The Energy & Carbon Intensity of Mining: Understanding the Growing Importance of Renewable Energy

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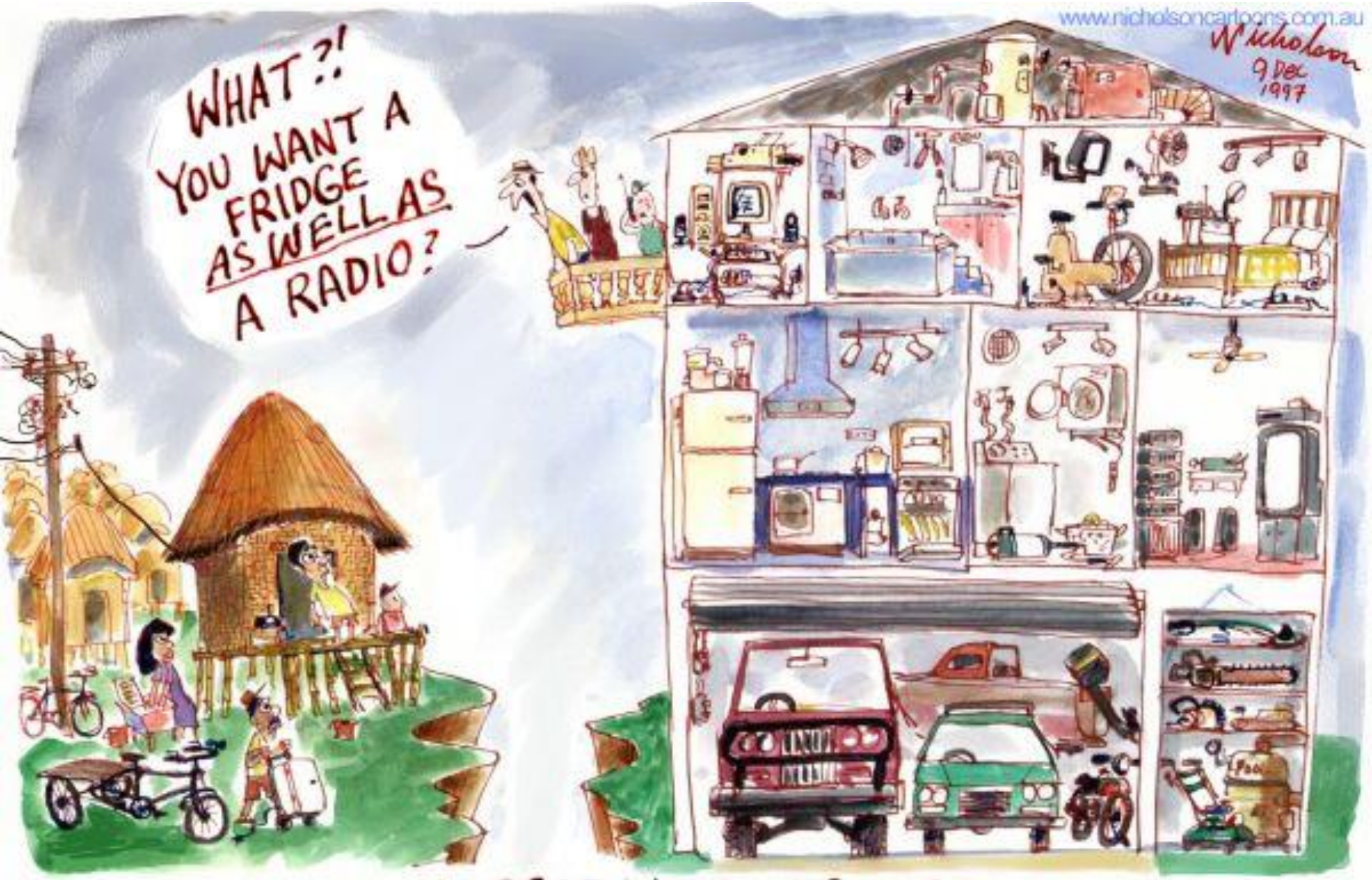
Georgius Agricola (1556) :

"… the strongest argument of the detractors is that the *fields are devastated by mining operations* … Also they argue that the *woods and groves are cut down*, for there is need of an endless amount of wood for timbers, machines, and the smelting of metals. And when the woods and groves are felled, then are exterminated the beasts and birds, very many of which furnish a pleasant and agreeable food for man. Further, when the ores are washed, *the water which has been used poisons the brooks and streams*, and either destroys the fish or drives them away. Therefore the inhabitants of these regions, on account of the devastation of their fields, woods, groves, brooks and rivers, find great difficulty in procuring the necessaries of life.

Thus it is said, it is clear to all that *there is greater detriment from mining than the value of the metals which the mining produces*."



A GREENHOUSE NIGHTMARE...

Presentation Overview

- **Energy Use in Mining '101' = Carbon Emissions**
- **Current 'Mega-Trends' in Mining**
  - *these underpin likely energy/carbon intensity*
- **Life Cycle Assessments of Metal Mining**
- **Examples & Case Studies**
- **Growing Need for Renewable Energy**
- **Metals for Renewable Energy & Batteries**
- **Summary**

Energy Use in Mining '101'

- **Mining is very simple with its energy needs:**

DIESEL & ELECTRICITY

- **Diesel is used in haul trucks, excavators, underground vehicles, on-site power plants**
- **Electricity is used in ore processing, site administration buildings, etc.**

Really, it's that simple

- **Energy also used to make machines, chemicals, transport stuff / people, etc …**

Energy Intensity in Mining

- **There are many factors which can affect the energy needed to operate a mine:**
  - ore body depth: deeper = more energy
  - Age of a mine: older mines often deeper, longer haul roads / shafts, sometimes more waste rock at greater distance to dump, …
  - Ore processing configuration: SX-EW v flotation, especially comminution grind size, scale, …
  - Environmental requirements: need for water treatment (or not), tailings disposal configuration (especially if paste / thickened tailings are used), etc …

Carbon Issues in Mining

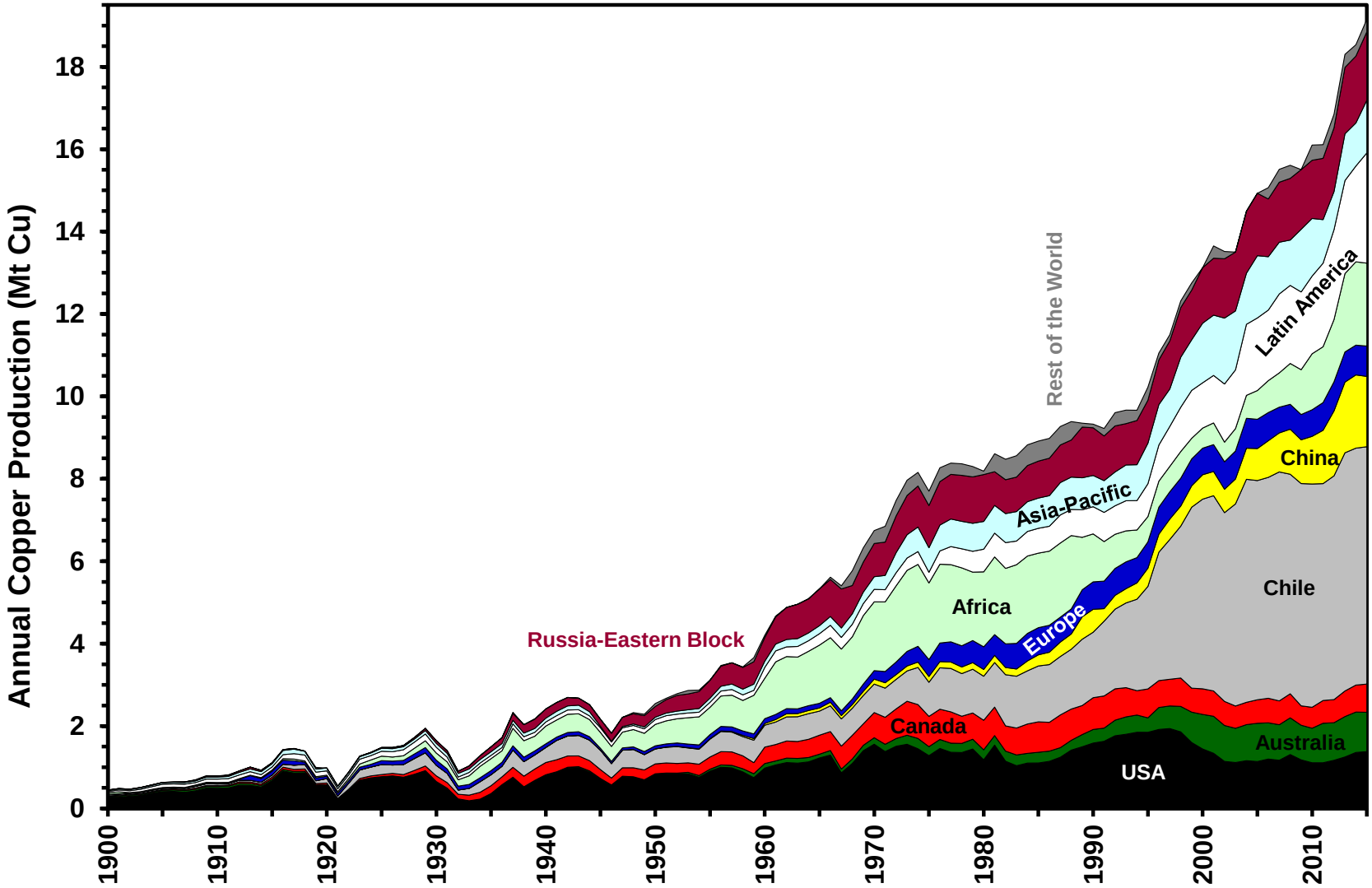
- **Carbon emissions derived mostly from direct diesel use (Scope 1) & indirectly from electricity (Scope 2) (minor amounts from explosives, land use change, some chemicals)**
- **For electricity, carbon intensity is closely linked to power plant type: coal, gas, diesel, solar, geothermal, etc …**

Put simply, more energy intense mines are typically more carbon intensive

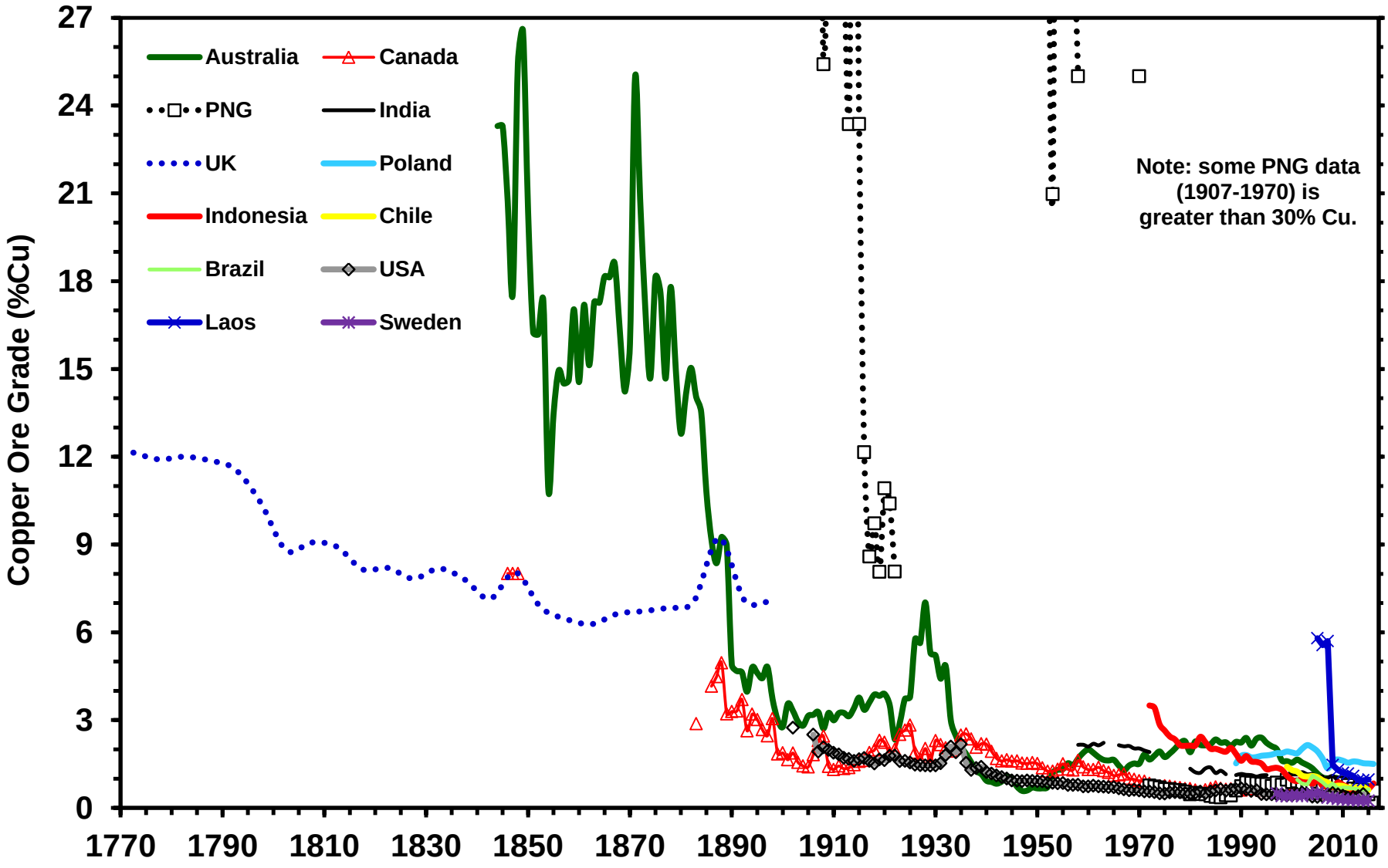
Key Global Mining MEGA-Trends

- Globally, we have plenty of mineral resources already know to meet reasonable societal demands for decades … primary metals, critical metals, etc.
- The real issues are how / what / where / when / why we mine different commodities … e.g. coal v lithium
- Global mega-trends already affecting mining include:
  - continually growing demand (with demand for 'critical metals' expected to grow substantially)
  - declining ore grades … sometimes declining ore quality
  - deeper deposits … variable around the world but still very real
  - increasing wastes to manage: tailings & waste rock (& slags)
  - growing community, investor & regulatory concerns
  - gradually growing chemicals / energy / water inputs

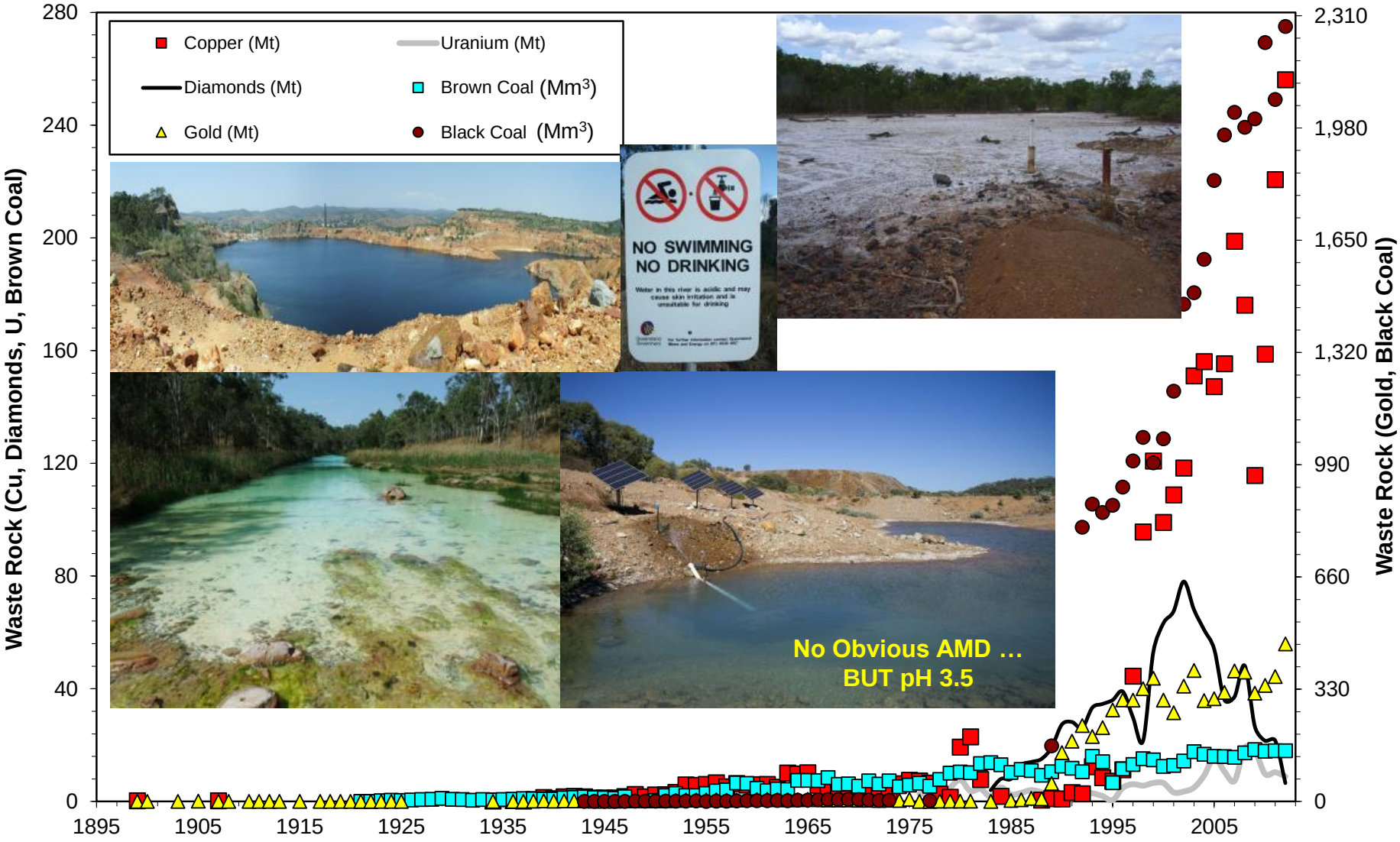
Global Cu Mine Production by Country



Declining Ore Grades: Very Real



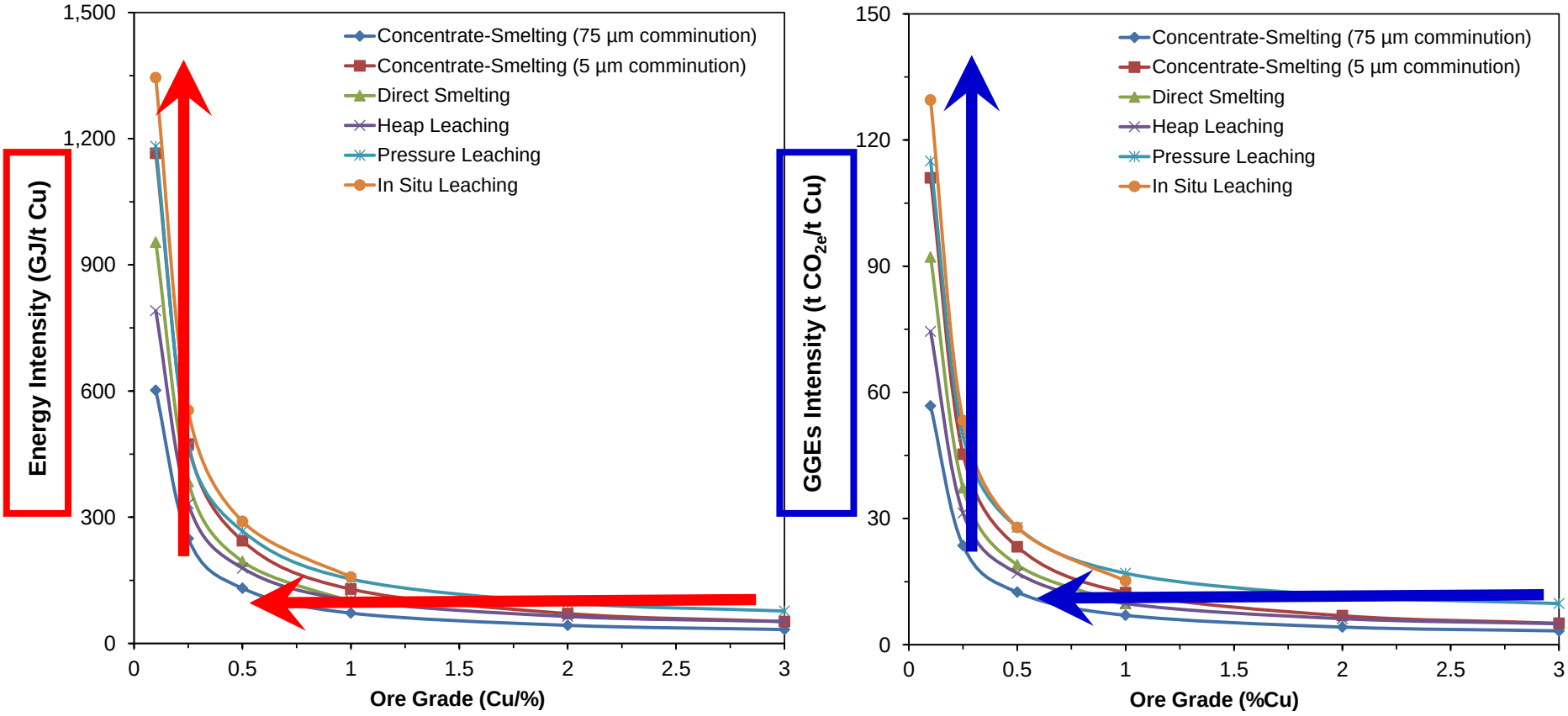
Ever-Growing Waste Rock Piles …



Life Cycle Assessment of Mining

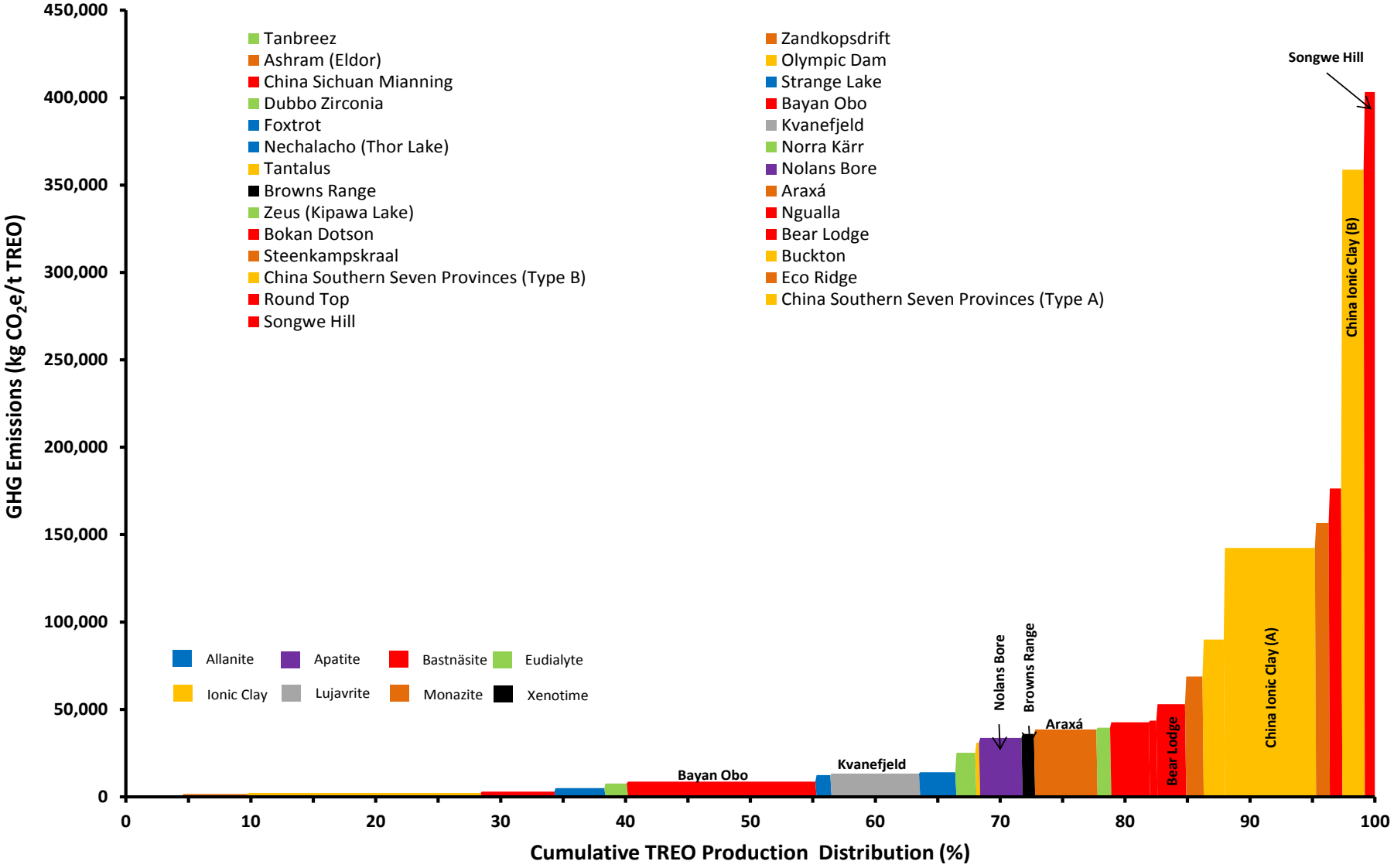
- **LCA is a formal methodology to quantify the inputs & outputs to produce a good or service**
- **Literature covers most metals reasonably well**
- **Often the key metrics focussed on are energy, carbon, water … sometimes toxicity, land use, but waste rarely *(not sure why!)***
- **One tricky issue is the allocation for multi-metal mines – typically solved by value**
  - ***e.g. Cu-Au mine splits energy inputs / carbon outputs based on respective value of each metal***

Theoretical LCA Studies: Cu

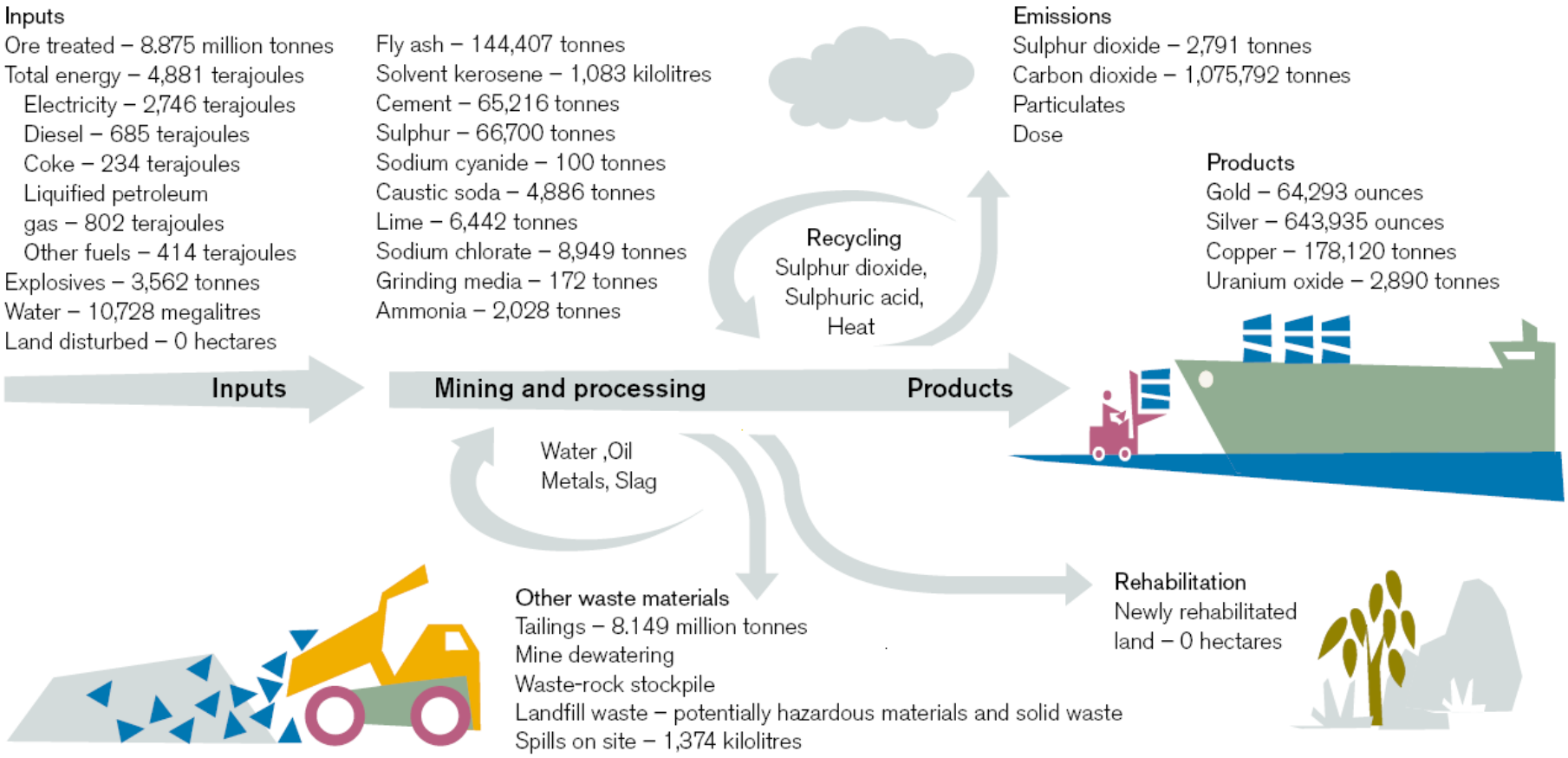


Norgate-Jahanshahi, 2010, Mins. Eng.

Theoretical LCA Studies: Rare Earths

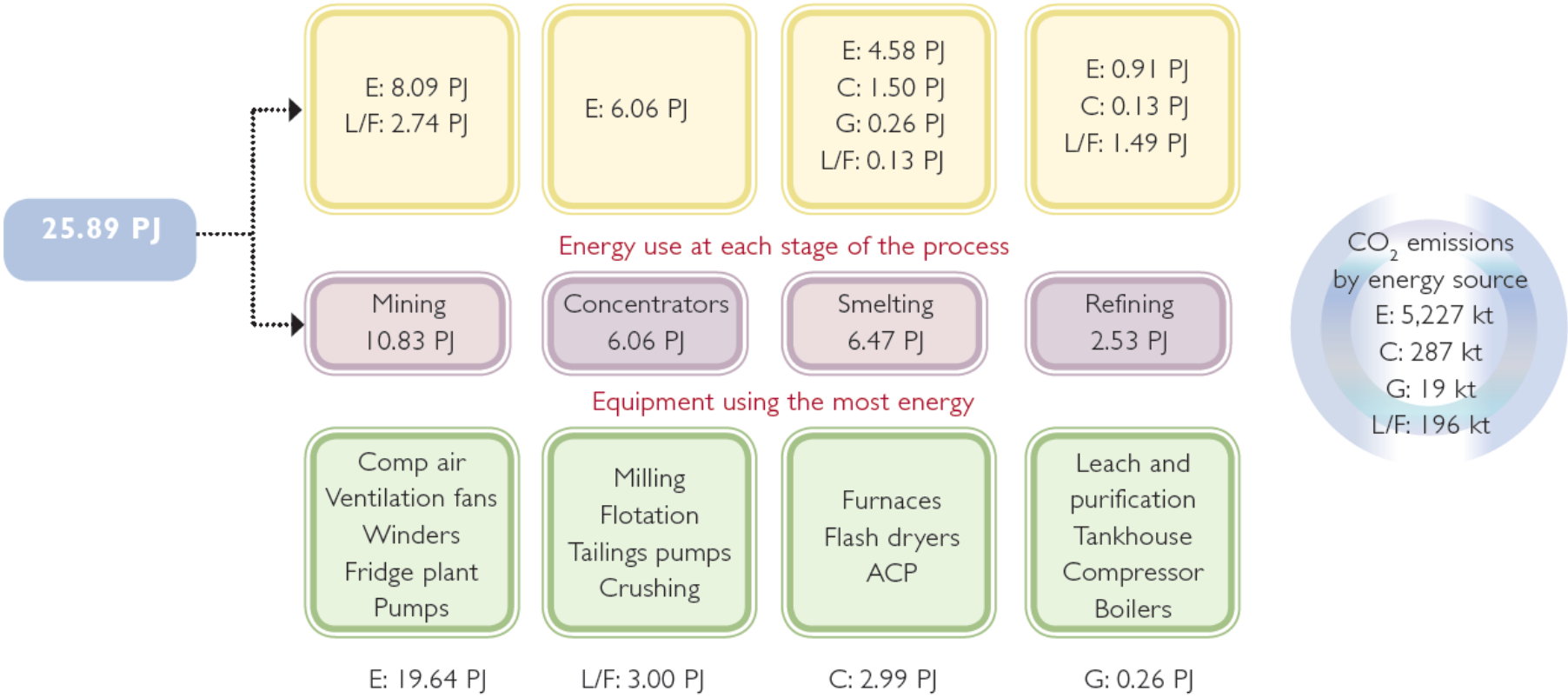


Sustainability Reporting: Real LCA Data



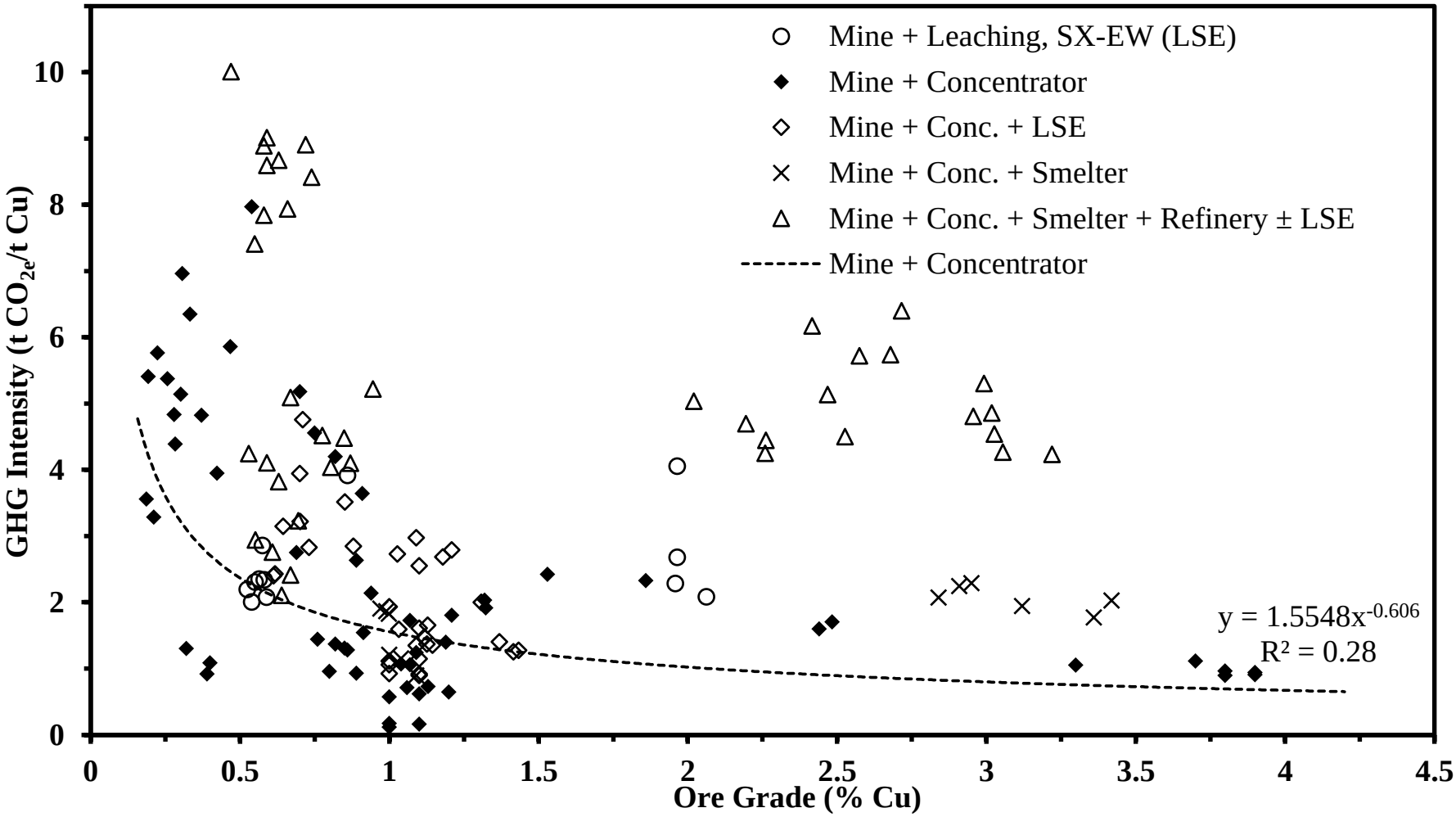
Source: WMC

Sustainability Reporting: Real LCA Data

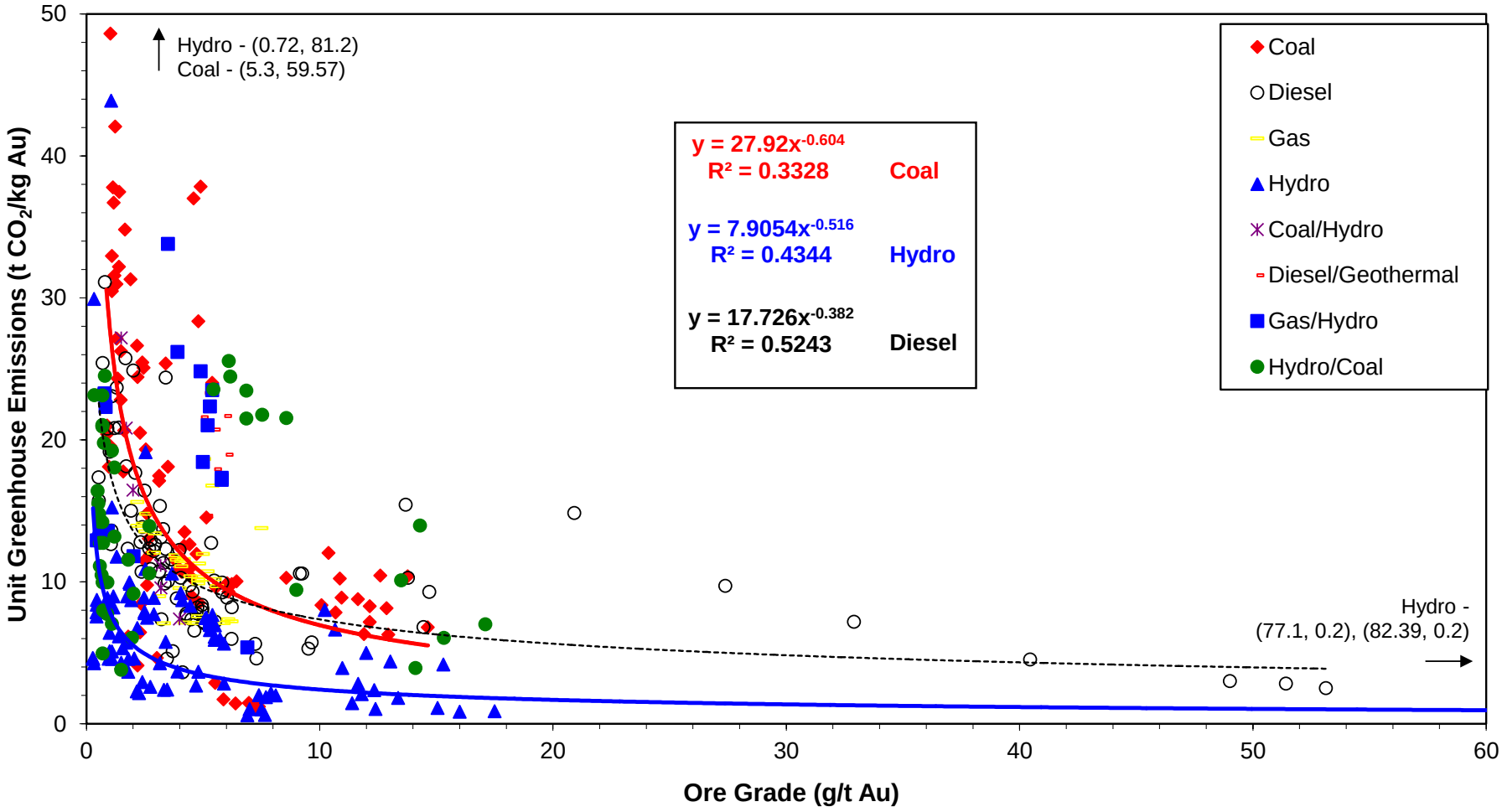


Source: Anglo Platinum

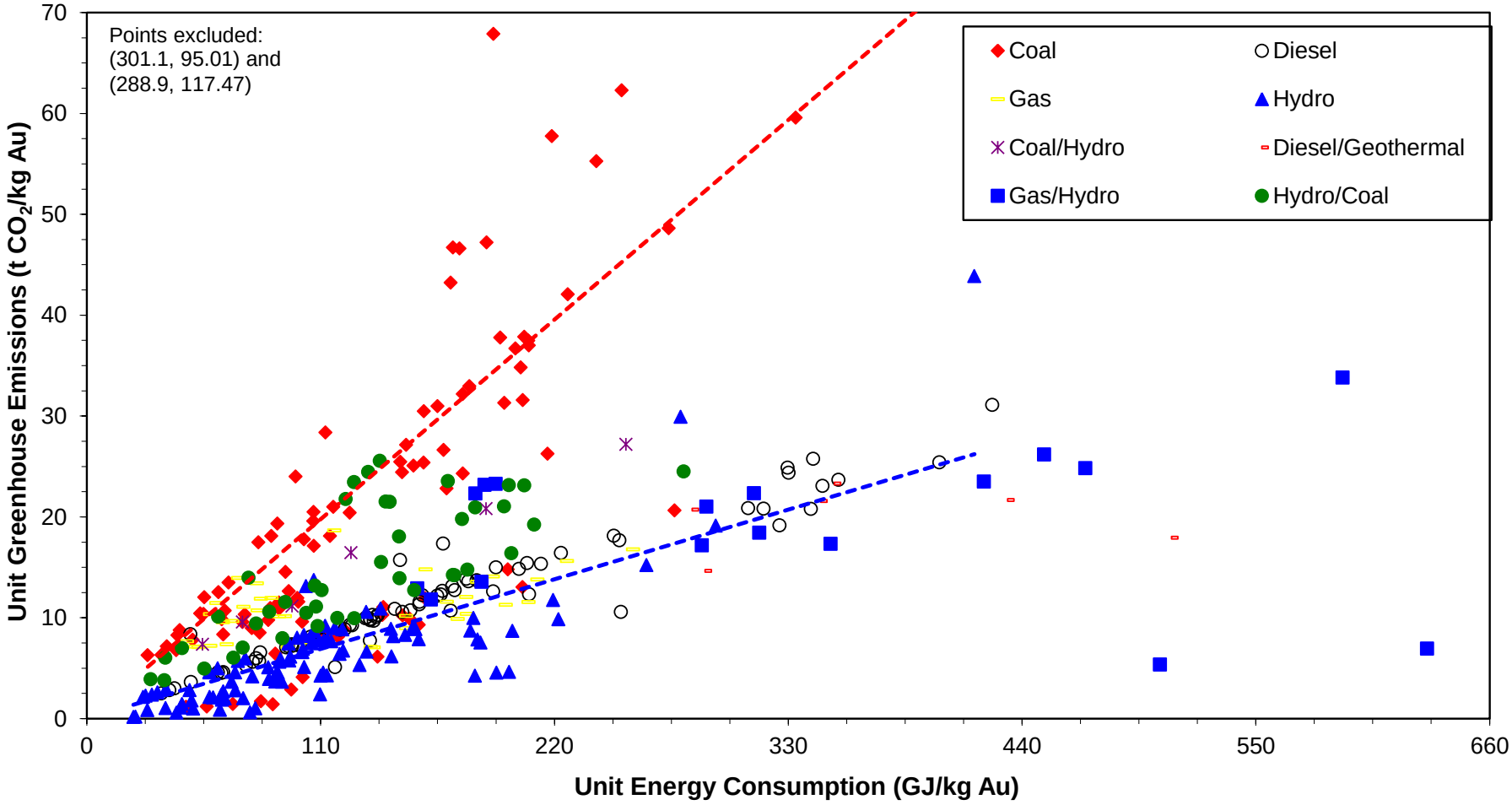
Case Study: LCA of Copper Mining



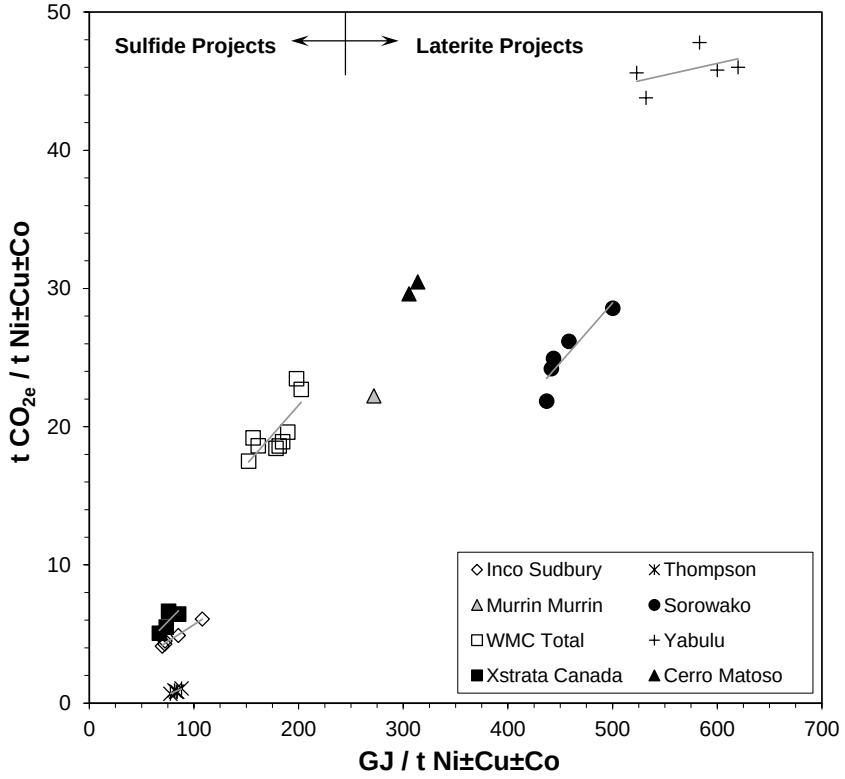
Case Study: LCA of Gold Mining



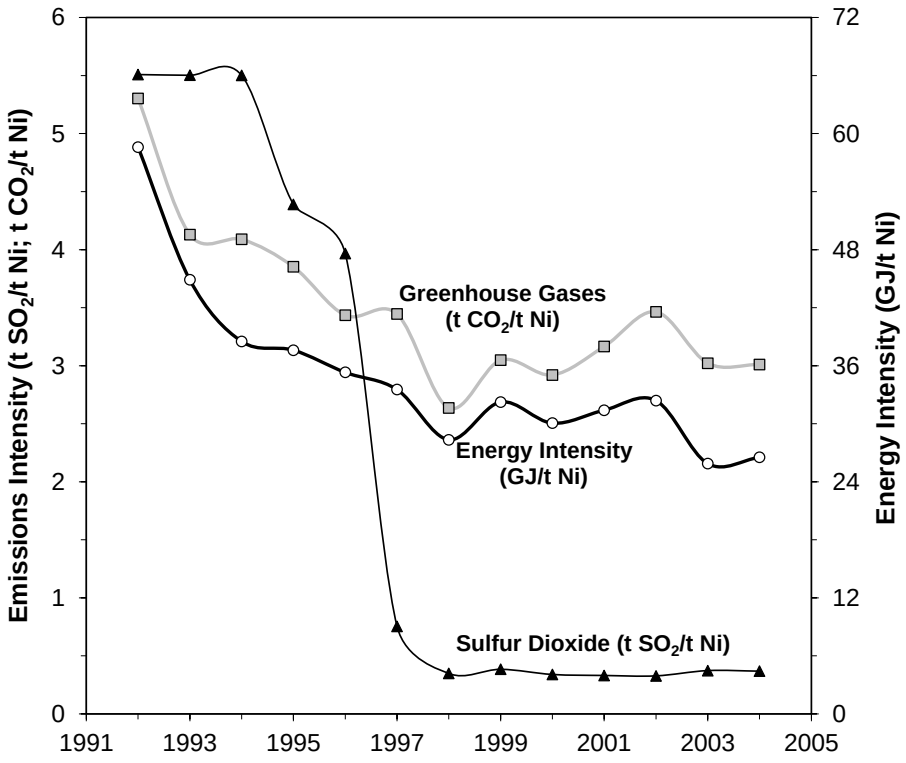
Case Study: LCA of Gold Mining



Case Study: LCA of Nickel Mining

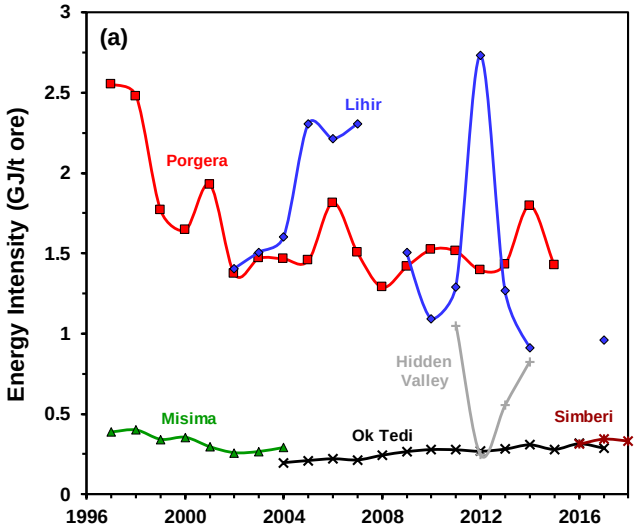


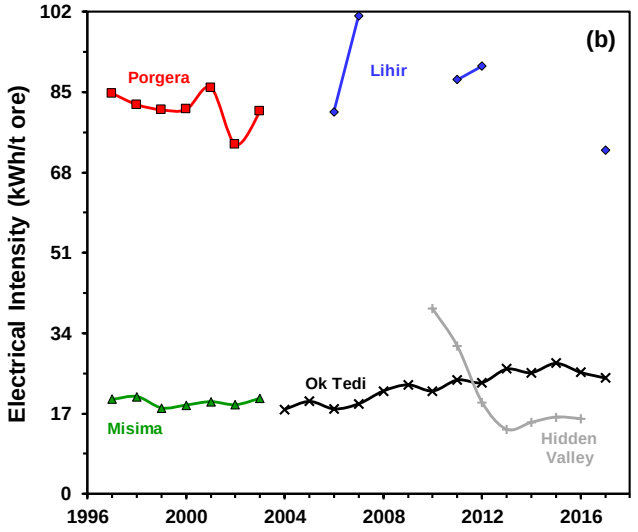
Global Nickel Mines

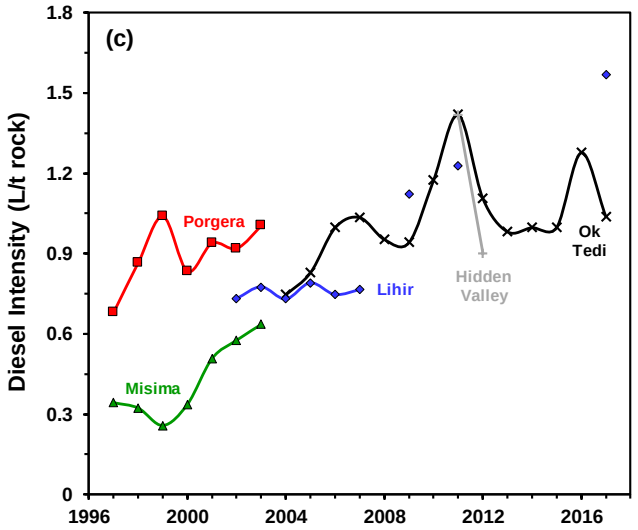


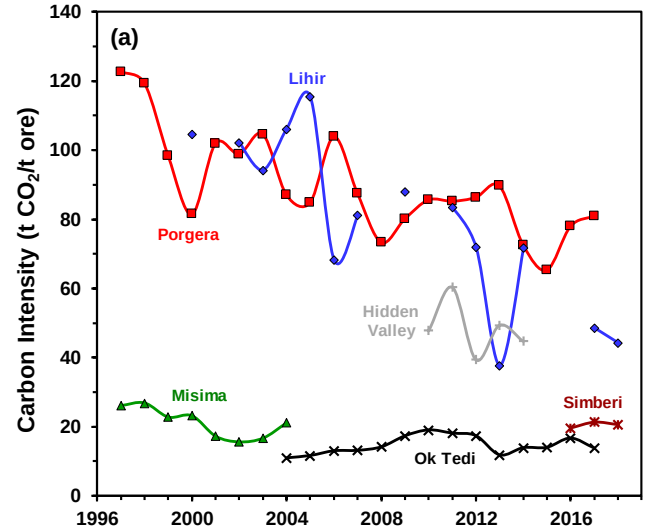
Kalgoorlie Nickel Smelter

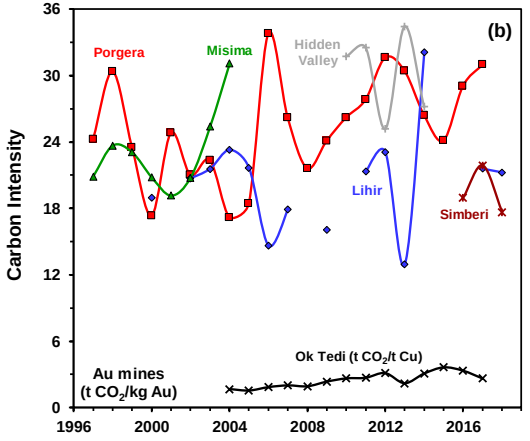
LCA of Mining in Papua New Guinea







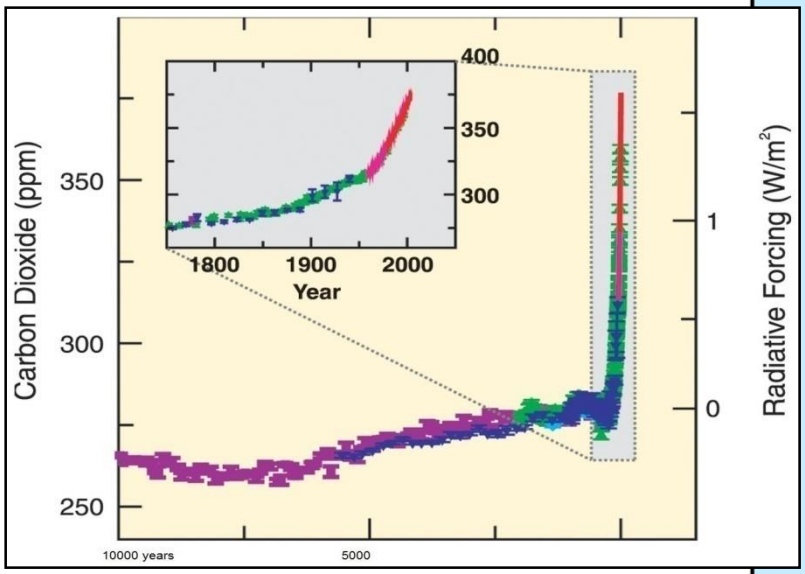




Growing Need for Renewable Energy

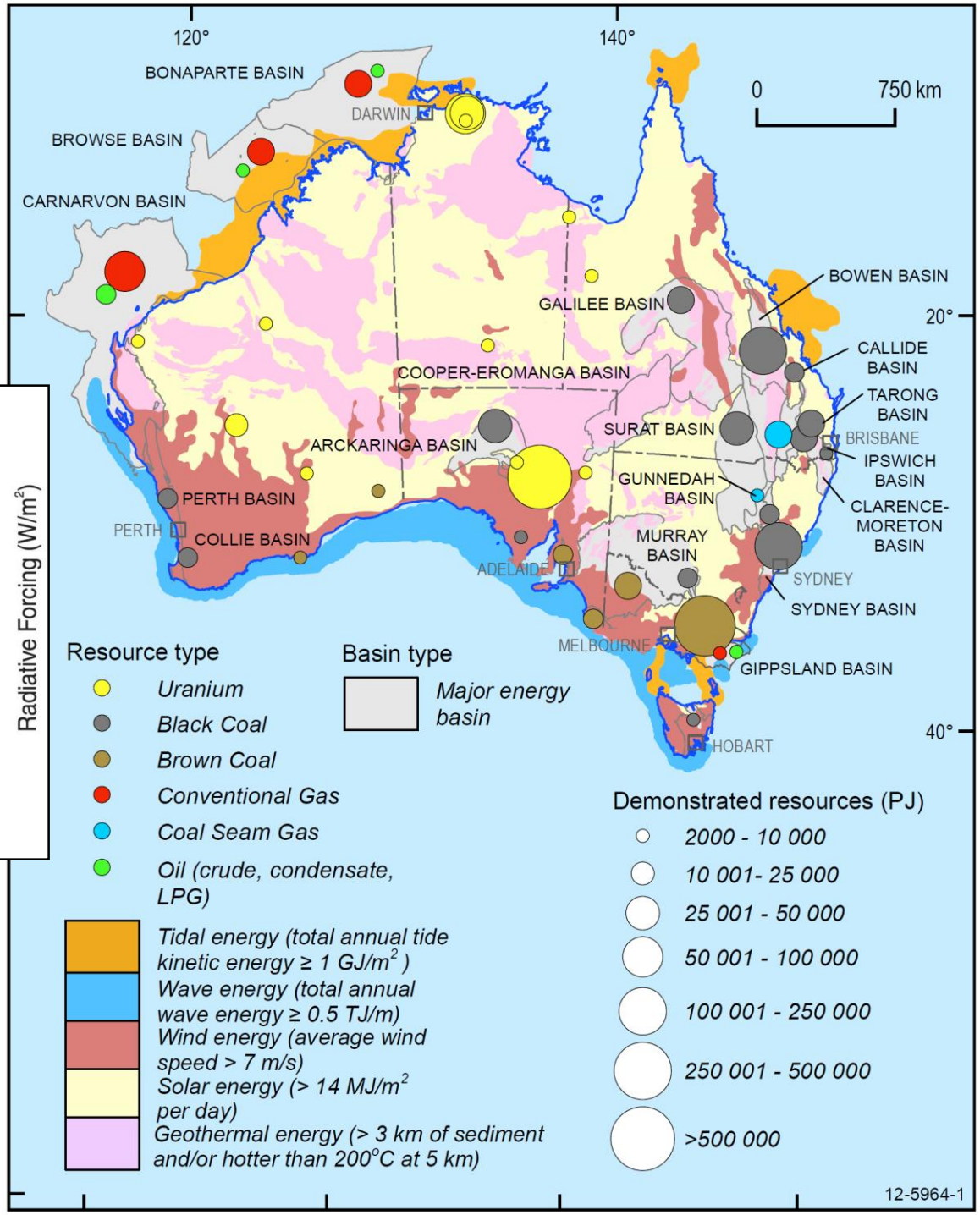
- Mining is only just beginning to explore the full potential of renewable energy technologies as well as shifting to electric vehicles
- Goldcorp's enw Borden Lake Au mine is now fully electric … a remarkable step change
- Chilean mines are building 100's MW of solar panel farms … in contrast Australia is minimal
- Australia's former Kidston Au mine is now being transformed into a solar-wind-pumped hydro project
- PNG's Lihir mine extracts energy from geothermal activity related to the geology of the mine … although initially it ignored this resource

Energy … Oz Style



Energy in Australia 2012

BREE for RET



Sandfire's Solar Farm at DeGrussa (WA)

Geothermal Energy at Lihir (PNG)

Metals for Renewable Energy & Batteries

- **There is widespread concern about the ability to meet the rapidly growing demand for metals and minerals used to make energy storage batteries and various renewable energy technologies**
  - *e.g. batteries need lithium, nickel, cobalt, graphite, … future V? Zn? Na?*
  - *Renewable energy can use Te, In, Cd, Ga, … plus common metals*
- **There is often confused concern about resource depletion versus concentration of supply: these are not the same thing !**
- **Based on known resources – we have absolutely plenty of deposits already known to continue the roll-out of renewable energy & batteries to meet current climate targets (e.g. Paris Agreement) or even more ambitious targets**
- **There remain real issues of supply concentration, as well as resource concentration … but these can be addressed in numerous ways by governments, industry and community**

Summary: Energy & Carbon vs Mining

- **The energy & carbon intensity of mining will continue to grow … often despite efforts to be more efficient or deploy new technology**
  - ***declining ore grades are crucial in this regard***
- **Critical to understand the energy-carbon drivers for each mine site – every mine can be quite different (sometimes surprisingly so)**
- **Growing reliability of sustainability reporting is providing extensive data which can be used to understand energy-carbon intensity of mining**
- **Mining is crucial to supply the metals required for renewable energy & energy storage batteries**

Acknowledgements

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- The many communities I've visited who live with mines (& their companies & governments) in all sorts of creative ways !