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What will surprise us?
Minerals-Energy Nexus

Some key considerations

- Functional critical minerals for clean energy
- Energy requirements in minerals – now and future
- Rates of change in demand and supply

Thoughts on energy-minerals nexus…

- Energy essential for minerals production
- Energy need increases with deeper and lower grade (to an extent)
- Too slow turning fossil-fuels into renewable technologies
- Nexus restriction on supply – e.g. South Africa examples of energy and water stopping or reducing operations

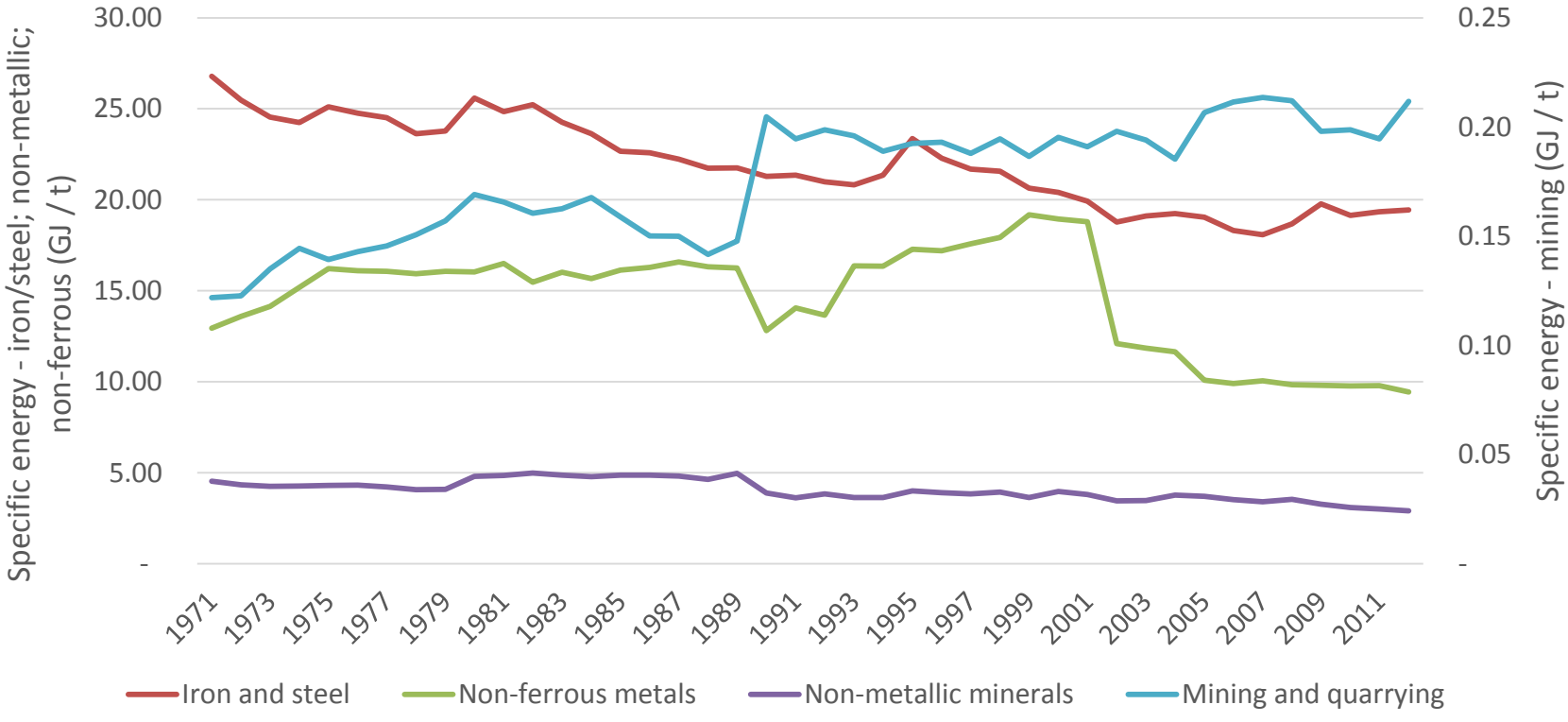
Thoughts on potential surprises…

- Rapid coalescence of diffuse demand
  - SNS-style diffusion of popularity and uptake
- Rapid market convergence of supply and demand
  - May lead to conflict, market control, or just capping demand

Some random thoughts

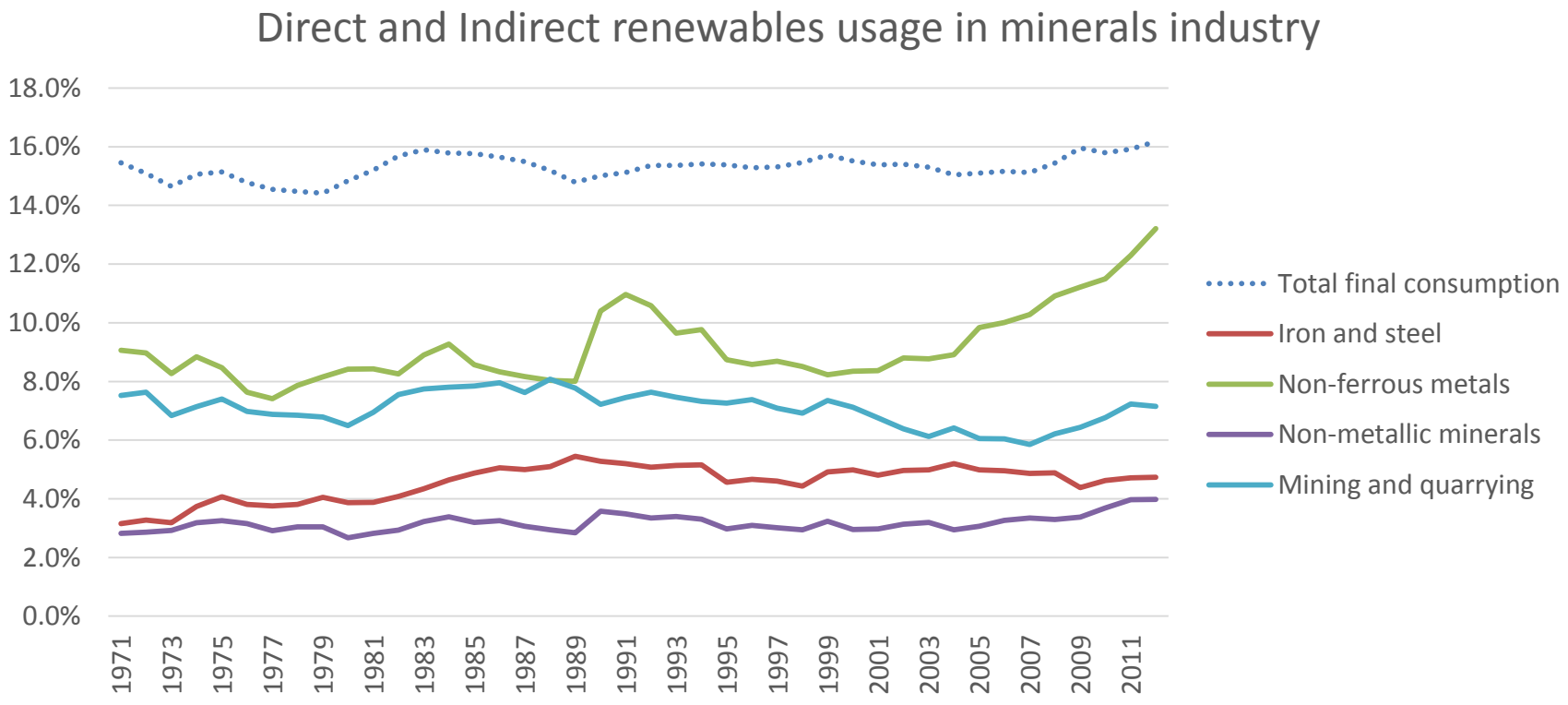
- Decreasing grades:
  - increasing energy and impacts
  - Pre-emptive extraction of deep ocean resources
- Complex ores with detrimental elements
  - e.g. deep ocean massive sulphides with high As / Hg
- Recycling not living up to potential:
  - Dissipative losses
  - Energy and reagent reuse

Estimated energy per tonne



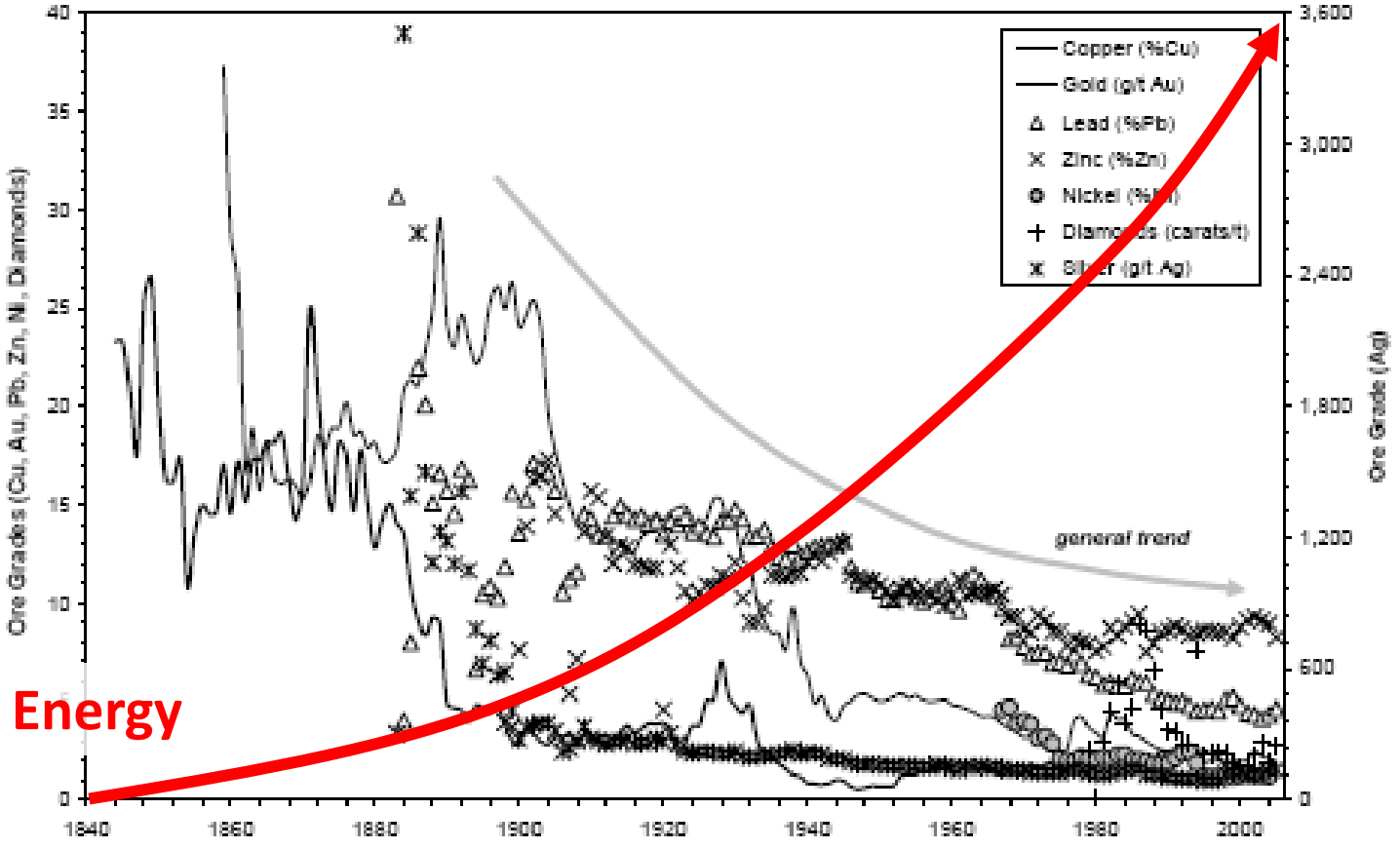
Based on USGS and IEA data; Iron and steel includes blast furnace and coke production;

Renewable energy usage in the minerals industry



Direct and indirect (electricity) usage of renewables in the minerals industry globally
Total Final Consumption includes all sectors (not just minerals)

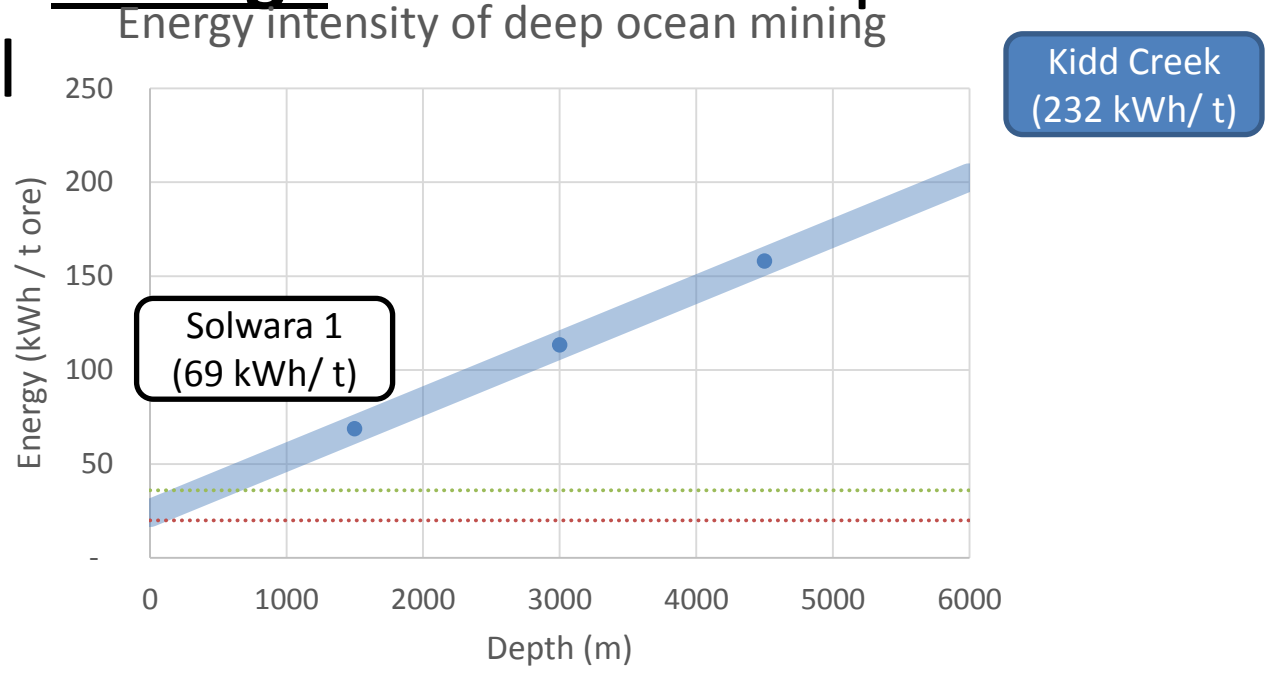
...and the Grades are getting lower...



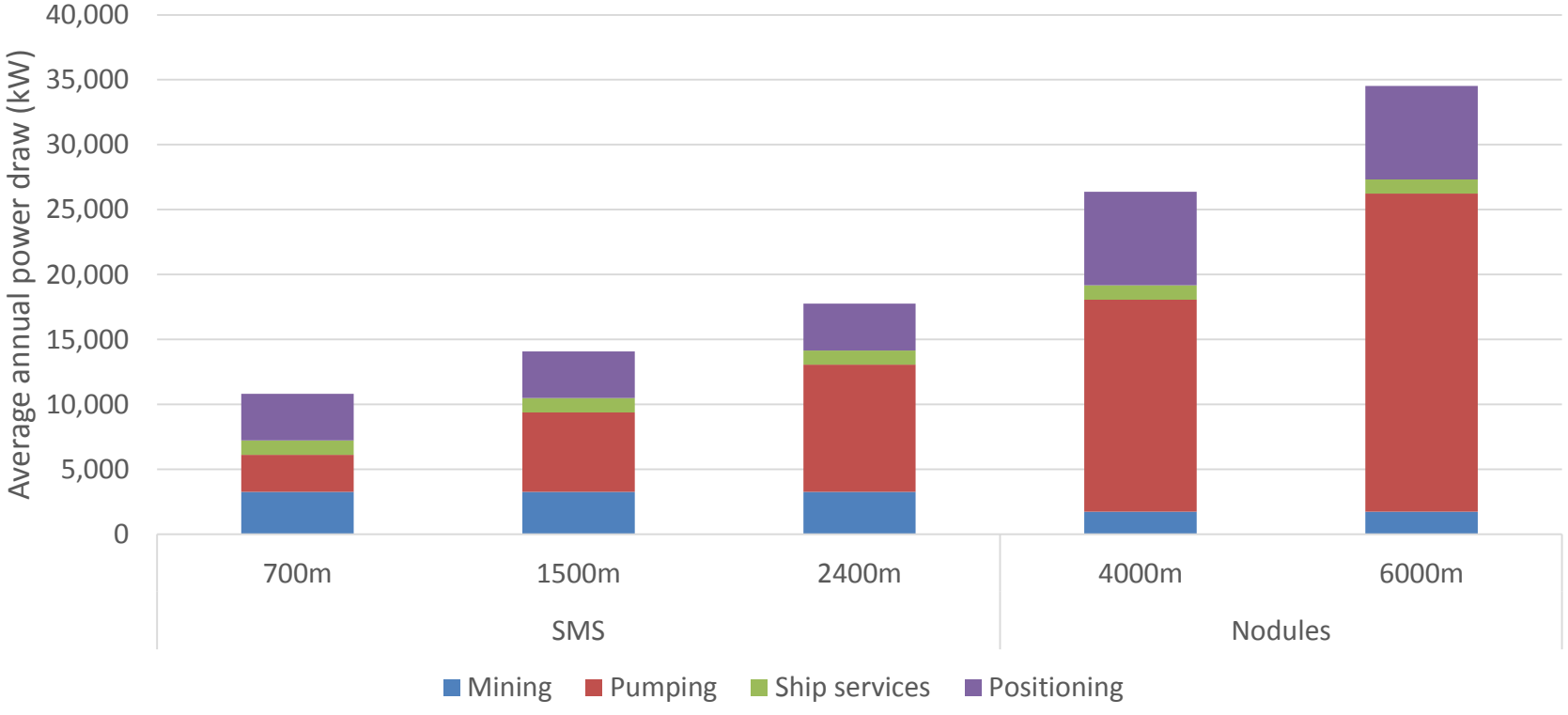
(Mudd, 2007)

Deep ocean mining

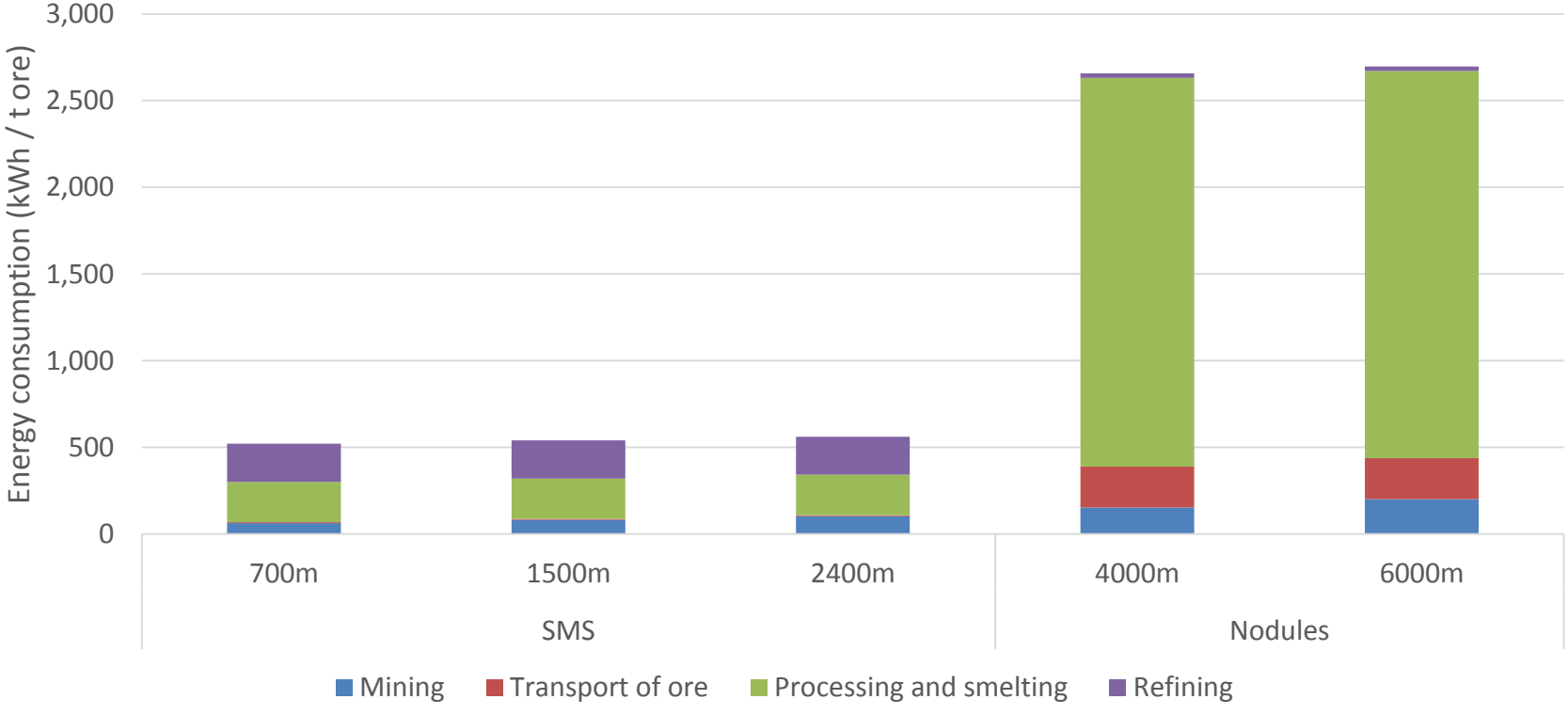
- **<u>2-3 times</u>** the energy for extraction compared to global **<u>average</u>** of mined and quarried material



Depth considerations



Deep ocean mining – mining not the only issue (or perhaps the most important…)



Potential reduction in emissions

Thermal energy (71% of total minerals industry emissions)	
Solar thermal	Low (3~7%)
Geothermal	Low
Biomass – charcoal and biofuels	Good (~65%)
Hydrogen	Moderate (~40%)

Electrical energy (29% of total minerals industry emissions)	
Solar	Low (~8%)
Wind	Moderate
Hydropower	Good (~75%)

Renewable energy in minerals producing countries – from McLellan (2012)

Considerations for Urban Energy and Deep Ocean Ores

- Low deposit size (orders of magnitude)
- Low deposit geographical density (material spread out across a wide area, particularly if residential usage is anticipated)
- Variable deposit grades (not always higher than conventional resources).

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QUESTIONS?






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