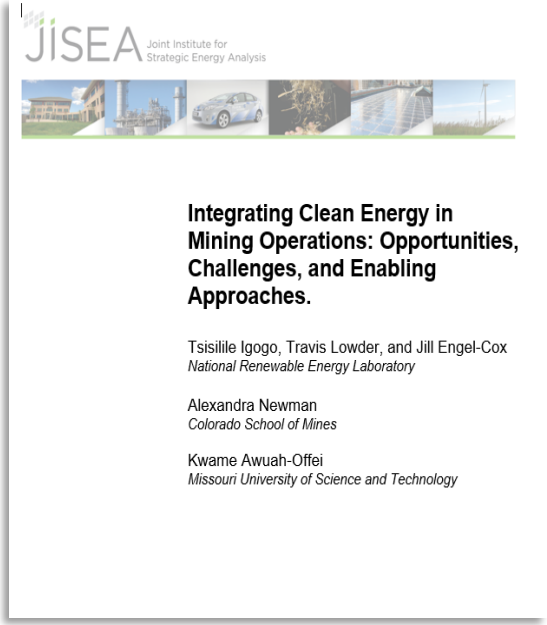
NREL Publications on Renewables for Mining and Oil & Gas


JISEA Joint Institute for Strategic Energy Analysis

Integrating Clean Energy in Mining Operations: Opportunities, Challenges, and Enabling Approaches.

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[*Integrating Clean Energy in Mining Operations*]

JISEA Technical Report, 2020


Applied Energy

Integrating renewable energy into mining operations: Opportunities, challenges, and enabling approaches

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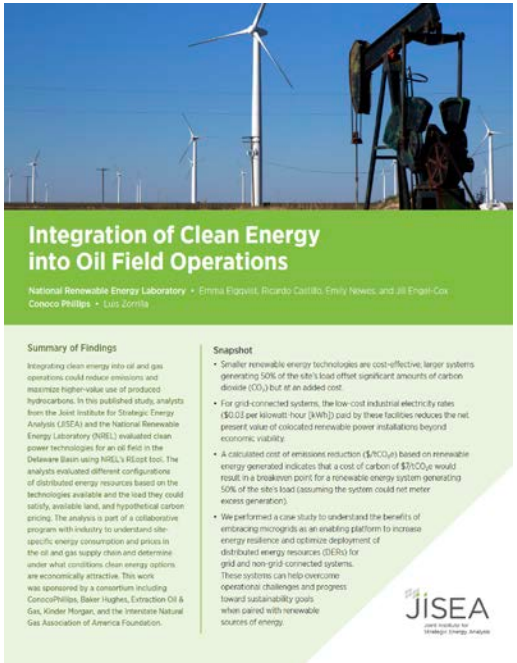
ARTICLE INFO

ABSTRACT

1. Introduction

[*Integrating Renewable Energy in Mining Operations*]

Applied Energy 2021


Integration of Clean Energy into Oil Field Operations

National Renewable Energy Laboratory • Emma Elgqvist, Ricardo Castillo, Emily Newes, and Jill Engel-Cox
Conoco Phillips • Luis Zorrilla

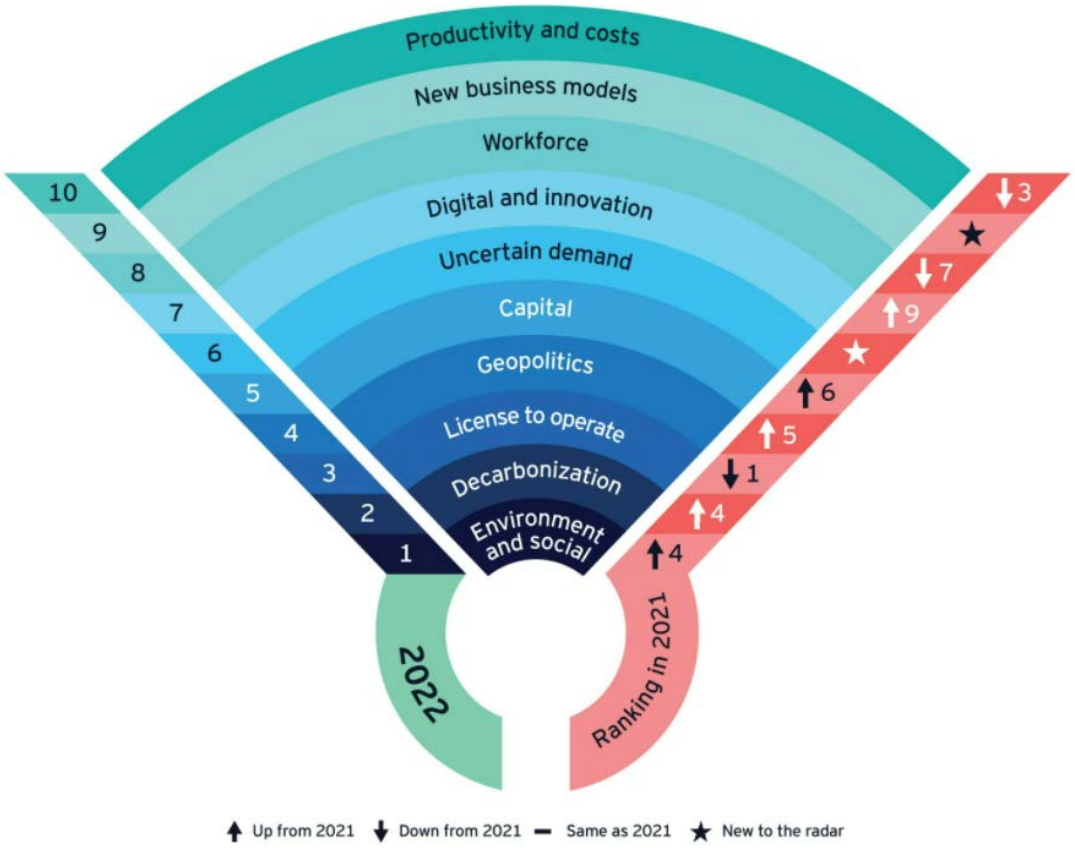
Summary of Findings

Snapshot

JISEA

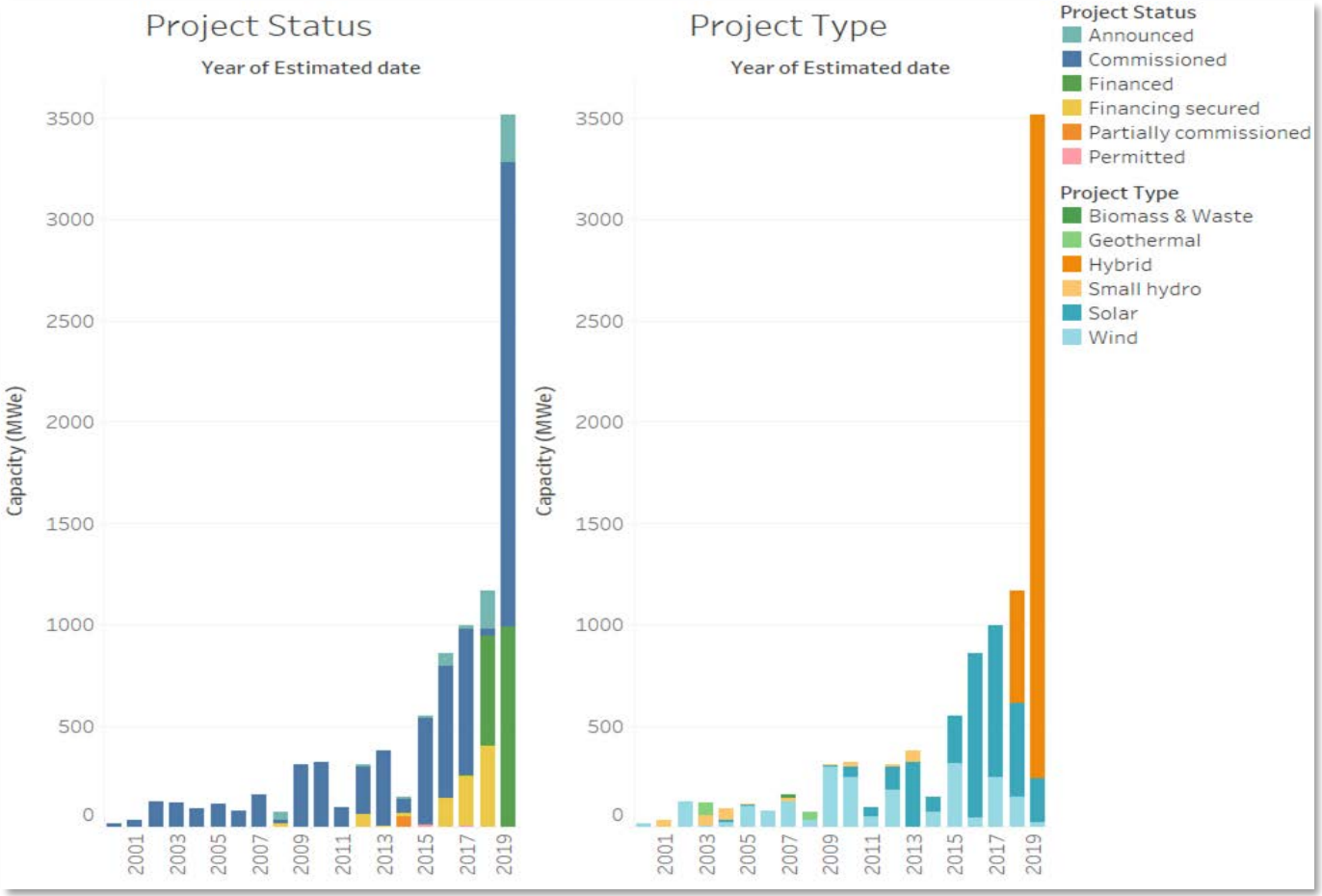
Series on Oil and Gas, see https://www.jisea.org/clean-energy-opportunities-in-the-oil-and-gas-sector.html

Clean Energy in the Mining Industry



Source: [Mitchell 2021]

Clean energy deployment addresses EY's top three business risks to the mining industry



Global Renewable Energy Projects Serving Mining Operations
Source: BNEF 2019

In 2015 there were about **600 MW** of renewable energy projects serving mine sites

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In 2020, over **5 GW** cumulative of renewable energy projects serving mining operations have either been installed or are planned

Carbon Reduction and Net-Zero Goals

21 of 30 largest mining and metals companies have set some kind of net-zero emissions target

Climate goals of top 30 metals and mining companies

Institution name	Market cap ($B)	Climate goal	Scope 1 & 2	Scope 3
Existing net-zero target				
BHP Group	134.21	BHP is party to a net-zero pledge by members of the International Council on Mining & Metals.* Additionally, BHP is "pursuing the long-term goal of net-zero Scope 3 greenhouse gas emissions by 2050."	Target 2050	Target 2050
Rio Tinto Group	109.65	Rio Tinto is party to a net-zero pledge by members of the International Council on Mining & Metals.* The company targets a 50% reduction in Scope 1 and Scope 2 emissions by 2030.	Target 2050	Not addressed**
Vale SA	70.83	Vale is party to a net-zero pledge by members of the International Council on Mining & Metals.* Vale set an interim target of a 15% reduction in its Scope 3 emissions by 2035 and to become carbon neutral by 2050.	Target 2050	Target carbon neutral by 2050
Glencore PLC	62.61	Glencore is party to a net-zero pledge by members of the International Council on Mining & Metals.* Glencore aims to achieve "net-zero total emissions by 2050."	Target 2050	Target 2050
Freeport-McMoRan Inc.	47.76	Freeport-McMoRan is party to a net-zero pledge by members of the International Council on Mining & Metals.* It separately pledged to "develop a more robust understanding of how we can move beyond our aspirational vision to a science-based net-zero pathway."	Target 2050	Not addressed
Anglo American PLC	43.52	Anglo American is party to a net-zero pledge by members of the International Council on Mining & Metals.* Additionally, Anglo American targets carbon-neutral Scope 1 and 2 emissions by 2040 and to halve Scope 3 emissions by 2040.	Target 2040	Halve Scope 3 emissions by 2040
Newmont Corp.	43.46	Newmont is party to a net-zero pledge by members of the International Council on Mining & Metals.* The company's ultimate goal is to be "carbon neutral" by 2050.	Target 2050	Target 2050
Fortescue Metals Group Ltd.	33.35	Fortescue is targeting net zero Scope 1 and Scope 2 emissions by 2030 and net-zero Scope 3 emissions by 2040.	Target 2030	Target 2040
Barrick Gold Corp.	32.18	Barrick Gold is party to a net-zero pledge by members of the International Council on Mining & Metals.* The company's ultimate "vision is net-zero greenhouse gas emissions by 2050 achieved primarily through [greenhouse gas] reductions and certain offsets for hard to	Target 2050	Target 2050

Source: Kuykendall 2021

Clean Energy in Mining

Mine Energy Loads and Sources

Mining process	Activities and Equipment	Fuel Source
Exploration, Extraction and Auxiliary Operations	Ventilation: HVAC	• Electricity • Natural Gas
	Drilling: Loader trucks, diamond drills, rotary drills, percussion drills, drill boom jumbos	• Electricity • Diesel • Compressed Air
	Dewatering: Pumps	• Electricity
	Digging: Hydraulic shovels, cable shovels, continuous miners, longwall mining machines, drag lines, front-end loaders	• Electricity • Diesel
	Power supply: Generators	• Fossil Fuel
Material Handling	Discrete transportation systems: Haul trucks, service trucks, bulldozers, pickup trucks, bulk trucks, load-haul dumps, shuttle cars, hoists	• Diesel • Electricity
	Continuous transportation systems: Conveyor belts, pumps, pipelines	• Electricity
Beneficiation and Processing	Comminution	• Electricity
	Crushing: Crushers	
	Grinding: Mills	
	Separations: Physical: Floating, centrifuge; and Chemical: Electrowinning	• Electricity • Fossil Fuels
	Drying, Firing, Smelting: Oven/Furnace	• Fossil Fuels
	Refining e.g. Electrolytic refining, fire refining	• Electricity • Fossil Fuels

Every mine operation has different requirements, but in general and across sites, **electricity** comprises the largest energy demand

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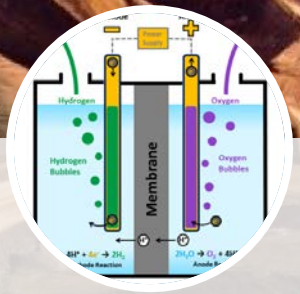
Most of that electricity is derived from **fossil fuels**

Clean Energy Applications in Mining

Renewable onsite electric loads

Zero-emissions mobility



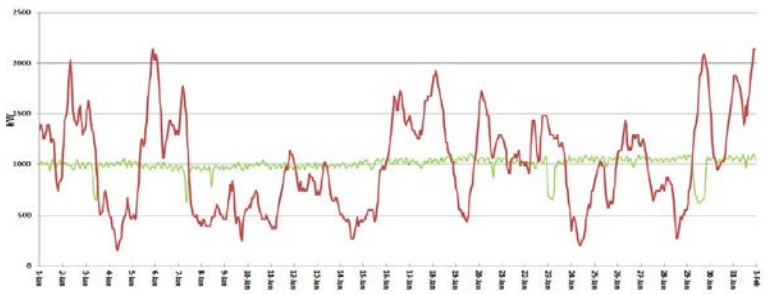
Green hydrogen applications

Low emission process heat and feedstocks

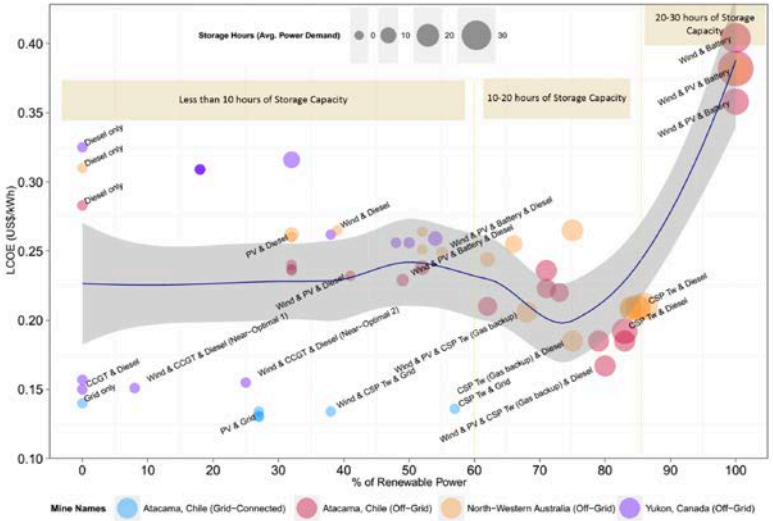
High — Technology Readiness Level — Low

Supplying Onsite Electric Loads

- Wind, solar, and—in some cases—energy storage—are commercial technologies that can offset diesel-fired electric generation
- Variability of generation is a challenge since mine sites often have consistent 24/7 loads.
- Long term energy storage or dispatchable modular power systems needed to enable higher levels of renewable energy
- Breakthrough technologies include electrolytic hydrogen, flow batteries, and small modular nuclear reactors



Wind generation curve overlaid on mine load curve
Source: Hatch 2019



Technology levelized cost of energy as a function of renewable power and storage for four mine sites
Source: Guilbaud 2016

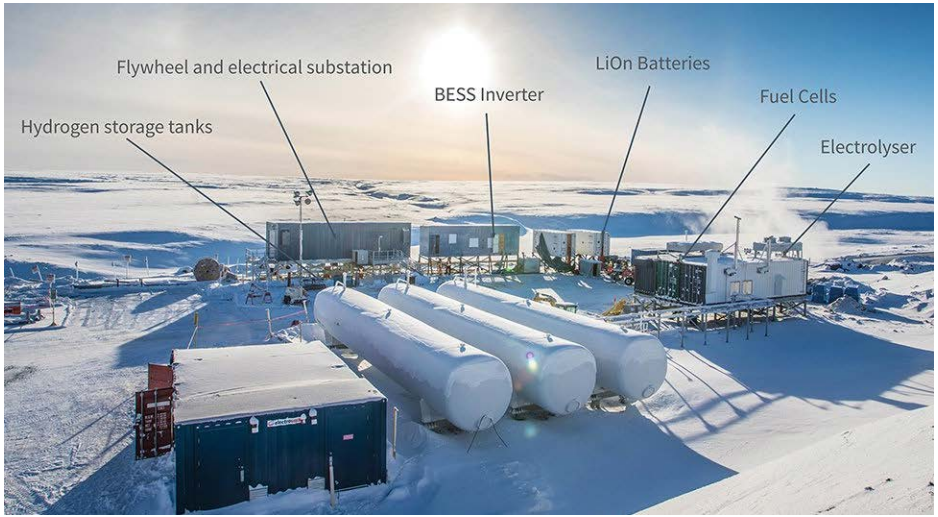
Zero Emissions Mobility

- Electrifying transport reduces both GHG and air emissions
- Can also facilitate deeper integration of variable renewable generation by having vehicle batteries act as storage devices, or having electrolyzers produce H_2 for use in haul trucks
- While trolley assist and other electric transport (e.g., conveyors) have a market track record, Li-ion and H_2 are still emerging technologies for heavy off-road vehicles

Hydrogen fuel cell excavator prototype
Source: JCB

Green Hydrogen

- H_2 can be used as an energy carrier for electricity generation, storage, mobility, process heat, or as a feedstock
- H_2 prices, supply chain, and technology readiness are still major barriers
- While some mining companies are investing heavily in an H_2 future, most analysts believe that low-cost green hydrogen at least a decade out from this reality



Glencore Raglan Mine
Source: Engineering News 2020

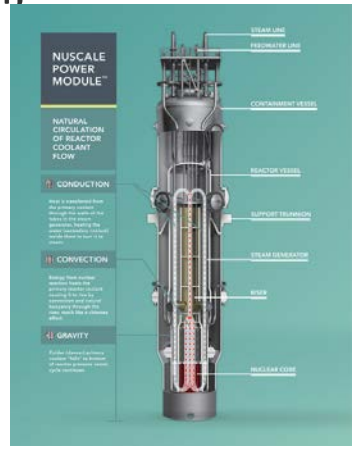
Process Heat and Feedstocks

- Many low- and no-carbon thermal technologies, such as concentrating solar, have not been commercially demonstrated for mining applications, but R&D is accelerating
- Electrification of process heat can be a pathway to incorporating renewable generation, both on mine sites and on the grid generally
- Alternative fuels and feedstocks for mineral processing require additional R&D to ensure process efficiency and product quality
  - E.g., H_2 reduction of iron ore

High-temperature heat pump

Biomass

Electric boiler



Small modular reactor
(Source: Nuscale)

Solar thermal

Challenges and Opportunities for Integration

Conclusion

Renewable energy technologies need mined materials, and mining operations can benefit from using renewable energy

Barriers:

- Conflicting business models between mine operators and renewable energy developers
- Lack of renewable energy expertise and demonstrations in the mining industry
- Land constraints and suitability

Enablers:

- Aligning incentives and using innovating contract structures
- Designing mine site energy management and making loads more flexible
- Capacity building and training
- Technology development and R&D
- Supply chain certification
- Policy and regulatory measures
- Collaboration!

Thank you!

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