# Minerals and Metals for a Low Carbon Future: The Need for 'Climate Smart Mining'


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**Climate Change**


EGPS
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# Presentation outline

01

1. Why a low-carbon future will be more mineral intensive

02

2.Implications for mineral rich developing countries

03

3. Defining 'Climate Smart Mining

04

4. Conclusions and Next Steps

# Implications of a Carbon Constrained Future for Minerals and Metals

# Without metals there would simply be no low carbon future possible…



## One 3-MW turbine contains

- 335 tons of steel, including 1 ton of metallurgical coal
- 4.7 tons of copper.
- 1,200 tons of concrete (cement and aggregates)
- 3 tons of aluminum.
- 2 tons of rare earth elements.
- zinc
- molybdenum

Source: (NW Mining Association)

# Electric Vehicles (EVs): EVs are set to triple in two years



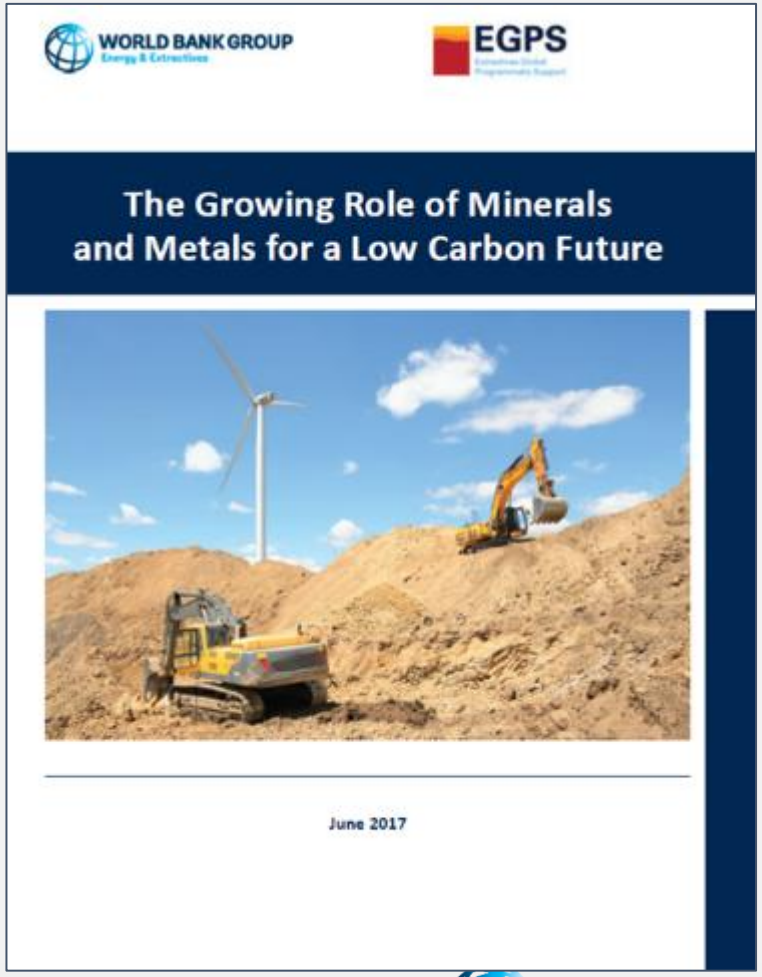
Electric hybrid cars use twice as much copper as non-hybrid cars


# The Growing Role of Minerals for a Low Carbon Future



**Examines the implications of changing material requirements for the mining and metals industry as a result of a low carbon energy future.**

- How can resource rich developing countries in Latin America best position themselves to take advantage of the evolving commodities market ?

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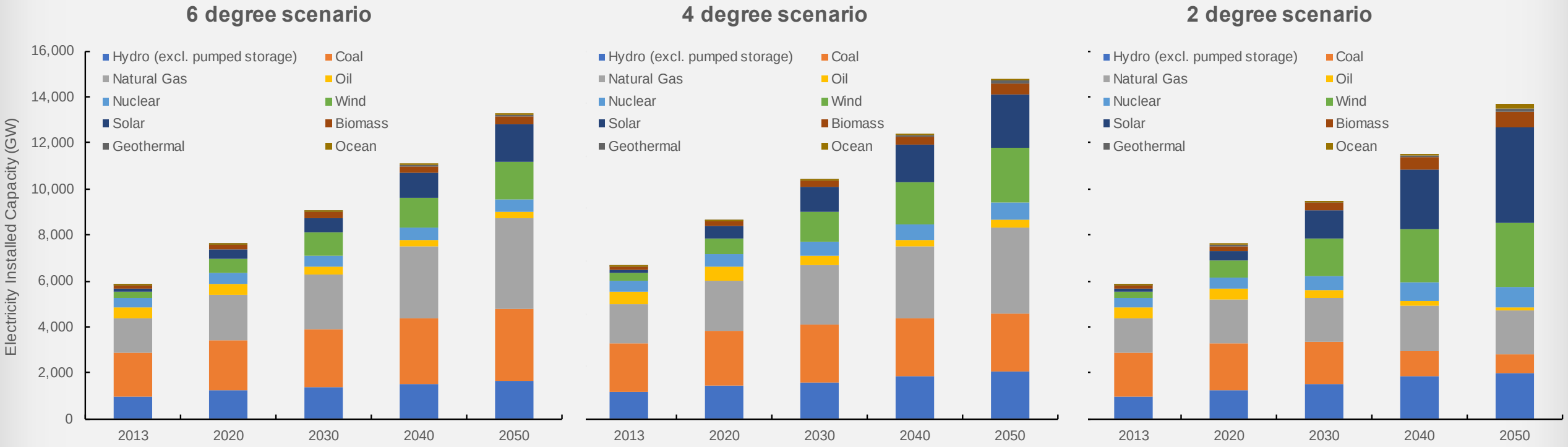
# IEA's ETP 2016 Scenarios



IEA's Energy Technology Perspective Scenarios For Electricity Installed Capacity




Source: IEA ETP 2016

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# Technology Studied



| | |
|---|---|
| Wind | Onshore |
| | Offshore |
| Solar | Photovoltaics – crystalline silicon |
| | Photovoltaics – CdTe |
| | Photovoltaics – CIGS |
| | PV – amorphous silicon |
| | CSP |
| Energy Storage (split between li-ion, lead-acid, other) | Automotive |
| | Grid-scale |
| | Decentralise |

- Additionally, metal demand from key fossil fuel technology was accounted for to provide a baseline
- Limitation on inclusion of other technology, such as CCS, because of lack of studies on the material demand of those technologies
- Limited to generation technologies. Aspects such as a metal demand from grid expansion are not accounted in the study.

# Intra-Technology Choice Matters



## Comparison of Metal Content

### Wind Turbines Technologies

| | Geared | Direct drive |
|---|---|---|
| Aluminum | X | X |
| Copper | X | X |
| Chromium | X | X |
| Iron | X | X |
| Lead | | X |
| Manganese | X | X |
| Nickel | X | X |
| Neodymium | | X |
| Steel | X | X |
| Zinc | X | X |

### Solar PV Technologies

| | c-silicon | CIGS | CdTe | a-silicon |
|---|---|---|---|---|
| Aluminum | X | | | |
| Copper | | X | X | |
| Indium | | X | | |
| Iron | X | | | |
| Lead | X | | | |
| Nickel | X | | | |
| Silver | X | | | |
| Zinc | | | X | X |

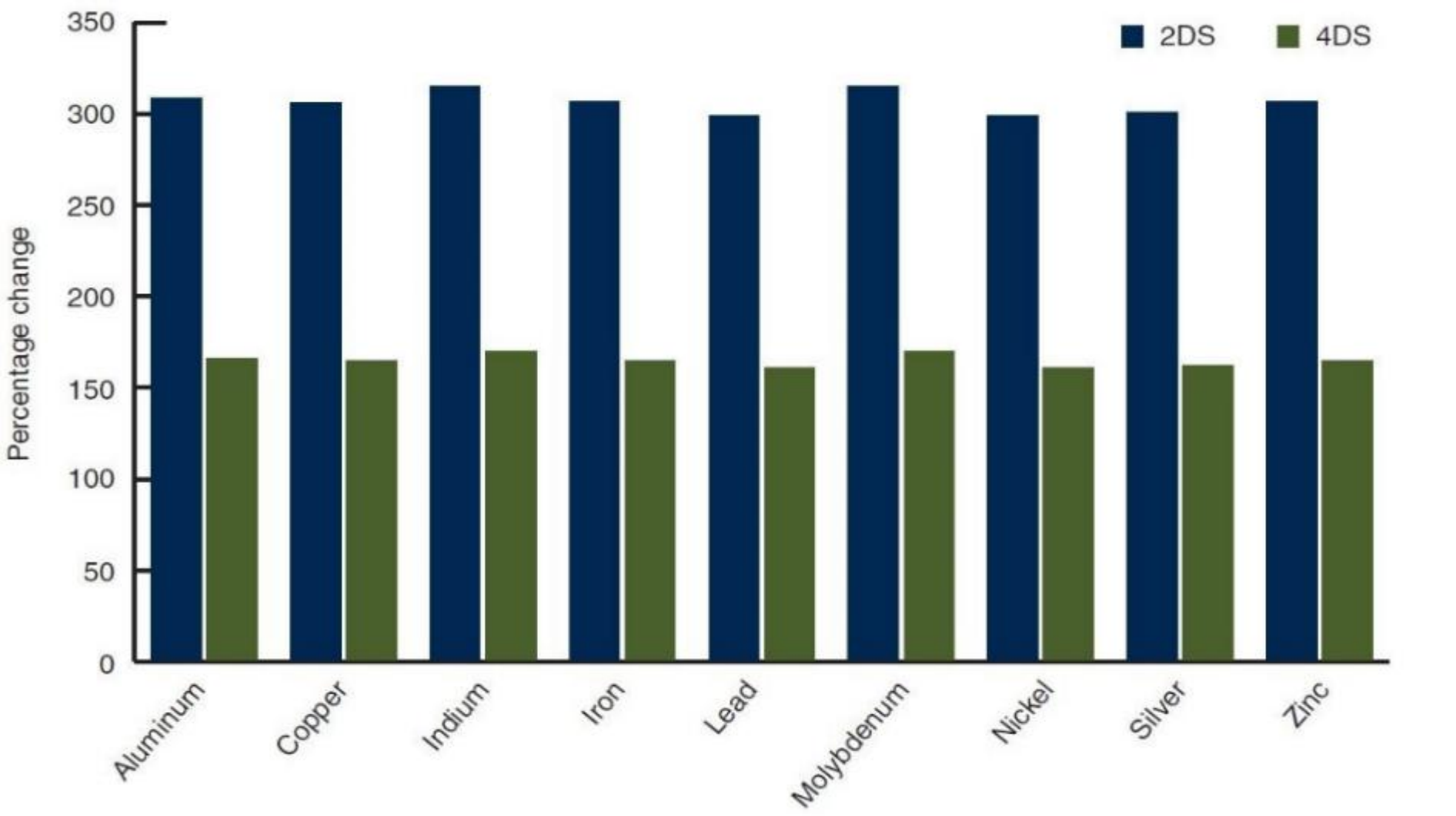
### Battery Technologies

| | Lead-acid | Lithium-ion |
|---|---|---|
| Aluminum | | X |
| Cobalt | | X |
| Lead | X | |
| Lithium | | X |
| Manganese | | X |
| Nickel | | X |
| Steel | X | X |

- Different sub-technologies have different metal demands
- Large level of uncertainty in intra-technology development trends

# Example: Change in metal demand from Solar PV
## (as percentage change from 6 degree scenario)



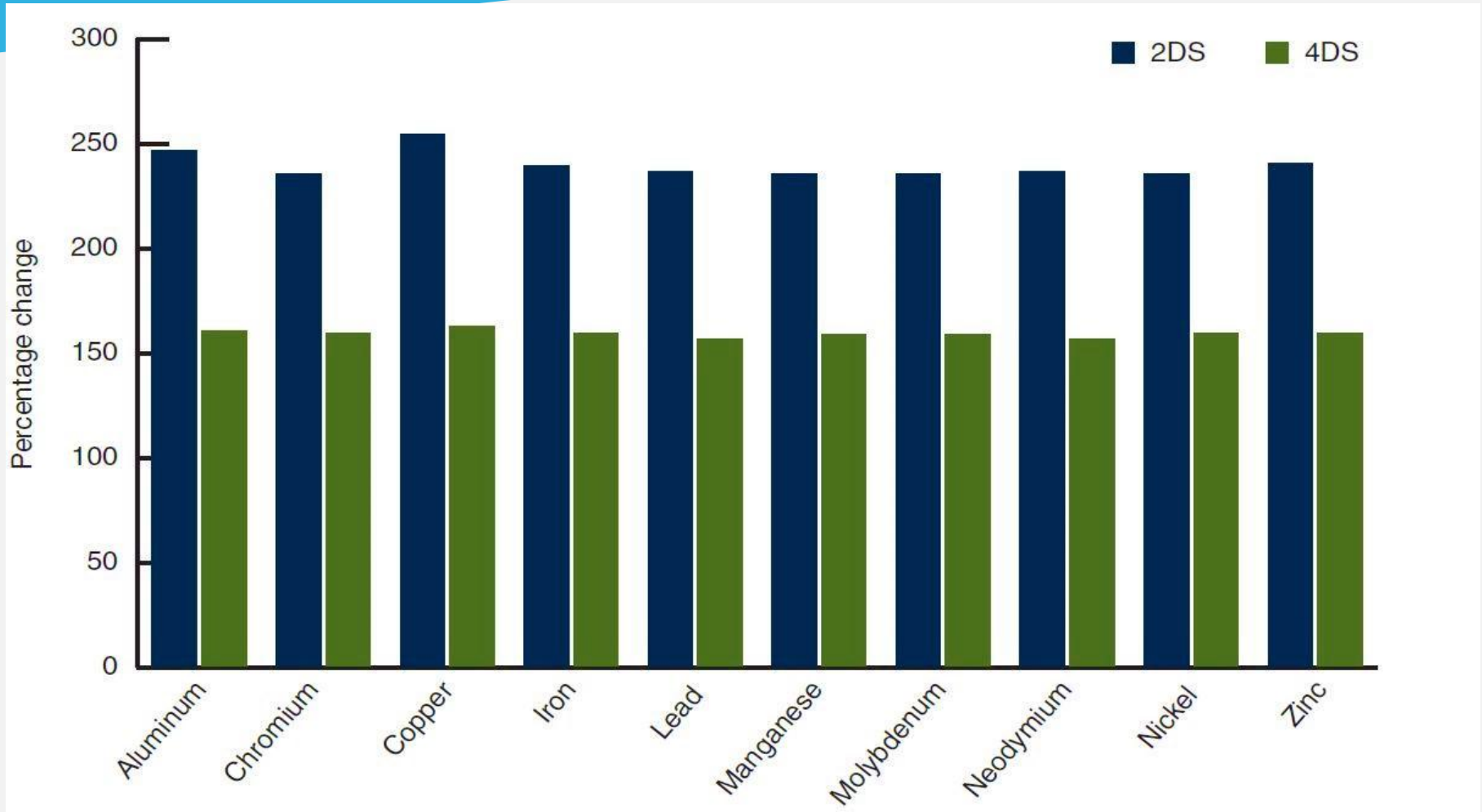



Source: WB Analysis
Note: Values are derived from mean value of 'metal per MW' demand

# Change in metal demand from Wind

## (as percentage change from 6 degree scenario)

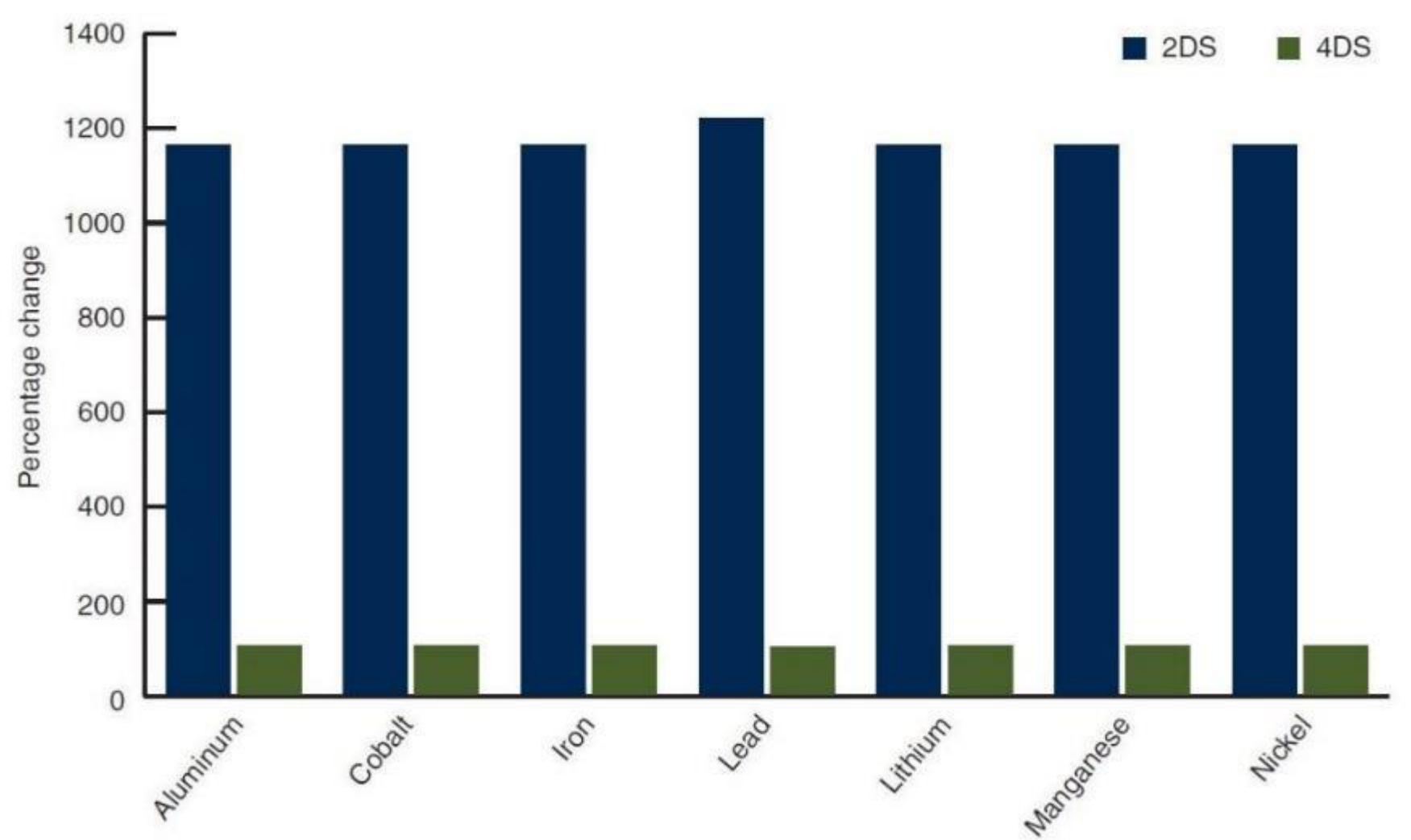





Source: WB – Cambridge Team Analysis
Note: Values are derived from mean value of 'metal per MW' demand

# Change in metal demand from Energy Battery Storage
## (as percentage change from 6 degree scenario)



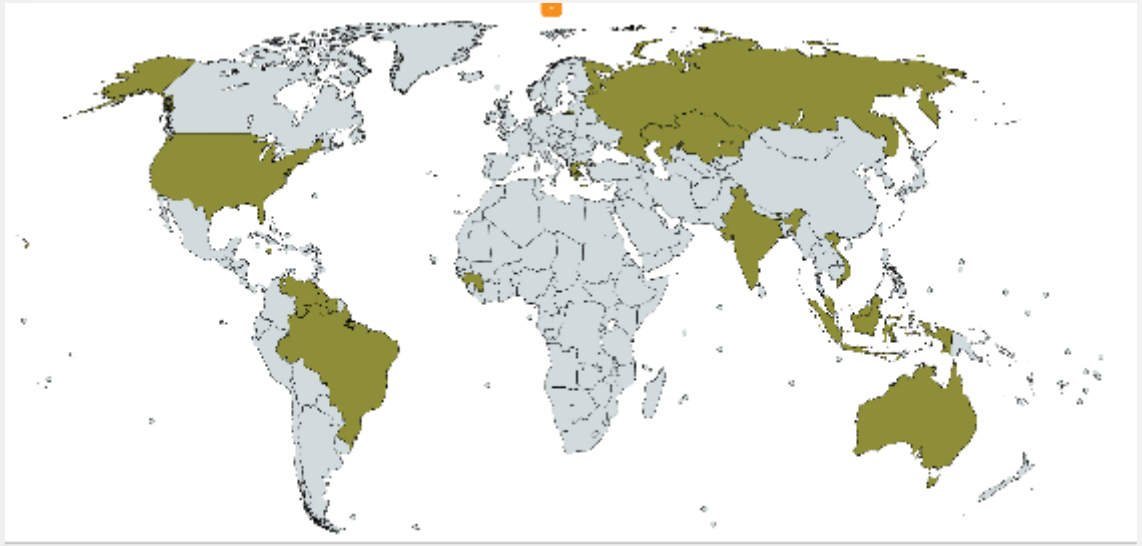



Source: WB Analysis
Note: Values are derived from mean value of 'metal per MW' demand

# Implications for Mineral Rich Developing Countries

# Mapping Critical Metals: Bauxite/Aluminum





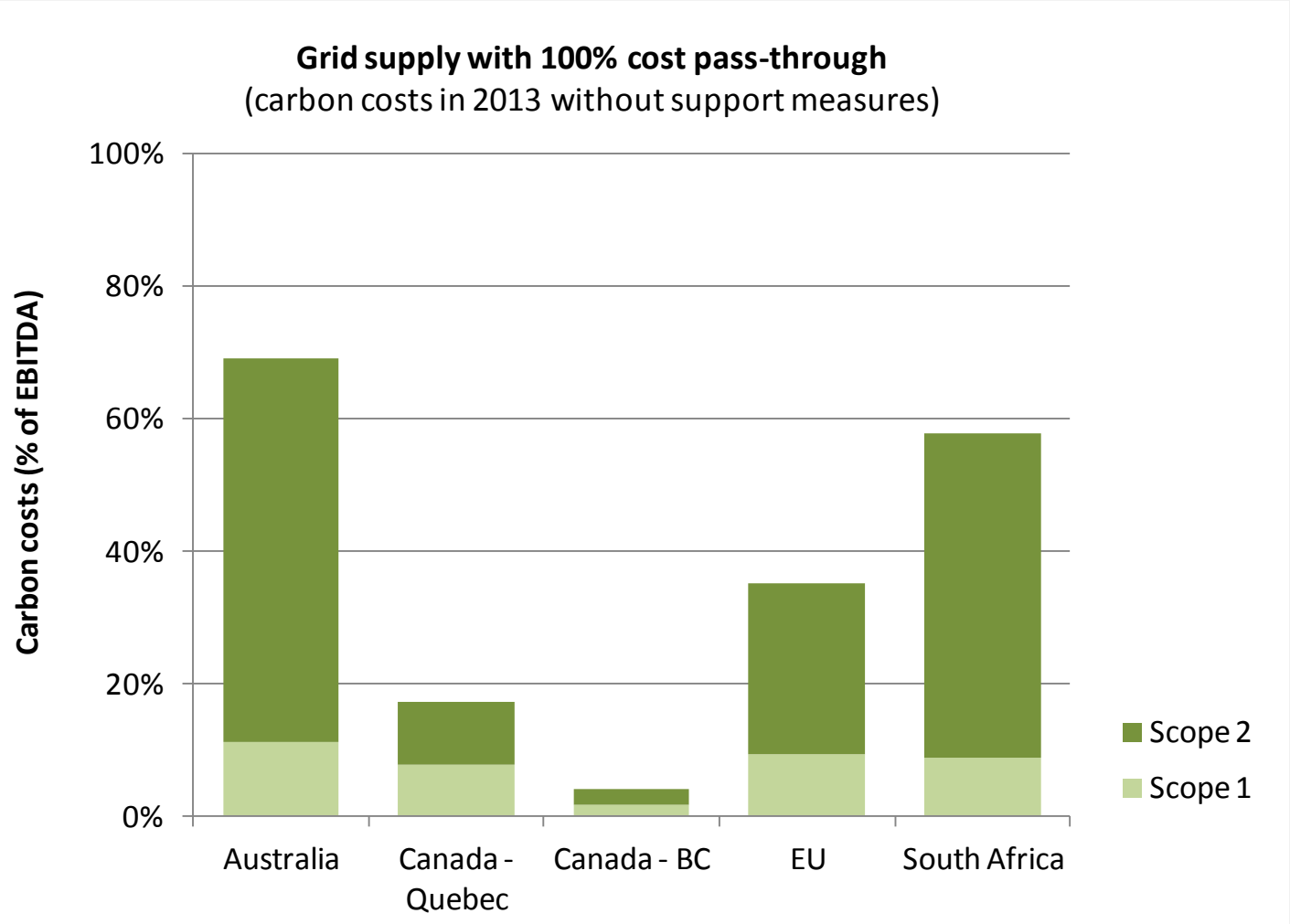
Developing Countries % of Bauxite Production represents 52%, without China, 30%.
Developing Countries % of Bauxite Reserves represents 65%, without China 63%.
Major Latin American producer/reserves: Brazil

**Production and Reserves for 2015 (Thousand Metric Tons)**

| | Mine Production | Reserves |
|---|---|---|
| AUSTRALIA | 80,000 | 6,200,000 |
| CHINA | 60,000 | 830,000 |
| MALAYSIA | 21,200 | 40,000 |
| INDIA | 19,200 | 590,000 |
| GUINEA | 17,700 | 7,400,000 |
| JAMAICA | 10,700 | 2,000,000 |
| GREECE | 6,600 | 250,000 |
| RUSSIA | 6,600 | 200,000 |
| KAZAKHSTAN | 5,200 | 160,000 |
| SURINAME | 2,200 | 580,000 |
| BRAZIL | 2,000 | 2,600,000 |
| GUYANA | 1,700 | 850,000 |
| VENEZUELA | 1,500 | 320,000 |
| VIETNAM | 1,100 | 2,100,000 |
| INDONESIA | 1,000 | 1,000,000 |
| USA | N/A | 20,000 |
| OTHER COUNTRIES | 8,500 | 2,400,000 |
| TOTAL | 274,000 | 28,000,000 |

# Challenges for Aluminum and Bauxite

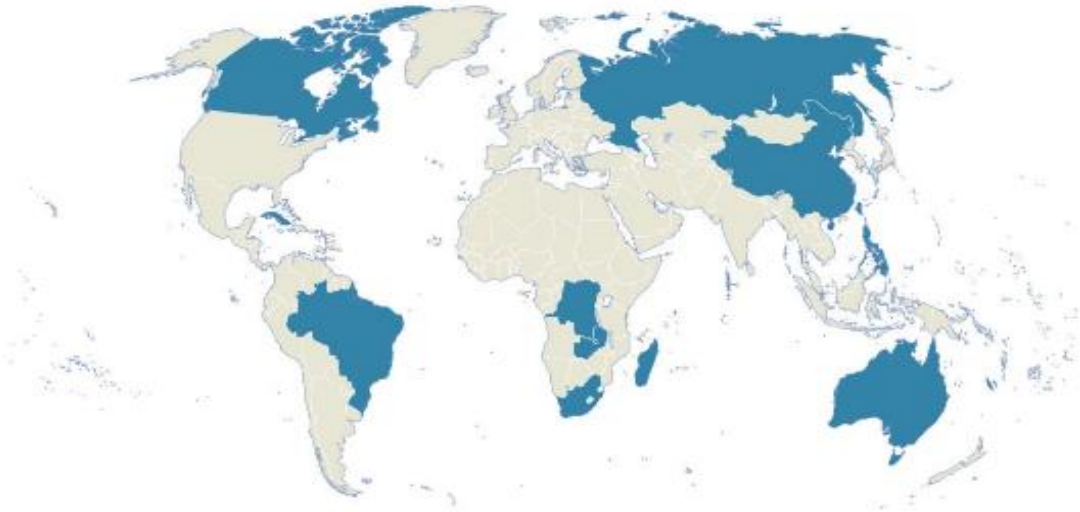
- **Energy source is a huge variable in competitiveness of aluminum producers in a carbon constrained world**
- **Contamination and water issues with bauxite mining in Brazil**



# Mapping critical Metals: Cobalt



FIGURE 3.6 Cobalt Production and Reserves



*Source:* USGS 2016, 52.
Calculation of developing-countries' share does not include "Other countries" row in table 3.6.

Developing countries' share of cobalt production: 75%; without China, 70 %.
Developing countries' share of cobalt reserves: 68%; without China, 67%
Major Latin American producers/reserves: Brazil

**Production and Reserves for 2015 Metric tons)**

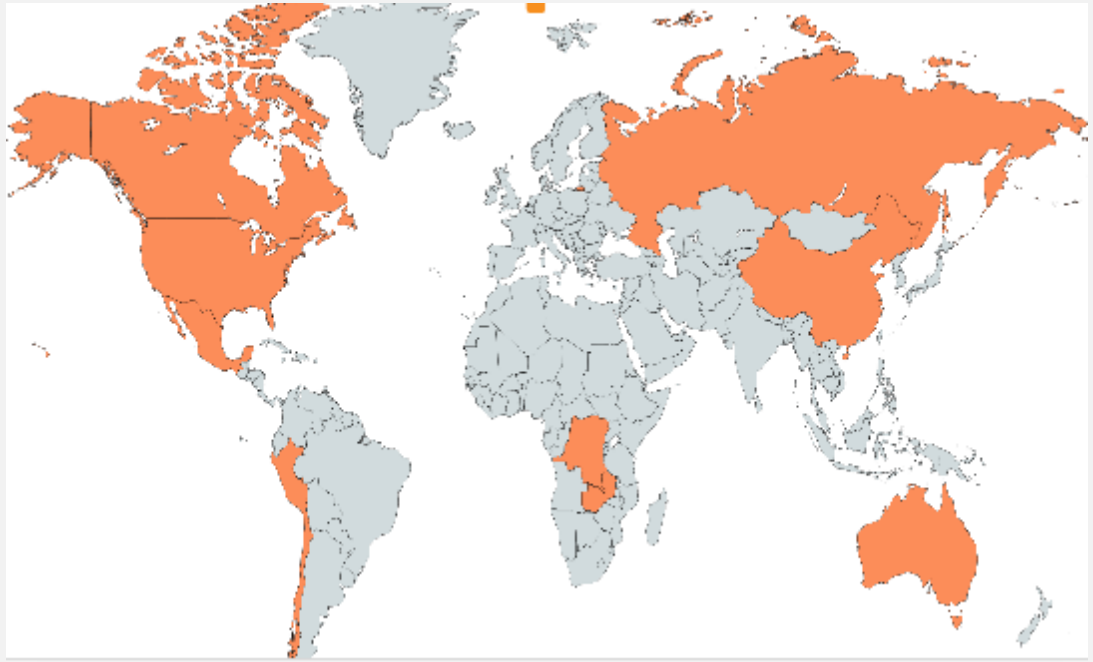
| | Production | Reserves |
|---|---|---|
| CONGO (KINSHASA) | 63,000 | 3,400,000 |
| AUSTRALIA | 6,000 | 1, 100,000 |
| ZAMBIA | 2,800 | 270,000 |
| PHILIPPINES | 4,600 | 250,000 |
| RUSSIA | 6,300 | 250,000 |
| CANADA | 6,300 | 240,000 |
| NEW CALEDONIA | 3,300 | 200,000 |
| MADAGASCAR | 3,600 | 130,000 |
| CHINA | 7,200 | 80,000 |
| BRAZIL | 2,600 | 78,000 |
| SOUTH AFRICA | 2,800 | 31,000 |
| OTHER COUNTRIES | 7,700 | 633,000 |
| TOTAL | 120,400 | 7, 162,000 |

# Challenges for Cobalt

- **Poor data and governance systems in key developing countries**
  - **Predominated by artisanal practices (ASM)**
- **Child labor**
- **Mostly a by-product of copper and nickel extraction**

# Mapping critical Metals: Copper





Developing countries' share of copper production: 57%; without China, 47%.
Developing countries' share of copper reserves: 50%; without China, 46%.
Major Latin American Producers/Reserves: Chile, Peru

**Production and Reserves for 2015 (Thousand Metric tons)**

| | Production | Reserves |
|---|---|---|
| CHILE | 5,700 | 210,000 |
| AUSTRALIA | 960 | 88,000 |
| PERU | 1,600 | 82,000 |
| MEXCIO | 550 | 46,000 |
| USA | 1,250 | 33,000 |
| RUSSA | 740 | 30,000 |
| CHINA | 1,750 | 30,000 |
| CONGO | 990 | 20,000 |
| ZAMBIA | 600 | 20,000 |
| CANADA | 695 | 11,000 |
| OTHER COUNTRIES | 3,900 | 150,000 |
| TOTAL | 18,700 | 720,000 |

# Challenges for Copper

- Ever decreasing ‘concentration levels’ means growing:
  - GHG emissions
  - Energy requirements
  - Water impacts
  - Ecosystems and local communities impacts

# Mapping critical metals: Lithium



Developing countries % of lithium production 52%, without China 45%
Developing countries % of lithium reserves 91%, without China 68%

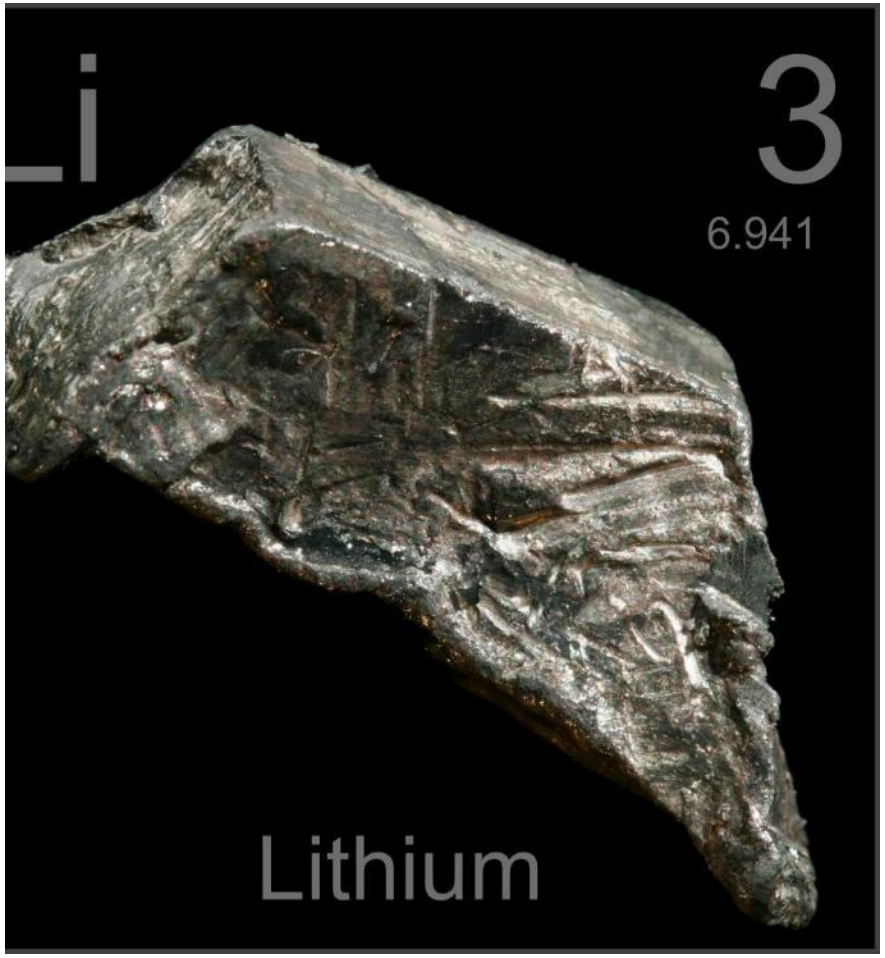
Major Latin American Producers/Reserves: Chile, Argentina, Brazil (Bolivia)

**Lithium Production and Reserves for 2015 (Metric tons)**

| | Production | Reserves |
|---|---|---|
| AUSTRALIA | 13,400 | 1,500,000 |
| CHILE | 11,700 | 7,500,000 |
| ARGENTINA | 3,800 | 2,000,000 |
| CHINA | 2,200 | 3,200,000 |
| ZIMBABWE | 900 | 23,000 |
| PORTUGAL | 300 | 60,000 |
| BRAZIL | 160 | 48,000 |
| USA | N/A | N/A |
| TOTAL | ~ 32,500 | ~ 14,000,000 |

# Challenges for Lithium

- Poor data and governance systems on lithium in key developing countries
- Hard mining activities require significant energy and chemicals, as well as significant land clearing
- Brine ponds can involve water quality/accessibility issues for local communities



# Mapping critical Metals: Manganese



Developing countries % of manganese production 79%, without China 63%
Developing countries % of manganese reserves 54%, without China, 47%
Major Latin American Producers/Reserves: Brazil, Mexico

**Manganese Production and Reserves for 2015 (Thousand metric tons)**

| | Production | Reserves |
|---|---|---|
| SOUTH AFRICA | 6,200 | 200,000 |
| CHINA | 3,000 | 44,000 |
| AUSTRALIA | 2,900 | 91,000 |
| GABON | 1,800 | 22,000 |
| BRAZIL | 1,000 | 50,000 |
| INDIA | 950 | 52,000 |
| MALAYSIA | 400 | N/A |
| GHANA | 390 | 13,000 |
| KAZAKHSTAN | 390 | 5,000 |
| UKRAINE | 390 | 140,000 |
| MEXICO | 240 | 5,000 |
| BURMA | 100 | N/A |
| USA | N/A | N/A |
| OTHER COUNTRIES | 740 | SMALL |
| TOTAL | 18,000 | 620,000 |

# Challenges for Manganese

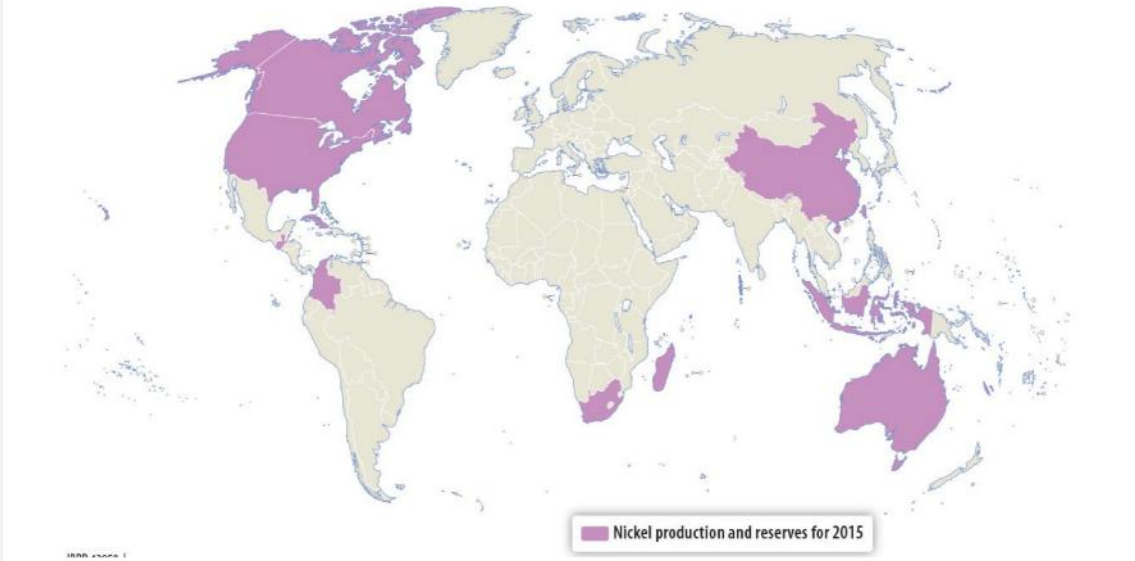
- Impact of open pit manganese mining on long term health of children living in local areas

- Water contamination in local river systems

# Mapping Critical Metals: Nickel



**FIGURE 3.15** Nickel Production and Reserves




*Source:* USGS 2016, 115.
Calculation of developing-countries' share does not include "Other countries" row in table 3.15.

Developing countries % of nickel production 29%, without China 25%
Developing countries % of nickel reserves 37%, without China, 34%
Major Latin American Producers/Reserves: Cuba, Guatemala, Colombia

**Manganese Production and Reserves for 2015 (Metric tons)**

| | Production | Reserves |
|---|---|---|
| AUSTRALIA | 234,000 | 19,000,000 |
| NEW CALEDONIA | 190,000 | 8,400,000 |
| CUBA | 57,000 | 5,500,000 |
| INDONESIA | 170,000 | 4,500,000 |
| SOUTH AFRCIA | 53,000 | 3,700,000 |
| CHINA | 102,000 | 3,000,000 |
| CANADA | 240,000 | 2,900,000 |
| GUATEMALA | 50,000 | 1,800,000 |
| MADAGASCAR | 49,000 | 1,600, 000 |
| COLOMBIA | 73,000 | 1, 100,000 |
| UNITED STATES | 26,500 | 160,000 |
| | | |
| OTHER COUNTRIES | 410,000 | 6,500,000 |
| TOTAL | 2,530,000 | 79,000,000 |

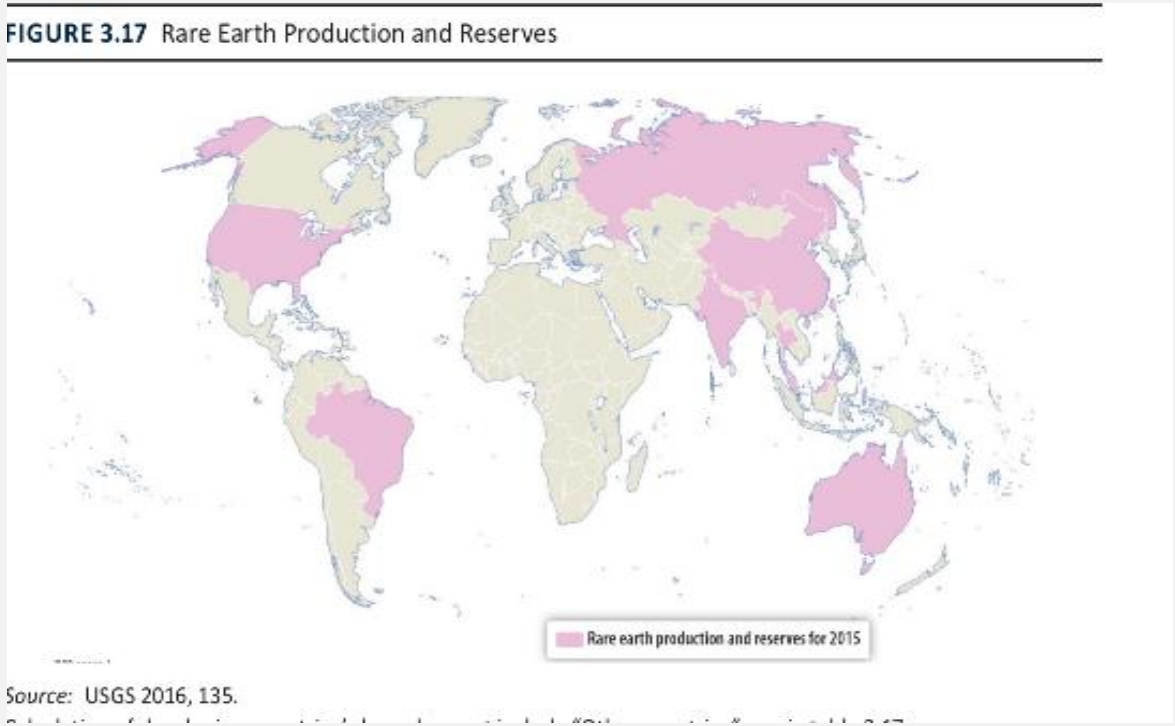
# Challenges for Nickel

- **Significant environmental and health impacts from local air pollutants and water contamination**

- **Global warming potential of mining and processing nickel the eighth highest amongst 63 metals examined (Life Cycle Assessment of Metals)**

# Mapping Critical Metals: Rare Earth Elements






**Production and Reserves for 2015 (Metric tons)**

| | Production | Reserves |
|---|---|---|
| CHINA | 105,000 | 55,000,000 |
| BRAZIL | 0 | 22,000,000 |
| AUSTRALIA | 10,000 | 3,200,000 |
| INDIA | N/A | 3,000,000 |
| USA | 4,100 | 1,800,000 |
| MALAYSIA | 200 | 30,000 |
| RUSSIA | 2,500 | LISTED IN OTHER COUNTRIES |
| OTHER COUNTRIES | N/A | 41,000,000 |
| TOTAL | 124,000 | 130,000,000 |

Developing countries' share of rare earth production: 86%; without China, 2%
Developing countries' share of rare earth reserves: 62%; without China, 19%
Major Latin American Producers/Reserves: Brazil

# Challenges of Rare Earth Elements

- Monopoly of supply and production in China
- Poor data in key regions: currently Africa is completely ‘blank’ on Rare Earth Elements
- Mostly a by product of ’mainstream’ minerals, such as zinc, etc.

# Mapping Critical Metals: Silver



**FIGURE 3.19** Silver Production and Reserves


*Source:* USGS 2016, 153.
Calculation of developing-countries' share does not include "Other countries" row in table 3.19.

**Production and Reserves for 2015 (Metric tons)**

| | Production | Reserves |
|---|---|---|
| PERU | 3,800 | 120,00 |
| AUSTRALIA | 1,700 | 85,000 |
| POLAND | 1,300 | 85,000 |
| CHILE | 1,600 | 77,000 |
| CHINA | 4,100 | 43,000 |
| MEXICO | 5,400 | 37,000 |
| UNITED STATES | 1,100 | 25,000 |
| BOLIVIA | 1,300 | 22,000 |
| RUSSIA | 1,500 | 20,000 |
| CANADA | 500 | 7,000 |
| OTHER COUNRIES | 5,000 | 50,000 |
| | | |
| TOTAL | 27,300 | 570,00 |

Developing countries' share of silver production: 40%; without China, 25%.
Developing countries' share of rare earth reserves: 46 %; without China 38%.
Major Latin American Producers/Reserves: Peru, Chile, Mexico, Bolivia (Argentina)

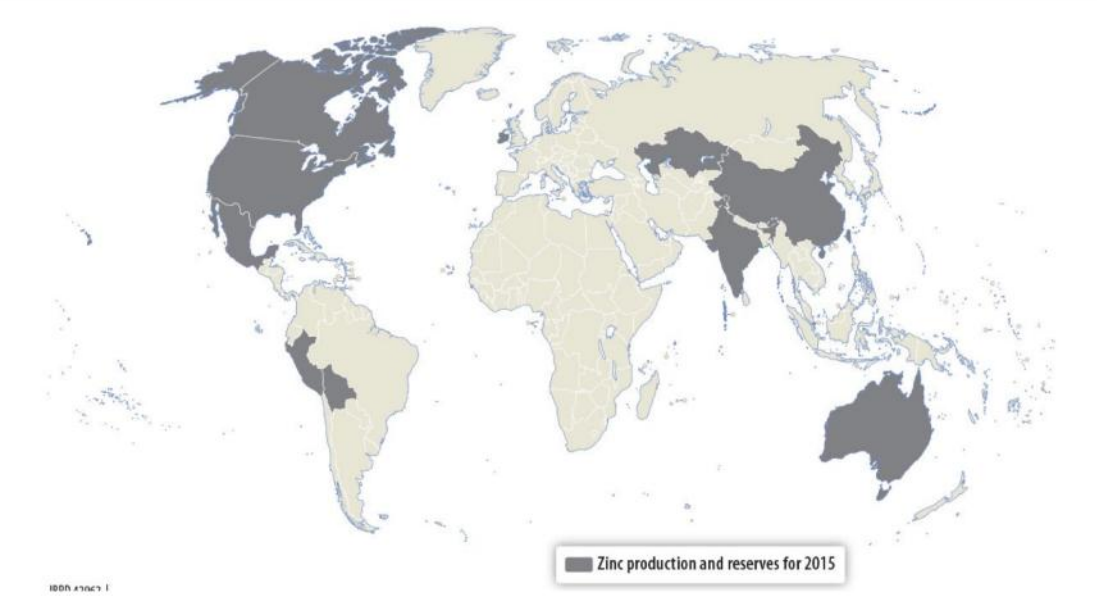
# Challenges of Silver

- Precious metal means supply is relatively limited
- Low concentration levels means greater pressure on managing environment and social issues (tailings, land management, etc.)

# Mapping Critical Metals: Zinc



**FIGURE 3.21** Zinc Production and Reserves




*Source:* USGS 2016, 193.
Calculation of developing-countries' share does not include "Other countries" row in table 3.21.

**Production and Reserves for 2015 (Thousand Metric tons)**

| | Production | Reserves |
|---|---|---|
| AUSTRALIA | 1,580 | 63,000 |
| CHINA | 4,900 | 38,000 |
| PERU | 1,370 | 25,000 |
| MEXCIO | 660 | 15,000 |
| INDIA | 830 | 10,000 |
| UNITED STATES | 850 | 11,000 |
| CANADA | 300 | 6,200 |
| BOLIVIA | 430 | 4,600 |
| KAZAKHSTAN | 340 | 4,000 |
| IRELAND | 230 | 1,100 |
| OTHER COUNTRIES | 1,870 | 26,000 |
| TOTAL | 13,400 | 200,000 |

Developing countries' share of zinc production: 59%; without China, 22%.
Developing countries' share of copper reserves: 41%; without China, 22%.
Major Latin American Producers/Reserves: Peru. Bolivia, Mexico

# Challenges of Zinc

- Extraction and processing can produce large amounts of sulphur dioxide (potentially acid rain)
- Significant impacts on water contamination, particularly heavy metal products out of processing
- Key base for extracting critical subset of minerals required for clean energy and mobility technologies (e.g. Indium and cadmium)

# Keeping It In Perspective



**If properly governed, managed and operated, particularly at the local level, the overall climate and economic benefits should far outweigh the challenges**

- 2015 UNEP report: **Green Energy Choices: the Benefits, Risks and Trade-Offs of Low-Carbon Technologies for Electricity Production** found ”cradle to grave” GHG emissions of clean-energy sources would be 90-99% lower than for coal power

- Significant economic development opportunity for resource-rich developing countries. **Latin America amongst most ‘prolific’ area in the world for supplying minerals and metals required for future clean energy technologies**



**Thank you!**

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*Full WB report*: The Role of Minerals and Metals for a Low Carbon Future

EGPS Extractives Global Programmatic Support

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