The Critical Mineral Foundations of the Energy Transition

Peru

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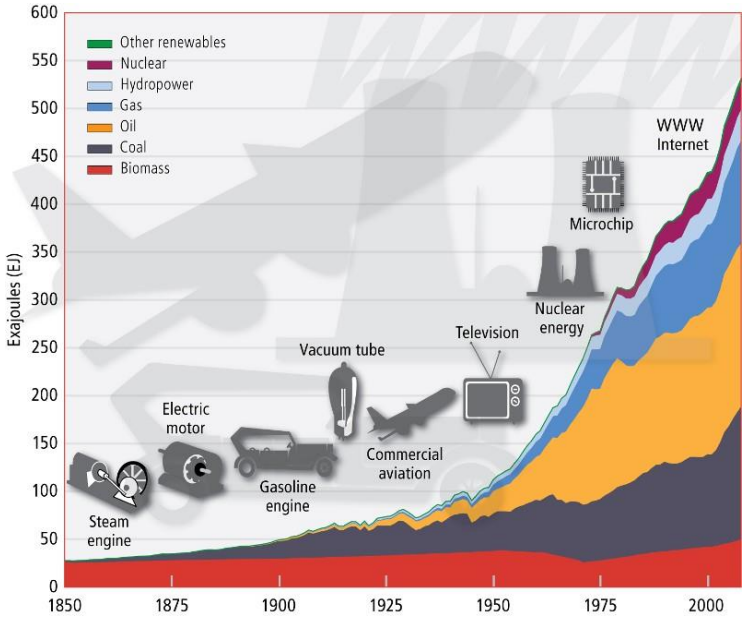
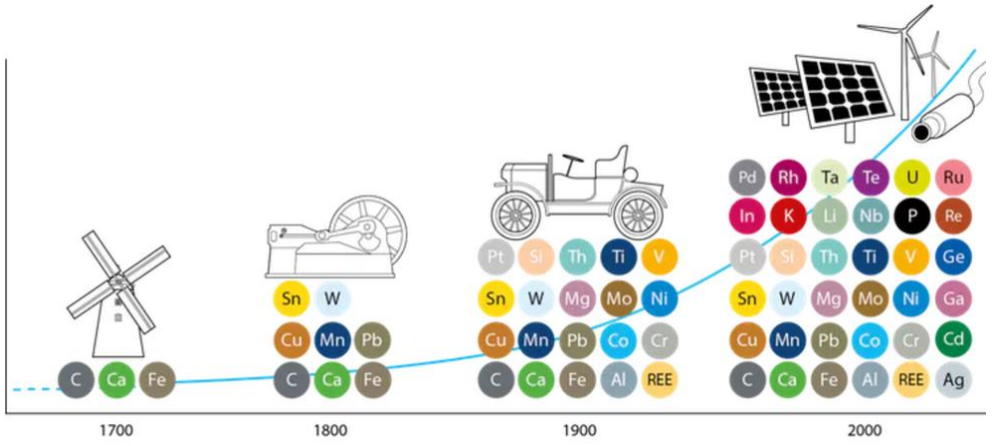
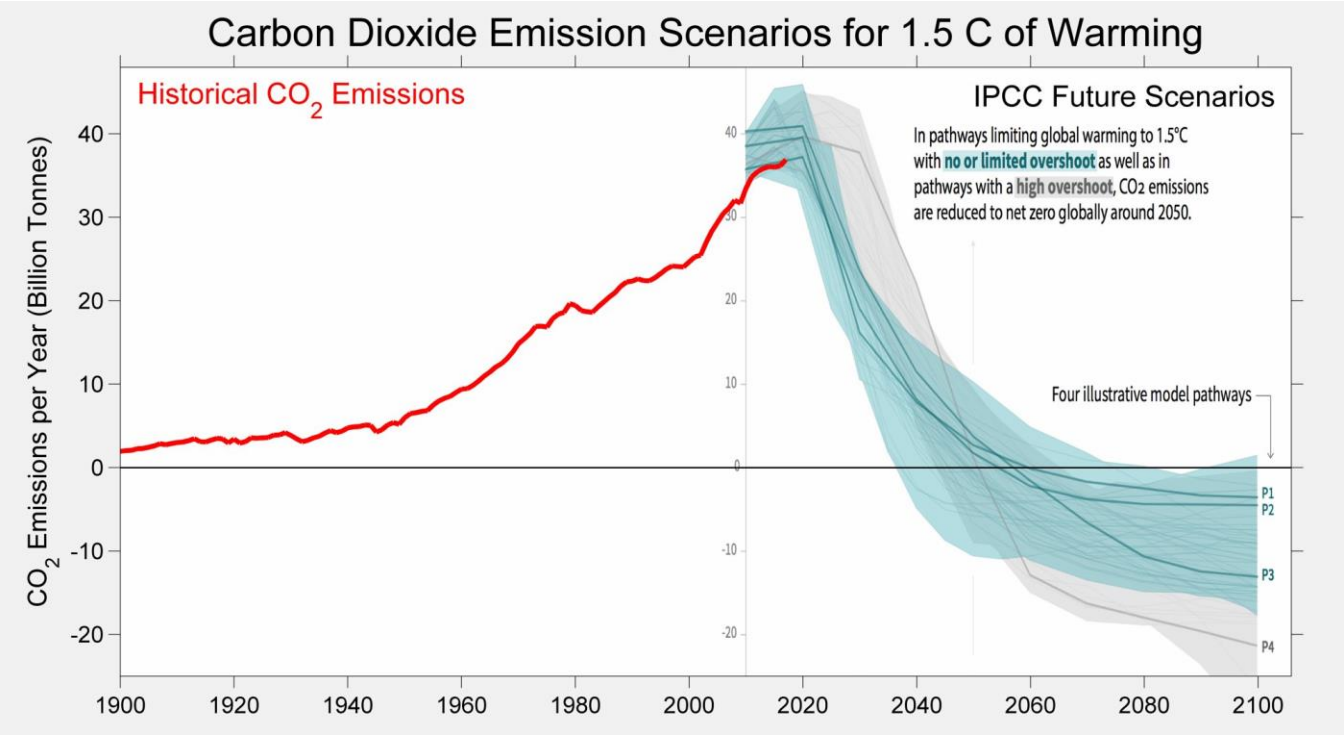
Of non-linear (upward) curves…



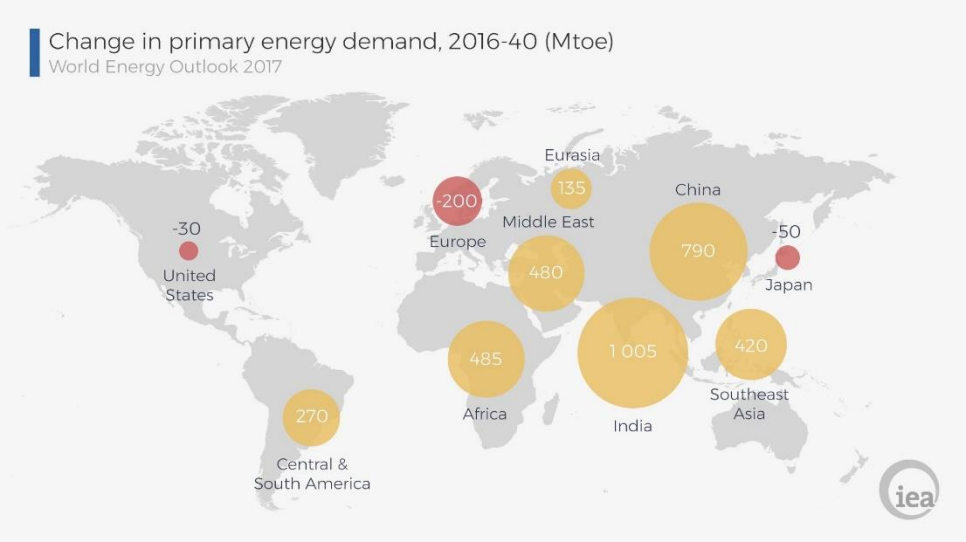


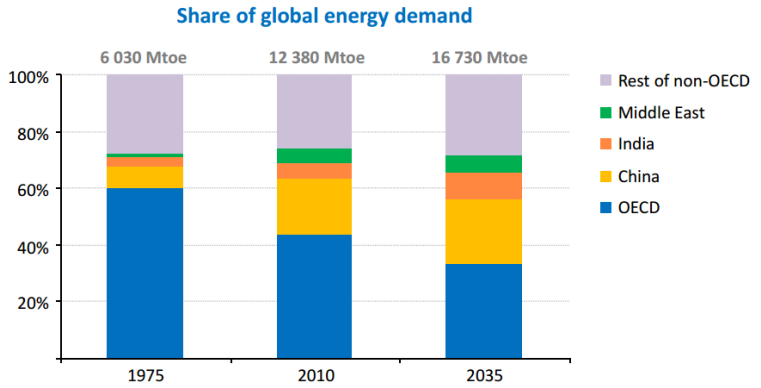
IIASA, Nakicenovi, Zepf, 2014c

….and downward



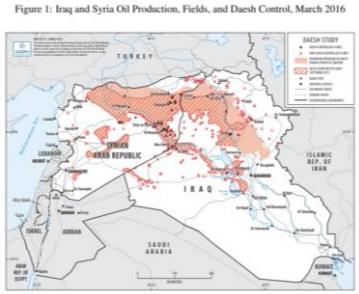
The energy transition is largely a developing country story





IEA WEO 2017

New ways to monitor the transition



Geopolitical contours

While climate change impacts are being well-monitored, less so are other energy-related considerations:

1. **Natural Gas** Accelerating trade through new international pipelines or liquefied natural gas (LNG)

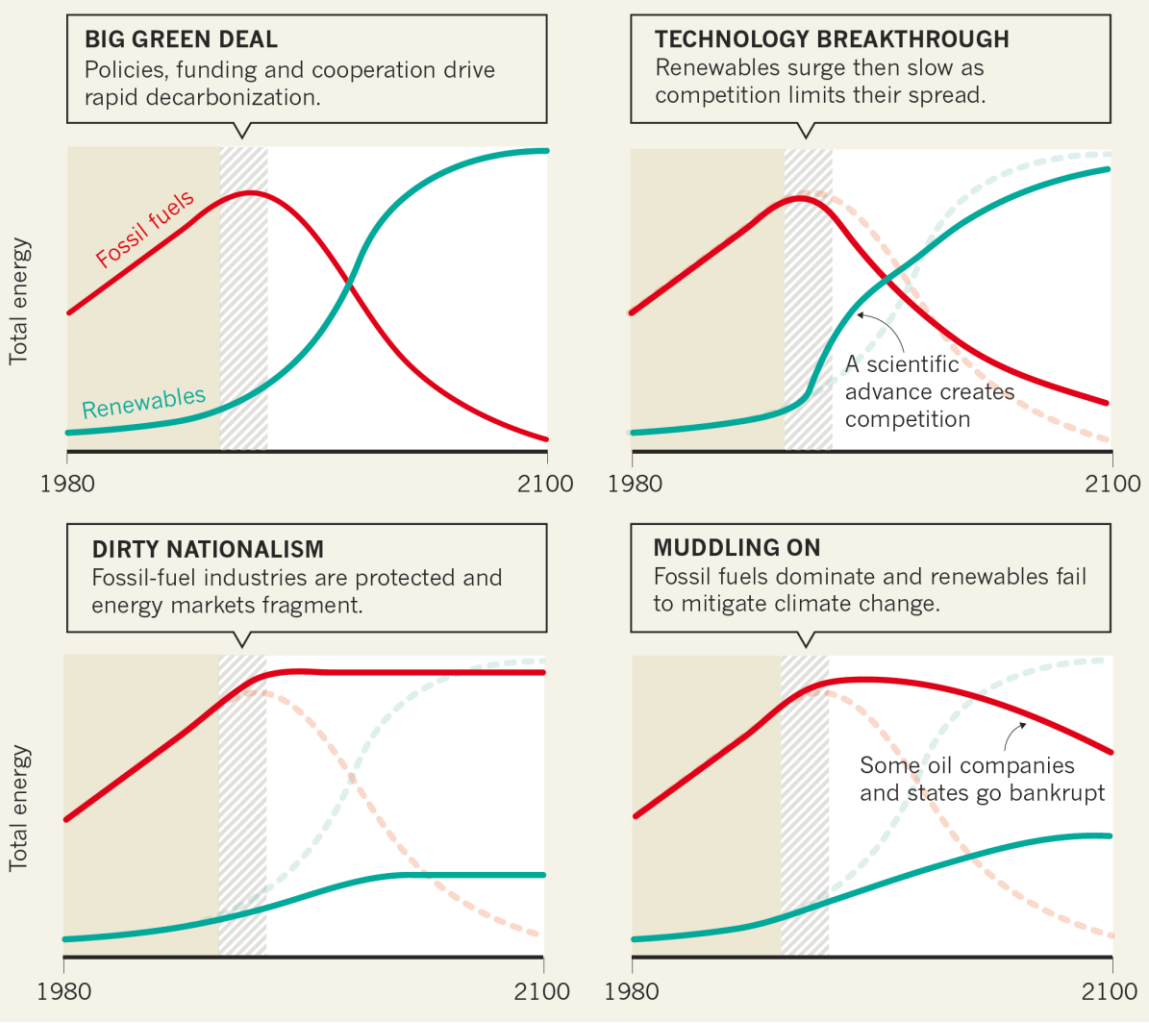
2. **Cybersecurity** Growing importance with rise of interconnected systems and new forms of metering & system operation

3. **Minerals** Conflict over minerals due to changes in technology and deployment in large numbers

4. **Grids** More regional interconnections in electricity grids from the Belt and Road to East Africa

5. **Inequality** Energy poverty and demand for reliable & affordable energy services to billions of people and businesses

Global energy transition: four alternative futures



GET drivers:

- Policy
- National politics
- Technology
- Markets

Source: Goldthau, Bazilian et al, Nature 2019

Key takeaways from scenarios

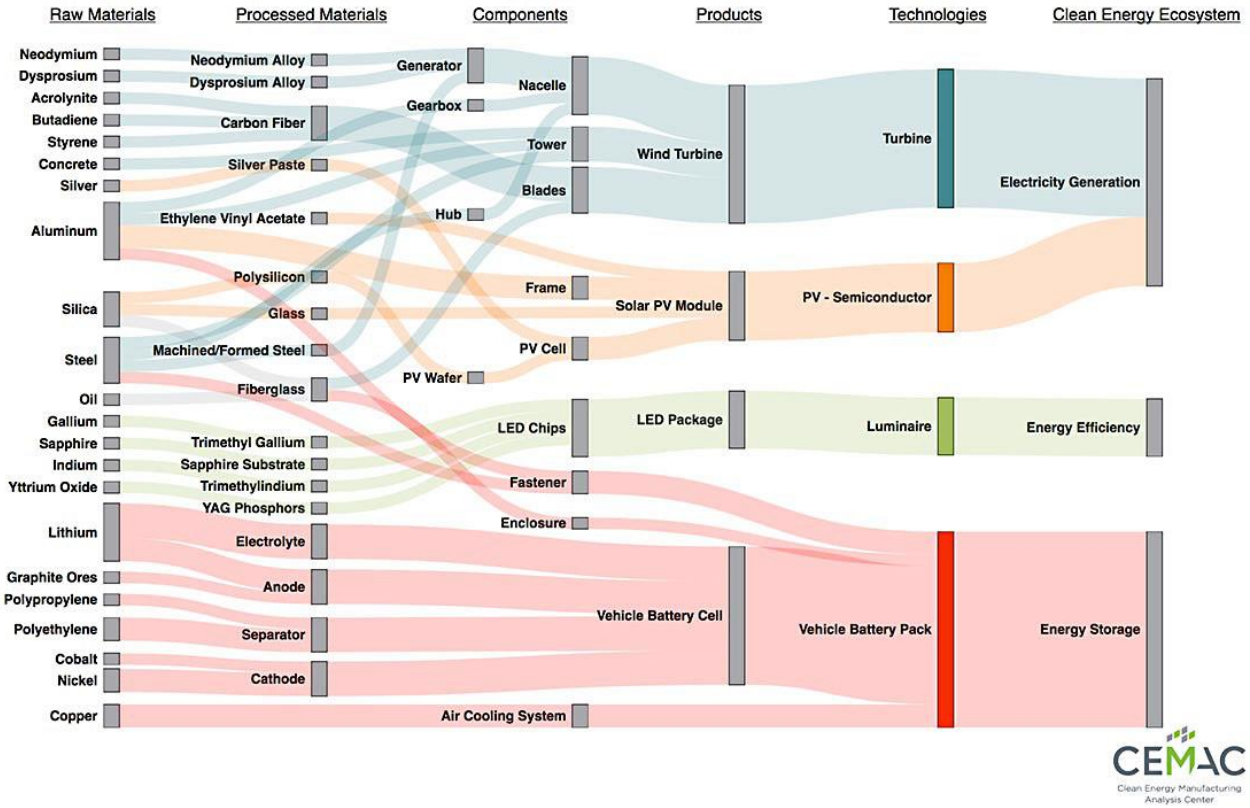
- A zero-carbon world does not do away with zero-sum games. It produces different ones.
- Global win-win is but one plausible outcome.
- The pace of change matters.
- Some pathways may not be politically palatable to all.

→ ***Acknowledge abating carbon creates losers & prepare for it***

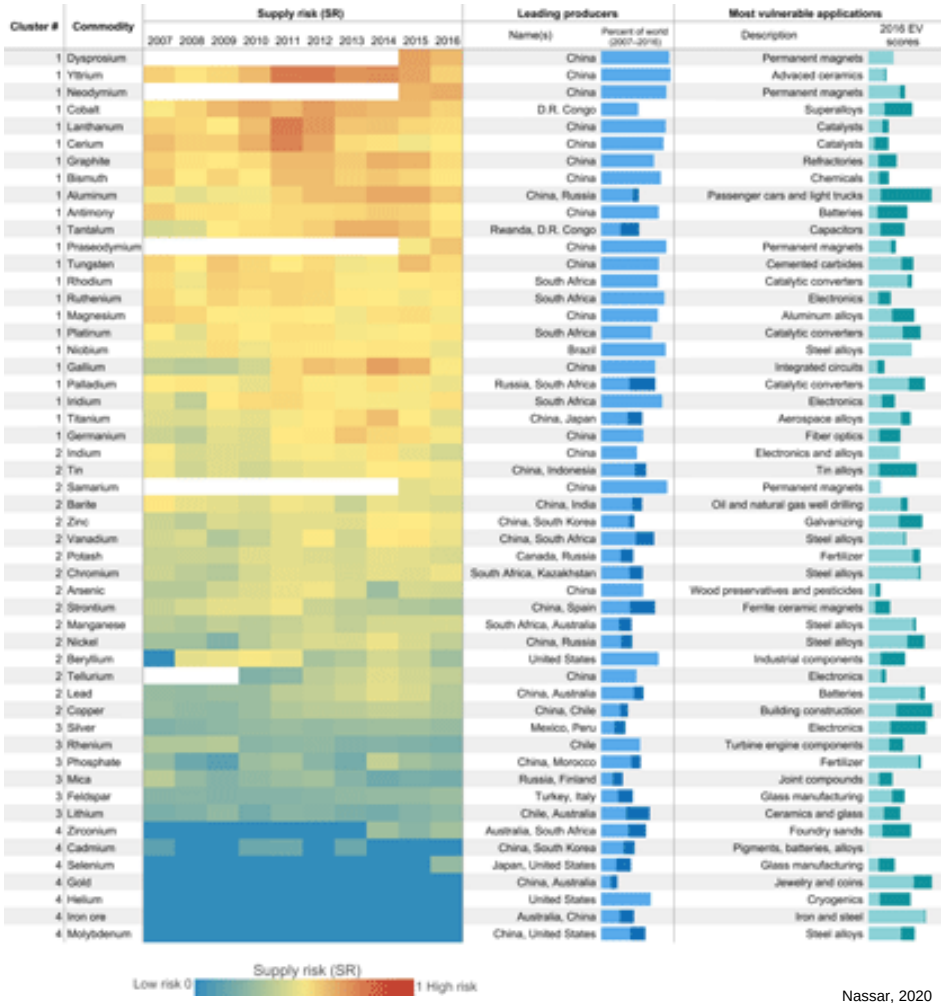
→ ***Shift attention from goals to pathways***

→ ***Draw lessons from past and parallel experiences***

Clean energy technologies and minerals



Defining criticality



Nassar, 2020

Other Countries….

Table 1: Table of critical minerals in Australia[4]

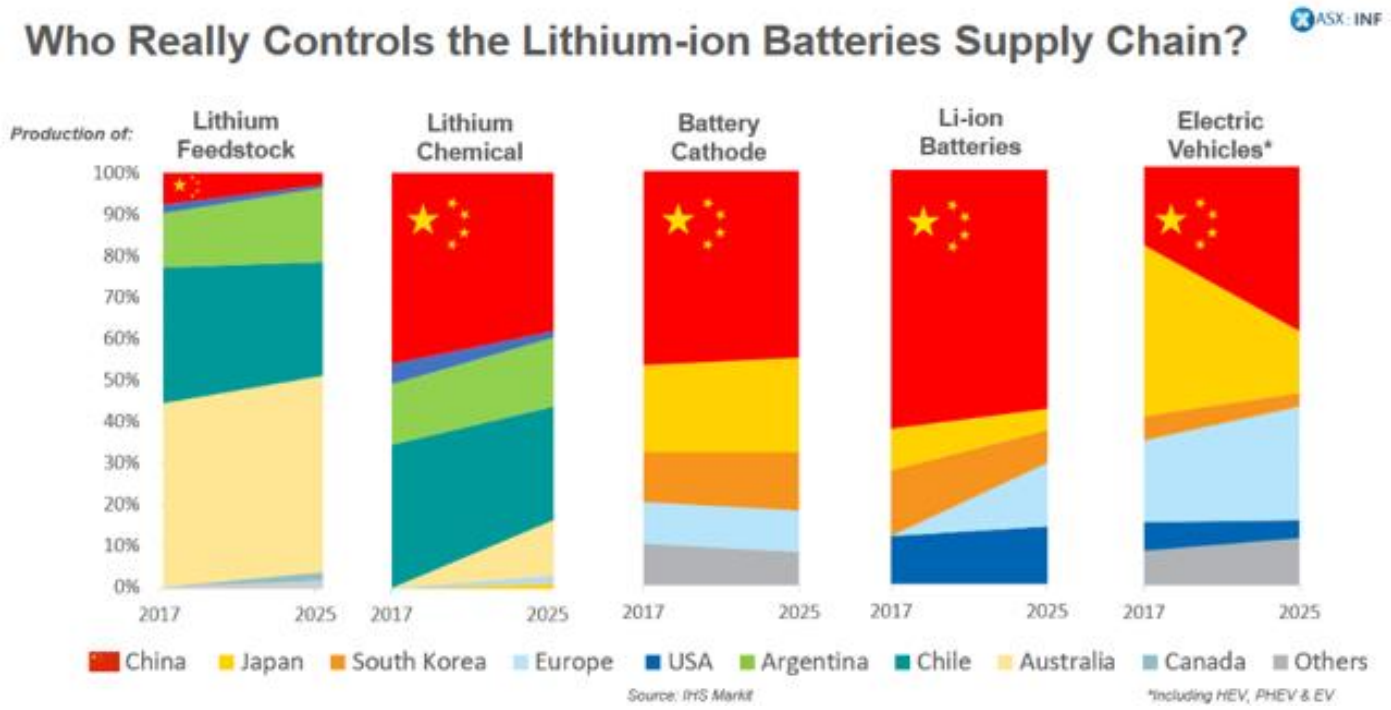
	Critical Mineral	U.S. list[5]	E.U. list[6]	Japan list[7]	Australia's Geological Potential[8]	Australia's Economic Demonstrated Resource[9]	Australia's Production	Global Production	Market Value (Global) (US$m)[10]
1	Antimony	✓	✓	✓	Moderate	138 kt	5.5 kt	150 kt	$185.2
2	Beryllium	✓	✓		Moderate	-	-	230 t	$918.6[11]
3	Bismuth	✓	✓		Moderate	-	-	14 kt	$69.2
4	Chromium	✓		✓	High	-	-	31 000 kt	$4,705.3
5	Cobalt	✓	✓	✓	High	1221 kt	5 kt	110 kt	$541.8
6	Gallium	✓	✓	✓	High	-	-	495 t	$918.6[11]
7	Germanium	✓	✓	✓	High	-	-	134 t	$918.6[11]
8	Graphite	✓	✓	✓	Moderate	7140 kt	0	1200 kt	$1,076.1
9	Hafnium	✓	✓		High	756 kt	-	-	$918.6[11]
10	Helium	✓	✓		Moderate	-	4 hm³	160 hm³	$591.0
11	Indium	✓	✓	✓	High	-	-	0.72 kt	$918.6[11]
12	Lithium	✓		✓	High	2803 kt	14.4 kt	43 kt	$1,430.6
13	Magnesium	✓	✓	✓	Moderate	-	0	1100 kt	$716.4
14	Manganese	✓		✓	High	231 000 kt	3200 kt	16 000 kt	$5,443.7
15	Niobium	✓		✓	High	216 kt	-	64 kt	$1,709.5[12]
16	Platinum-group elements	✓	✓	✓	High	24.9 t	2.6 t	200 kt	$19,316.6
17	Rare-earth elements	✓	✓	✓	High	3270 kt	14 kt	130 kt	$415.4[13]
18	Rhenium	✓		✓	Moderate	-	-	52 kt	$918.6[11]
19	Scandium	✓	✓		High	-	-	-	-[13]
20	Tantalum	✓	✓	✓	High	55.4 kt	-	1.3 kt	$1,552.9
21	Titanium	✓		✓	High	Ilmenite: 276 500 kt Rutile: 32 900 kt	Ilmenite: 1400 kt Rutile: 300 kt	Ilmenite: 6700 kt Rutile: 750 kt	$1,609.9
22	Tungsten	✓	✓	✓	Moderate	386 kt	0.11 kt	95 kt	$164.0
23	Vanadium	✓	✓	✓	Moderate	3965 kt	0	80 kt	$1,709.5[12]
24	Zirconium	✓		✓	High	52 662 kt	600 kt	1600 kt	$1,003.4

Australian Government, 2019,

- **The United States** lists 35 minerals and commodities as critical to their economic and national security.
- **The European Union** lists 27 raw materials as critical due to risks of supply shortage and their impacts on the economy being higher than those of most of the other raw materials.
- **The Japanese** report that identified the 31 critical

  minerals

It's the supply chain



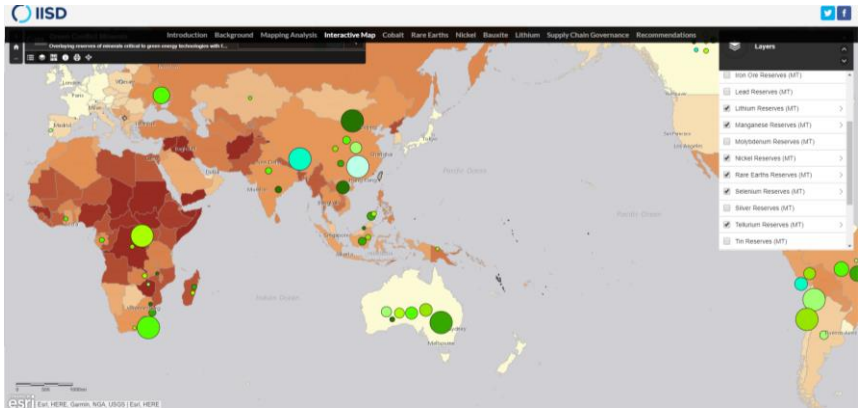


Table 2
Cobalt production and reserves (metric tons) (Drexhage et al., 2017 based on USGS, 2016).

Country	Mine production	Reserves
Congo (Kinshasa)	63,000	3,400,000
Australia	6000	1,100,000
Cuba	4200	500,000
Zambia	2800	270,000
Philippines	4600	250,000
Russia	6300	250,000
Canada	6300	240,000
New Caledonia	3300	200,000
Madagascar	3600	130,000
China	7200	80,000
Brazil	2600	78,000
South Africa	2800	31,000
Other countries	7700	633,000
Total	120,400	7,162,000

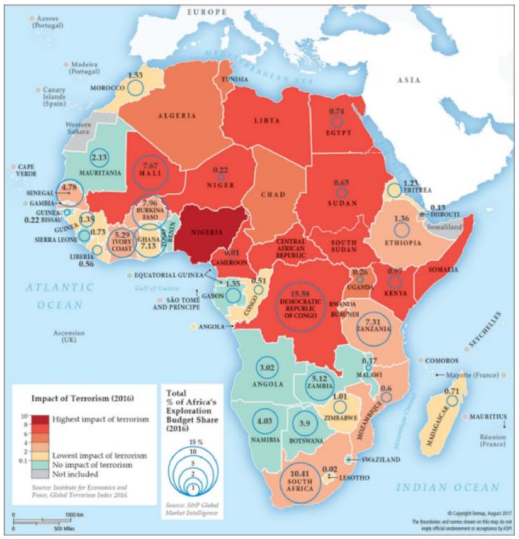
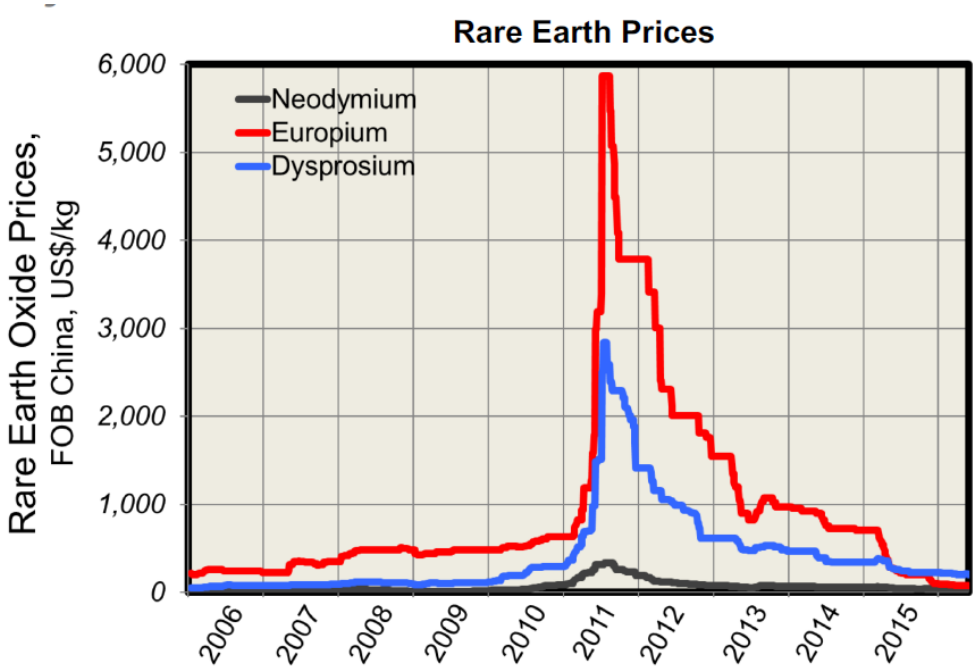
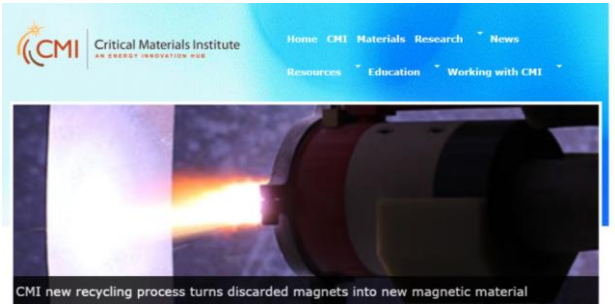


Fig. 3. Mining exploration budget and terrorism impact (Sharland et al., 2017).

Motivation to start CMI





Parting thoughts (1 of 3)

- The minerals markets for most of the critical minerals are not at all transparent. As a result, there are glaring governance issues which need to be addressed. Market development takes decades to develop properly as we can see from those for natural gas and oil. The ERGI initiative from DoS begins to address some of these issues. Still, more needs to be done - broader coalitions are needed and multilateralism can play an important role – and a continued focus on equity is essential.

- Related to issues of market design and governance, the lack of price discovery and liquidity in these markets is limiting appropriate investment signals. This seems empirically evident in the investment gaps in, say, lithium. There are additional challenges around market size being relatively small in many cases. Adding complexity is the fact that some of the critical minerals are secondary or tertiary. It is very hard to understand the incentives for those types of product.

Parting thoughts (2 of 3)

- One needs to think about supply chains when considering minerals and metals. Just thinking of rocks and the upstream is limiting. It is also complicated by the fact that there are many different supply chains to keep an eye on in this space. The data and methodologies to track finances or emissions across these chains are hard to find or overly complex.

- The understanding of the security issues of critical minerals is still nascent. The methodologies and metrics are still somewhat simplistic, and too tied to a supply-side focus or flawed notions like independence. They also blur the bounds between energy and security. Think of the market for germanium in space solar panels as an example.

Parting thoughts (3 of 3)

- The balance between domestic security issues and fostering “good” trade is key to designing US policy. That said, the main issue for US foreign policy makers is China. The US can't approach material issues the same way. It's going to be difficult to compete with China’s trade agreements, their state-owned enterprises, and their relatively weak labor and environmental standards. They also have a large head start.

- So what can or will the US do under a new administration? In the Congress, one of the highlights of the last four years has been on this topic under the leadership of Senators Murkowski and Manchin in their committee. So the good work underway may in fact continue. Issues from product R&D, to stockpiling, to procurement, to siting, to financial risk mitigation tools, to institutions will all likely be revisited. But recall that policy is largely about prioritization and implementation. Whether this area gets sufficient policy prioritization in the coming years is not at all clear.

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