COEUR MINING

Hotspot Analysis

MGMT 543 - LCA

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1. Overview

For thousands of years, the precious metals[1] of gold and silver have been a benchmark and symbol of wealth, prosperity, and opulence. The economic and societal repercussions for the pursuit of these high-value resources have held considerable influence over our day-to-day lives, penetrating aspects from jewelry and art to currency, electronics, culture, and history.[2] From El Dorado to the California Gold Rush and beyond, civilization's persistent infatuation with and search for gold and other precious metals has been a driving factor in the structuring of modern-day economics, policy, and consumerism. Although no government currency still relies directly on The Gold Standard,[3] it is far from being decoupled from monetary value, and therefore seems improbable that humanity's pursuit for gold, silver, and other metals will regress through the 21st Century and beyond.

While demand expects to remain unchanged overall or even increase,[4] the scale and magnitude of extracting ever more minerals from the natural environment has led to growing concern over environmental and societal impacts that traditionally accompany precious metal mining operations. Given the industrious nature that commercial mining activities typically entail, with high energy, land, and chemical intensities necessary for extraction and refining, this analysis performs a life cycle assessment (LCA) review while exploring one growing North American precious metals producer, to estimate the company's relative hotspots of environmental and social concern and formulate recommendations for improvement.

2. Coeur Mining

Coeur Mining Inc. (Coeur) is a Chicago based precious metals producer with operations located throughout the United States, Canada and Mexico. Coeur's primary business involves the discovery, development and extraction of Gold, Silver, Zinc and Lead across their five owned & operated mines, covering over 200,000 acres of land and employing approximately 2,000 people across the geographies. Two of their mines focus on gold-only production, two mines produce gold-silver, and one mine produces silver-zinc-lead.[5] As of year-end 2020, Coeur had 421,088,000 short tons of proven reserves plus another 85,518,000 short tons of probable reserves across their operations (all ores).[6]

Coeur's company values include a dedication to "Pursuing a Higher Standard" by protecting people, places and planet, developing quality resources and delivering impactful results. Although Coeur allegedly violated several of US EPA's mine pollution discharge regulations in 2015[7] and holds a contiguous track record of expensive environmental fines,[8] the company claims to be actively monitoring and addressing their overall footprint, including the creation of a leadership overviewed Environmental, Social and Governance (ESG) program focused on environmental and societal benefits including:

[1] "Precious metals are rare, naturally occurring metallic chemical elements of high economic value." https://onlygold.com/facts-statistics/history-of-gold/
[2] https://yourstory.com/mystory/43c15dc59b-top-usage-of-gold-in-various-industries
[3] https://www.investopedia.com/ask/answers/09/gold-standard.asp#:~:text=For%20example%2C%20if%20the%20U.S.,of%20the%20system%20in%201973
[4] https://www.investopedia.com/financial-edge/0311/what-drives-the-price-of-gold.aspx
[5] https://www.coeur.com/company/about/
[6] https://www.coeur.com/operations/operations/reserves-resources/
[7] https://www.epa.gov/newsreleases/epa-and-coeur-alaska-settle-over-alleged-kensington-mine-pollution-discharges
[8] https://violationtracker.goodjobsfirst.org/parent/coeur-mining

[9]

3. Environmental Impacts of Mining

While it may be stereotypical to envision a lone "forty-niner" panning a clear stream for gold and other precious metals, modern day mining processes that support the likes of jewelry, electronics, and medical products are often highly industrialized, massive in scale, and have significant impacts on the environment.[10]

The prospecting process for large scale mines typically starts with a geological analysis to identify viable locations and potential yields of extracted metals. After a location has been adequately diligenced, permitted, and financed (a process that can take over ten years),[11] extraction operations can finally get underway. The building of infrastructure and deployment of human and physical capital needed to start operations can trigger significant impacts to the environment as well as nearby communities. Such startup activities encompass transportation of equipment and resources, land manipulation, sub-surface manipulation, water use, electricity use, and forced community livelihood impacts, all of which contribute to both local and global environmental health for ages to come.

Categorizing such impacts has been the task of several key life cycle assessments conducted to evaluate environmental and social impacts of extracting gold, silver, and other non-ferrous metals. Nuss and Eckelman (2014) investigated cradle-to-gate environmental burdens of 63 metals, finding that gold and platinum metal groups displayed the highest environmental concern, dominated by the purification and refining stages of transforming the ores to metallic form, and

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[9] https://www.coeur.com/_resources/pdfs/2019-Annual-Report.pdf

[10] González-Campo et al. 2020

[11] https://www.gold.org/about-gold/gold-supply/how-gold-is-mined/exploration

with the metals and mining sector overall constituting an estimated 9.5% of global primary energy demand. Fernandez and Klimas (2019) found the global warming potential (GWP) of a 14 carat (k) 8-gram piece of gold jewelry to be more than 100 times that of the equivalent mass of silver jewelry (288.2 kg CO_2e versus 2.68 kg CO_2e, respectively), a magnitude explained by Norgate and Haque (2012) to be largely due to the low grades of ore used in the production of gold as compared to silver and other metals. "Operating activities, especially excavation, ore, and waste rock transportation, blasting, ore processing, and tailing treatments, are the main impacts produced during the exploitation phase and are involved in climate change, particulate matter formation, and land destruction".[12] A handful of studies shed light on the main environmental impact categories associated with mining besides GWP, spanning terrestrial acidification, human and freshwater toxicity, fossil fuel depletion, natural land transformation, water use, and metal depletion.[13] [14] [15] [16] By comparison, zinc and lead have been found to be relatively environmentally friendly,[17] and therefore have been excluded from the scope of analysis despite these metals' inclusion in Coeur's scope of operations.

Not to be overlooked, considerations around social life cycle assessment and ethics impacts have also been examined for their role in understanding the sustainability of the jewelry industry, to which precious metal mining feeds.[18] Despite intuitive assumptions that extracting lucrative mineral resources can provide positive regional poverty-alleviation prospects, evidence suggests mining on average leads to poverty exacerbation and negative gross domestic product (GDP) growth, regardless of its importance to a national economy.[19] Land conflicts are also common, particularly in Latin America (where Coeur operates its Palmarejo, Mexico gold-silver mine).[20] Nonetheless, gold mining projects continue to spread due to international demand for gold.

4. Industry Comparison

To better understand the magnitude of the environmental impacts from Coeur and the precious metal mining industry, sustainability reports were reviewed from both Coeur and its expected competitors to identify key environmental categories that were publicly disclosed. All assessed mining companies were at least producers of gold.

Companies assessed along with Coeur included:

- Newmont - A large global player in the mining industry
- Kinross - A similar sized company as Coeur
- Royal Gold, Inc. - A company that disclosed almost no environmental benchmarks or plans

The following table (p. 4) highlights environmental impact categories most identified across all four analyzed mining companies; green indicates a company's acknowledgement of an impact being relevant to their organization, while red indicates no publicly available disclosure or corporate reporting about the impact could be found. Compared to industry competitors, Coeur calls attention to most categories, but is silent on certain relevant impacts that its competitors have called out.

[12] Yao et al., 2020
[13] Farjana et al. 2019a
[14] Farjana et al. 2019b
[15] Li et al. 2014
[16] González-Campo et al 2020
[17] Farjana et al. 2018
[18] D'Eusanio et al. 2019
[19] Pegg 2006
[20] Urkidi 2010

Environmental Impact	Coeur	Newmont	Kinross	Royal Gold Inc
GHG Emissions				
Climate Change				
Waste				
Permit Issues				
Water Management				
Biodiversity				
Tailings Management				
Closure (End of Mine Life) Plan				
Air Emission				
Cyanide Management				

It is important to note that Royal Gold, Inc. presents the least elaborate environmental reporting of all reviewed organizations. A single page on the company website states, "With fewer than 30 professional and administrative employees across four professional offices in [the] United States, Switzerland, and Canada, Royal Gold's direct environmental footprint is modest."[21] The company does not outline any impact categories qualitatively or quantitatively; therefore, Royal Gold will not be further analyzed in the following section.

The following analysis synthesizes and compares several reporting categories identified by Coeur, Newmont, and Kinross. Corporate reports presented by all three companies were relatively dense with generally low "skim value," but the authors of this analysis are newly discovered LCA enthusiasts and were nevertheless able to collect key findings.

Greenhouse Gas Emissions

All three companies tracked energy consumption and usage in different ways. Coeur was the only one to call out different scopes, though they omitted all scope 3 emissions. Kinross reported energy in gigajoules (GJ) where Coeur and Newmont recorded in metric tons of CO_2e .

Coeur Mining

Coeur "track[s] total energy usage and energy usage relative to tons processed and ounces produced,"[22] though they only callout scope 1 & 2 emissions in the annual report.

- Scope 1 emissions rose from 145,820 Metric Ton CO_2e in 2015 to 184,876 Metric Tons CO_2e in 2019[23]
- Scope 2 emissions dropped from 117,632 Metric Tons CO_2e in 2015 to 91,943 Metric Tons CO_2e in 2019 (up slightly from 2018)

Newmont Corporation

Newmont states a will to "[switch] from diesel to natural gas or biofuels, as well as purchase or generate renewable energy."[24] They also aim to reduce GHG emissions in accordance with the Paris Climate Accord of 2015

- From 2013 to 2019, Newmont's annual GHG emissions dropped from 3.81 million metric tons of CO_2e to 3.55 million metric tons of CO_2e
- During the same period, energy intensity dropped from .65 tons of CO_2/ GEO to .56 CO_2/ GEO

[21] https://www.royalgold.com/esg/environment/
[22] https://www.coeur.com/responsibility/environment/
[23] https://www.coeur.com/responsibility/environment/
[24] https://s24.q4cdn.com/382246808/files/doc_downloads/2019/sustainability/Newmont-2019-sustainability-report.pdf

Both reductions seem small, leaving Newport work to do if they are to abide with the Paris Climate Accord.

Kinross Gold Mining

Kinross boasts significantly lower emissions per kg of gold mined versus their competition.

However, Kinross' total annual emissions and energy intensity have gone up in the last five years.

- Annual emissions rose from 16,571 GJ/ year to 21,592 gG/ year between 2015 and 2019[25]
- Energy intensity rose from 141.4 MJ/ ton of ore processed to 158.2 MJ / ton between 2015 and 2019

While the results are not encouraging, Kinross does have the most extensive, and easily digestible energy section of the mining companies examined. Unlike their competition, Kinross delivers skimmable graphs and charts, while clearly outlining company goals.

Water Management

Coeur Mining

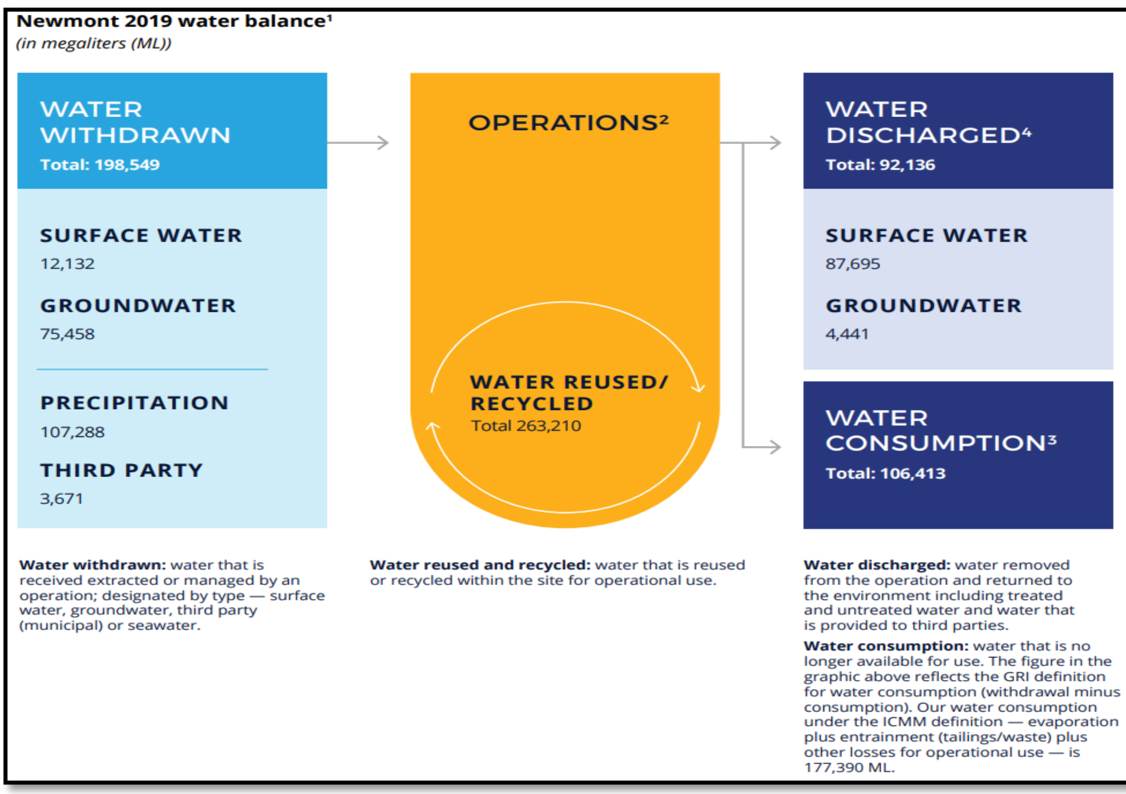
Coeur Mining did not attach any quantitative measures or impacts to their water management strategy on a meta level.

They do highlight one project, Rochester, where the plan to "implement the process of recycling cooling water for the furnace emissions control system (the Wet Electrostatic Precipitator) which is estimated to save approximately 25 million gallons (94,635 cubic meters) of water each year."[26]

Newmont Corporation

Newmont Mining provided a more detailed assessment of their water use, as displayed in the figure below.

Newmont clearly illustrates the process in which they withdraw, use, and discharge water. The operations section, where they reuse and recycle water, is a key metric they aspire to grow in the coming years. A simple graphic such as this goes a long way in terms of transparency and tracking metrics like water management.



[27]

[25] https://s2.q4cdn.com/496390694/files/doc_financials/2020/Kinross-Gold-2019-Sustainability-Report.pdf

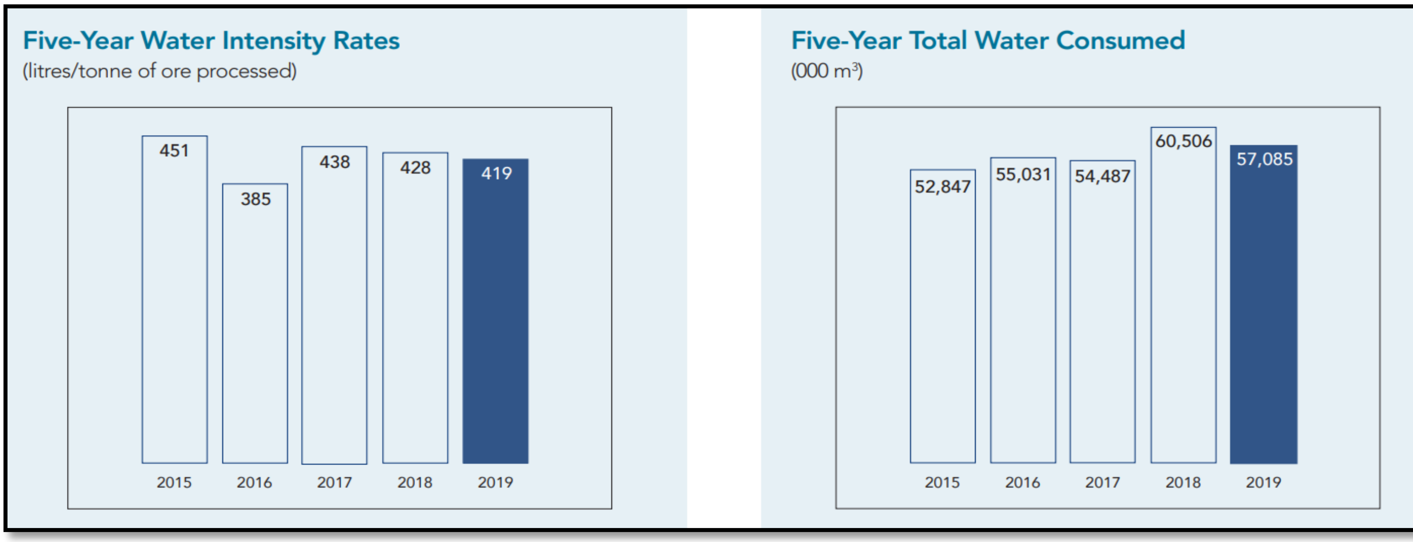
[26] https://www.coeur.com/_resources/pdfs/2019-Responsibility-Report.pdf

[27] https://s24.q4cdn.com/382246808/files/doc_downloads/2019/sustainability/Newmont-2019-sustainability-report.pdf

Kinross Gold Mining

Kinross provided in-depth performance reviews in terms of water management, and offered quantitative charts to supplement the progress, as displayed in the following chart.

While water intensity dropped from 2015-2019, water consumed rose, peaking in 2018. Kinross' water recycling rates have stayed consistent over the same 5-year period.[28]



Closure Planning

Coeur, Newmont, and Kinross all boast qualitative best practices concerning resource management, and end of mine life cycle reclamation projects. All three state they monitor and minimize environmental impacts and do what they can to return their sites to pre-project natural levels.

Newmont is the only to attempt to quantify, and actually make, closures a true impact category, as displayed below. In 2019, Newmont met these metrics across all former sites, reclaiming ~150 hectares of land.

Target definition	Target for regions/sites
• Percent of concurrent final reclamation activities/associated actions executed against the site plan	• 90 percent of concurrent final reclamation/ associated activities annual plan achieved

[28] https://s2.q4cdn.com/496390694/files/doc_financials/2020/Kinross-Gold-2019-Sustainability-Report.pdf

5. Life Cycle Assessment (LCA) - Literature Hotspots

Environmental

Gold and silver mining occurs throughout the world, and due to global differences in economic dimensions, geological nuances, and technological advancement rates, various extraction systems exist. LCAs have been performed on some of these, from open-pit gold mining in China,[29] Peru,[30] and Côte d'Ivoire,[31] to small-scale artisanal mining in Peru.[32],[33] Direct comparison of environmental burdens between studies is difficult due to the incongruity of mining processes in each case, inconsistency of boundaries and units,[34] and the relative dearth of LCAs of precious metal mining overall that have been performed to date. Even several examined LCA studies admit to a lack of obtainable data (i.e., Valdivia and Ugaya 2011). Nevertheless, qualitative themes about impact categories emerge across all these existing LCAs, and because most studies have adopted a common practice of setting the functional unit as 1 Kg of metal, some quantitative comparisons can be interpreted as well. A comparison of impact category data across a diversity of precious metal mining LCAs follows.

LCA Study	Operation (Country)	Functional Unit	GWP/Climate Change (kg CO2 eq)	Ozone Depletion (kg CFC-11 eq)	Terrestrial Acidification	(Frsh, Mrn, Trr) (kg P+N eq)	Human Toxicity (C, NC)	Eco-Toxicity (T, F, M)	Mercury Emissions (Kg)	Cyanide (kg)	PM Formulation (kg PM2.5 eq)	Land Transformation (m^2)	Water Depletion	Metal Depletion (kg FE eq)	Fossil Depletion (kg oil eq)	Tailings (kg)
Chen et al. (2018)	Open-pit (China)	1 Kg Au	55,500	1.15×10^{-4}	207.25 kg SO_2 eq	5.7	4370 kg 1,4 DB eq	44.17 kg 1,4 DB eq			67.6	330.41	461.25 m^3	2.16×10^{10}	9.98×10^3	
Farjana et al. 2019 (b)	Open-pit Gold, Coupled (Au-Ag) (Papau NG)	1 Kg Au	33,000	2.17×10^{-3}	233.2 molc H+ eq	67.7	0.0016 CTUh	3100 CTUe	0.00185	8.93	28.55		225.67 m^3			3.3×10^5
	Open-pit Gold, Combined (Au-Ag-Zn-Cu-Pb) (Sweden)	1 Kg Au	5,670	1.34×10^{-4}	0 molc H+ eq	0.0	0.0072 CTUh	1630 CTUe	0.0017							3.17
	Open-pit Silver, Coupled (Au-Ag) (Papau NG)	1 Kg Ag	444	5.26×10^{-5}	191.71 molc H+ eq	62.1	0.0020 CTUh	1193.14 CTUe	5.4E-06	0.067			359.74 m^3			8.05×10^3
	Open-pit Silver, Combined (Au-Ag-Zn-Cu-Pb) (Sweden)	1 Kg Ag	97	2.29×10^{-6}	38.88molc H+ eq	4.3	0.0002 CTUh	288.84 CTUe	5.78E-05		0.000108					0.05
Fernandez and Klimas (2019)	Open-pit (Various)	8g Au	36,025													
	Open-pit (Various)	8g Ag	335													
González-Campo et al. 2020	Open-pit (Unspecified)	2.17×10^8g Dore	7.5×10^{22}									2.3×10^{23}	1.3×10^{22}	1.9×10^{22}		
Kahhat et al. (2019)	Large, Medium, Small, Artisinal (Peru)	1 Kg Au	31,000				1.92×10^{-2} cases	5.65×10^6 PAF*m3*day					67,000 - 100,000 m^3			
Valdivia and Ugaya (2011)	Open-pit Alluvial, Small Scale (Peru)	1 Kg Au (99.5%	20,223						0.06 - 0.14			373	49013 t			73000 t
	Alluvial, Underground (Peru)	(80.0% Purity)	65,357						0.2 - 2.2			364				22489 t

The table above reveals a commonality of impact categories across studies, particularly for gold mining: GWP/climate change, water use, land depletion, acidification, human- and eco-toxicity, mercury, and air quality impacts of particulate matter creation and ozone. Focus on these primary categories was evident throughout multiple studies ranging various mining types and locations. Extraction processes also varied between and within studies, causing large ranges in data even where functional units and boundaries could be compared.

Still, constants of high GWP (averaging 35,000 kg CO_2e per 1 kg gold), toxicities, and water and land depletion emphasize gold mining's harshest environmental tolls. (By comparison, the LCA review reiterated the significantly smaller environmental footprint of silver mining across all impacts.) Precious metal mining occurs across a variety of biomes, from barren desert to biodiverse rainforest, making land depletion a difficult impact to compare between studies or against Coeur. Finally, several studies highlight human and eco-toxicity impacts as key findings of gold mining, due to the use of mercury and/or cyanide in leaching, but Coeur is not transparent about the extent of their use or handling of these chemicals, little more than briefly mentioning either's use in only two of five mines' technical reports.[35] [36]

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[29] Chen et al. 2018
[30] González-Campo et al. 2020
[31] Yao et al. 2021
[32] Valdivia and Ugaya 2011
[33] Kahat et al. 2019
[34] Santero & Hendry 2016
[35] https://www.coeur.com/_resources/technical-reports/2020-12-16-Rochester-Technical-Report-Final.pdf
[36] https://www.coeur.com/_resources/pdfs/Technical%20Reports/Wharf%20TR.PDF

What environmental metrics and performance Coeur does disclose to the public are found in its 2019 Responsibility Report:[38]

- 3,736,606 thousand GJ of energy consumed in 2019
  - 78% on-site fuel usage (diesel, gasoline, and natural gas) vs. 22% grid electricity
  - 1 million+ MWh equivalent of electricity required (roughly the equivalent annual production of a 400 MW solar plant)
- Scope 1 CO_2-equivalent (CO_2e) emissions of 184,876 metrics tons (MT); Scope 2 CO_2e emissions of 91,943 MT
- 4,459 acres of disturbed land and 682 ac of reclaimed land
- 73% year-over-year reduction in 'significant spills'[37]
- In 2019, the Rochester mine in Nevada recycled 291% more water than it withdrew from ground, surface and municipal sources

These reporting categories are better than nothing, but certain figures lack contextual appreciation, while other categories important in many mining LCAs like water use and chemical waste are either absent in Coeur's reports or only draw on a single location's successes.

Social

Mining areas are generally higher in "economic inequity, AIDS, alcoholism, prostitution, and child labor, accentuating poverty and social conflict" than relatable non-mining areas.[38] Often, the places high-value metals are derived from receive little benefit. For Coeur, this appears to be a meaningful trend to buck, but is not as substantive as it could be.

A dedicated Responsibility page of the company's website highlights Coeur's proactivity in partnering with local communities for hiring employees (71% local in 2019), providing direct short and long-term financial support, charitable contributions, volunteering, and tax and royalty payments to local and indigenous governing bodies.[39] Its Silvertip, Canada operations appear particularly committed to First Nations communities; less is stated about whether Coeur actively engages with indigenous Native American or Indigenous Mexican peoples. The company alludes to their avoidance of high-conflict and geopolitically sensitive areas but appears to only highlight their achievements without any reference to areas of needed improvement. Given rising consumer awareness and purchasing preferences away from conflict jewelry, Coeur appears poised to disassociate itself from this negative image through its strong message of commitments to local communities.

6. Recommendations

Based on our review of Coeur Mining, certain competitors, and the mining industry, we recommend the following actions to address the environmental impacts from the extraction of precious metals:

- Increase the use of Grid Electricity:
  - Given the length of a mining operation, consider options to work with the closest electric utility to bring transmission lines to the mine
  - Consider on-site solar, wind, energy storage or other Distributed Energy Resource systems
    - Mining operations require wide swaths of land that could be used for renewable development
  - Sign a Power Purchase Agreement (PPA) that could be backed by renewables and include Renewable Energy Certificates (RECs)

[37] "Coeur internally defines a significant spill as the following amounts spilled outside of secondary containment: any amount of cyanide process solution; greater than or equal to 25 gallons of petroleum hydrocarbons; or greater than or equal to 5 gallons of untreated domestic sewage." https://www.coeur.com/_resources/pdfs/2019-Responsibility-Report.pdf p. 69
[38] Pegg, 2006
[39] https://www.coeur.com/responsibility/our-communities/#commitment-to-local-communities

    - Purchase Carbon Offset Credits
        - While this would not result in a direct reduction of emissions from their operations, the offset can serve as a benefit to the planet and help spur renewable development
- Continue to invest in modern equipment:
    - By investing in modern equipment and machinery such as electric, LNG, biofueled or high efficiency powered equipment, the overall fuel efficiency of the fleet will increase[40]
    - Purchase equipment with idling control technologies to reduce unnecessary emissions[41]
    - Continue to invest in LNG generators over diesel[42]
- Improve water management practices:
    - Continue to invest in recycled water systems to lower water use and reduce environmental impacts from run-off or leaching
- Expand local community interaction:
    - Hire more local employees, support the local economy (worker's dollars being spent, increased tax revenue)
    - Create mining education or local community support programs
- Include more transparent environmental practices, using Newmont and Kinross as benchmarks:
    - Provide easily digested, quantitative charts, graphs or other visual aids to tell the story, good or bad. Benchmarking needs to begin somewhere

7. Conclusion

Precious metals such as gold and silver are critical materials that penetrate numerous aspects of our everyday lives. Through our assessment, it is abundantly evident that operations to procure and produce these materials have significant environmental impacts throughout the entire life cycle. Given the rise in the need for precious metals to support new technologies (electronics, battery storage, etc.), combined with increased demand and growing consumer consciousness, mining companies such as Coeur will continue to be motivated to extract as much of the materials as logistically and economically possible.

Coeur's corporate disclosures identify key environmental and societal topics related to their operations including climate change, energy use, emissions, water management, waste, tailings, health & safety, diversity, and community. Understanding the magnitude of each of these components can not only help Coeur as a business but also the planet overall.

[40] https://www.cat.com/en_US/news/machine-press-releases/new-cat-d6-debuts-worlds-first-high-drive-electric-drive-dozer.html
[41] https://thermex-systems.com/idle-reduction-systems/
[42] https://www.kinetrexenergy.com/7-myths-lng-diesel-fleets/#:~:text=LNG%20produces%2020%25%20less%20carbon,free%20Three%2DWay%20Catalyst%20Aftertreatment

8. Appendix


"Dirty Gold"
This is how the world's commercial gold is processed today.
Waste rock from the mine is used to build the dam, retaining the toxic slurry in a pond where solids settle and compact.
Ore collected from gold mines
Gold dissolved using toxic cyanide
Gold recovered from the ore, remaining toxic slurry is disposed in tailings dam
Extracted gold is further refined for smelting
Molten gold is poured into moulds producing bars of bullion
"Clean Gold"
This is how the world's commercial gold should be processed.
Ore is clean and recovered from extraction
Cleaned ore is buried back into the earth
Ore collected from gold mines
Gold dissolved using non-toxic reagent
Gold is recovered from the ore using polymer
Leftover reagent is recycled and reused
Extracted gold is further refined for smelting
Molten gold is poured into moulds producing bars of bullion

Expanded view: Comparison of impact category data across mining LCA literature.

LCA Study	Operation (Country)	Functional Unit	GWP/Climate Change (kg CO2 eq)	Ozone Depletion (kg CFC-11 eq)	Terrestrial Acidification	(Frsh, Mrn, Trr) (kg P+N eq)	Human Toxicity (C, NC)	Eco-Toxicity (T, F, M)	Mercury Emissions (Kg)	Cyanide (kg)	PM Formulation (kg PM2.5 eq)	Land Transformation (m^2)	Water Depletion	Metal Depletion (kg FE eq)	Fossil Depletion (kg oil eq)	Tailings (kg)
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