

Welcome to

“The Coming Energy Transformation: Drivers, Consequences and Implications for Geopolitics”

with Dr. Morgan Bazilian, Director of the Payne Institute at Colorado School of Mines



**Honorary
Membership
Walter B. Ayers**



**Distinguished Service
Amy Sullivan**

Seminar Will Begin Shortly



AAPG

Energy Minerals Division

*The Energy Minerals Division of the AAPG is proud to
recognize and honor our 2020 awardees.*



**Past President
Wayne Camp**



**Certificate of Merit
Ursula Hammes**

**Frank Kottowski Memorial Award to
Ryan D. Wilson and co-authors of
“Parasequence Expression in
Epicontinental Organic-Rich
Mudstones: Examples from the
Middle-Late Devonian of North
America”**

**Lloyd Carlson Memorial
Award to Randy Blood and
Gary Lash for “The
Significance of Framboid-
Hosted Porosity in the
Marcellus Shale of the
Appalachian Basin, USA”**

**President’s Certificate of Merit to Tobi
Kosanke and co-authors for “Continuous
Mineral Mapping of Core Using
Hyperspectral Imaging; Example from the
Upper Cretaceous Austin Chalk Marathon
1 Robert Todd Core, Central Louisiana”**

**President’s Certificate of Merit
to Robert Reed and co-authors
on “Refining XRF Lithofacies
with SEM Analysis for the
Permian Wolfcamp Shale from
the Delaware Basin, Texas.”**

Geopolitics of the Energy Transition

Energy Minerals Division (AAPG) Annual Zoom Conference

June 9, 2020

Morgan D. Bazilian, Ph.D.

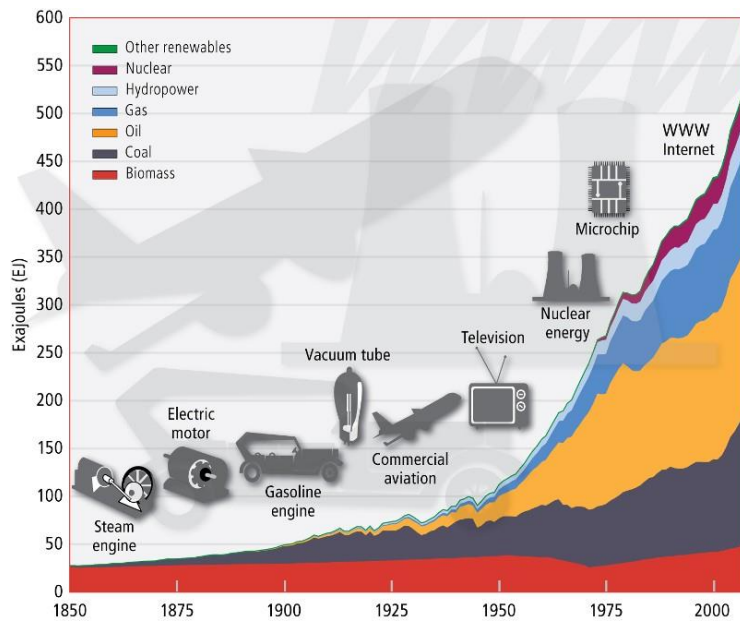
Director, The Payne Institute, and Professor of Public Policy

The Payne Institute *for* Public Policy

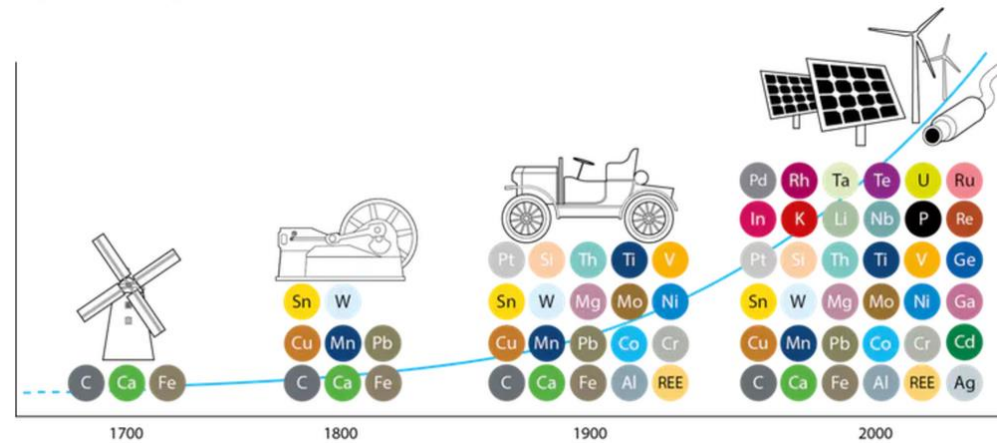


COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

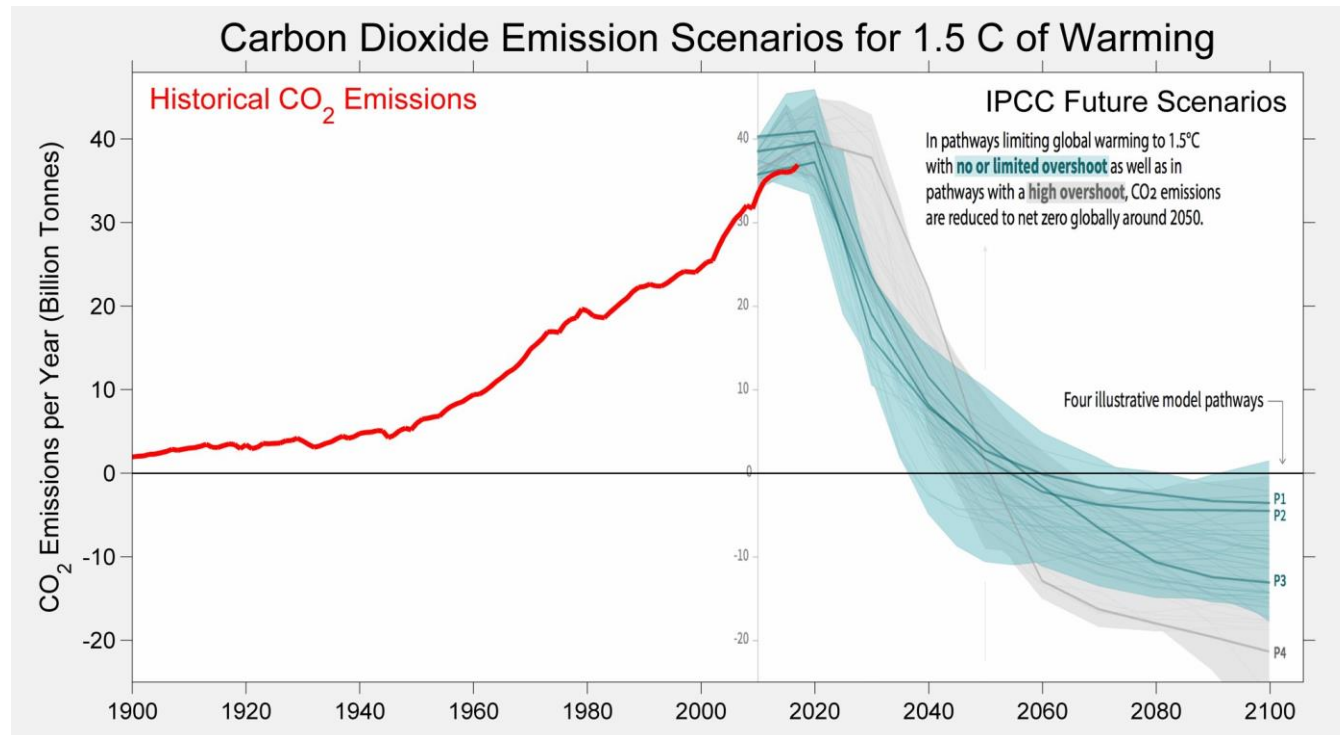
Of non-linear (upward) curves...



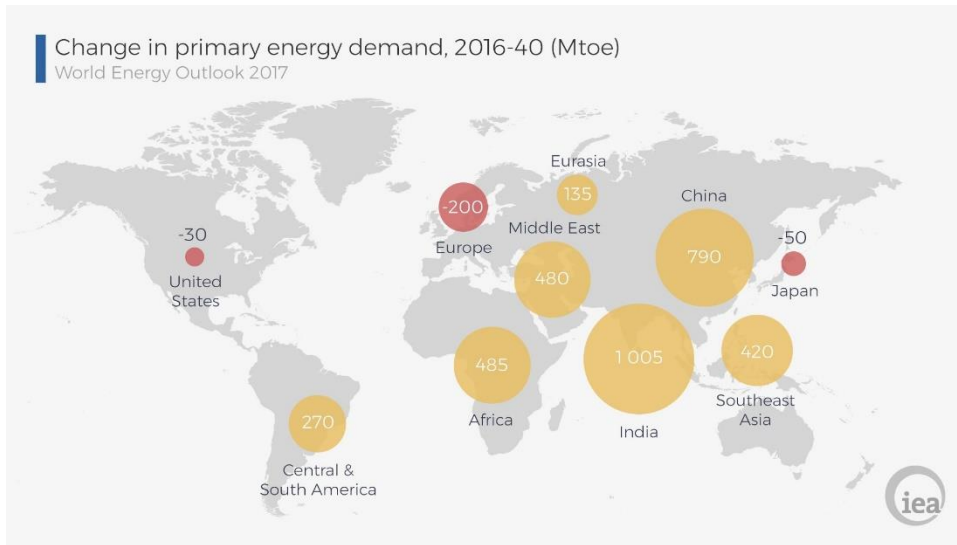
IIASA, Nakicenovi, Zepf, 2014c



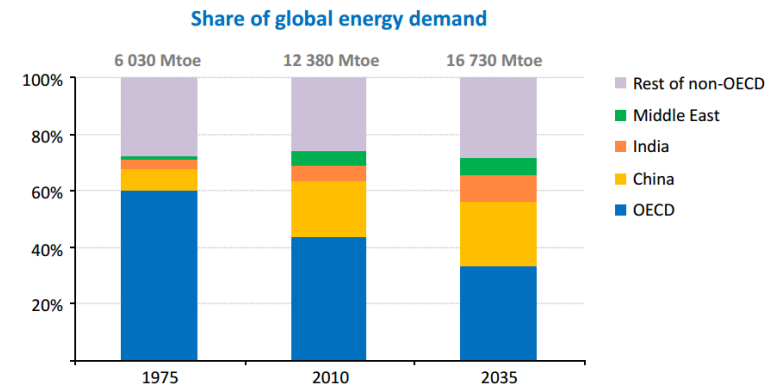
....and downward



The energy transition is largely a developing country story



IEA WEO2017

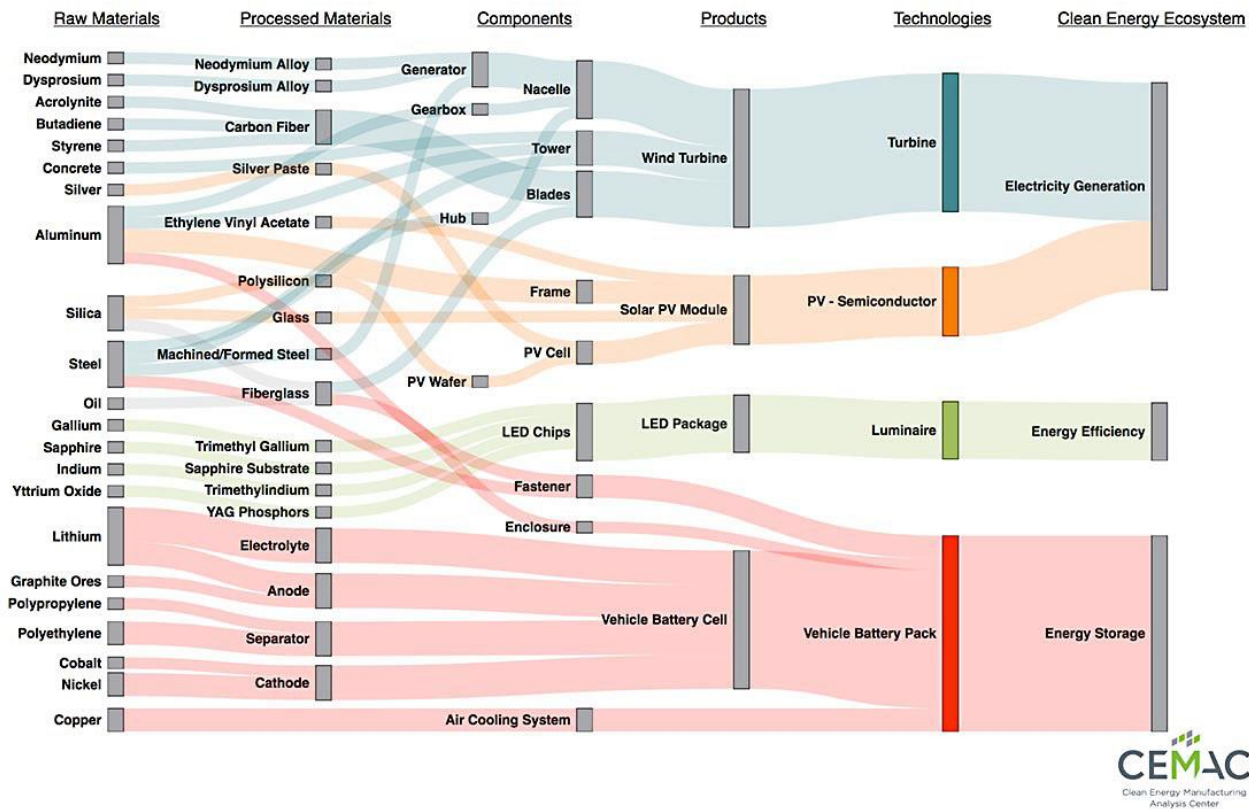


Geopolitical contours

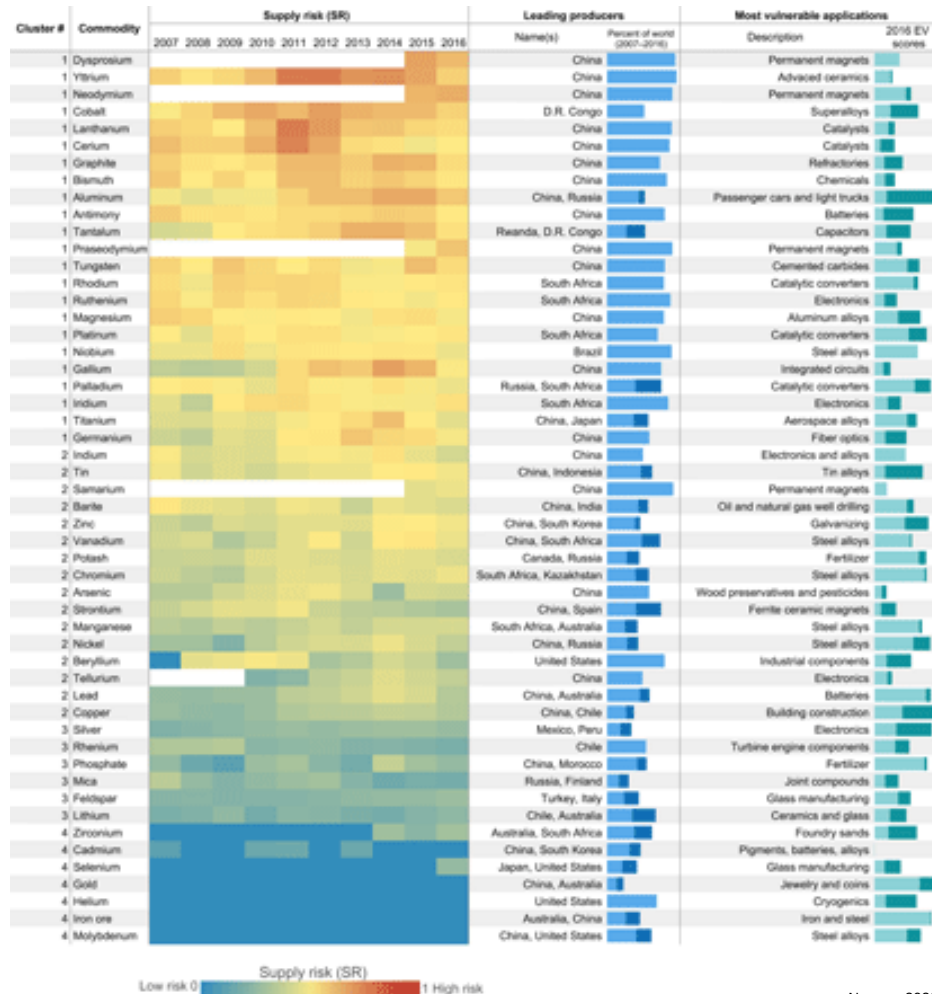
While climate change impacts are being well-monitored, less so are other energy-related considerations:

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

Clean energy technologies and minerals



Defining criticality



Nassar, 2020

Other Countries....

Table 1: Table of critical minerals in Australia*

Critical Mineral	U.S. list ²	E.U. list ⁴	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 ⁹
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 ⁹
7 Germanium	✓	✓	✓	High	-	-	134 t	\$918.6 ⁹
8 Graphite	✓	✓	✓	Moderate	7140 kt	0	1200 kt	\$1,076.1
9 Hafnium	✓	✓		High	756 kt	-	-	\$918.6 ⁹
10 Helium	✓	✓		Moderate	-	4 hm ³	160 hm ³	\$591.0
11 Indium	✓	✓	✓	High	-	-	0.72 kt	\$918.6 ⁹
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 ⁹
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 ⁹
18 Rhenium	✓	✓		Moderate	-	-	52 kt	\$918.6 ⁹
19 Scandium	✓	✓		High	-	-	-	.. ³¹
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 ⁹
24 Zirconium	✓	✓	✓	High	52 662 kt	600 kt	1600 kt	\$1,003.4

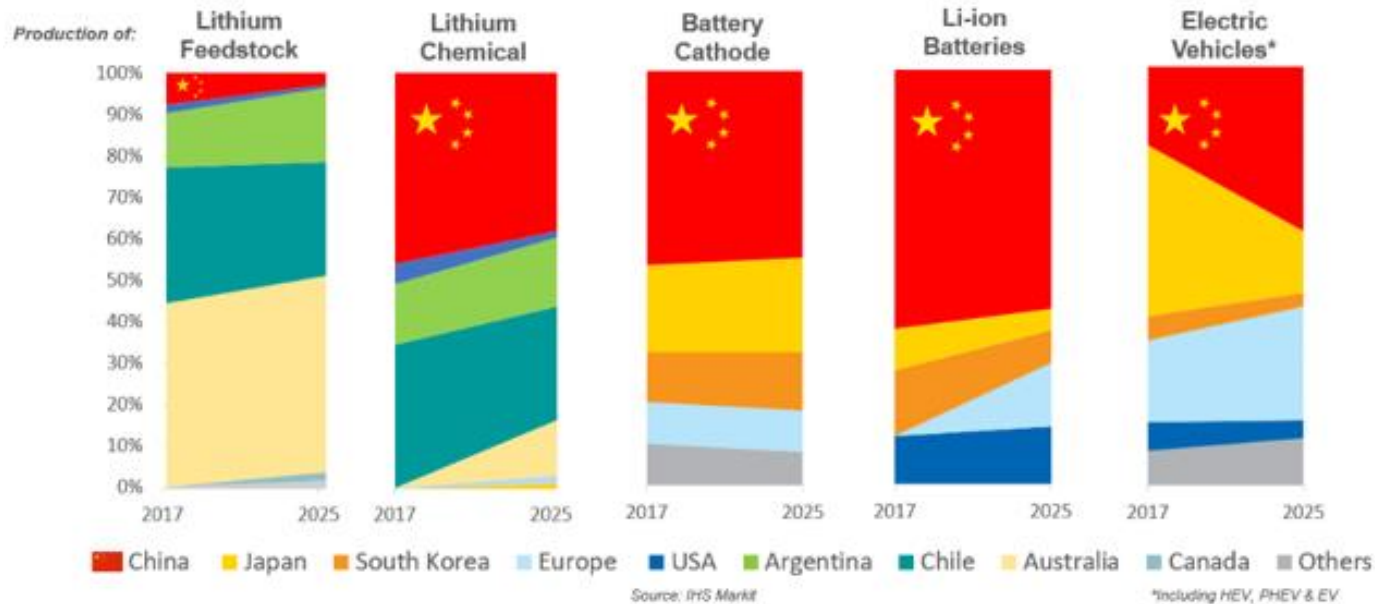
Australian Government, 2019,

- **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

Who Really Controls the Lithium-ion Batteries Supply Chain?

ASX:INF



Georgetown Journal of International Affairs

ABOUT US CURRENT ISSUE LATEST ARTICLES SUBMISSIONS CURRENT STAFF BUY PRINT CONTACT US



Human Rights & Governance
How Renewable Energy Could Fuel Future Conflicts

October 08, 2018 · Madison Freeman and Morgan Bazilian

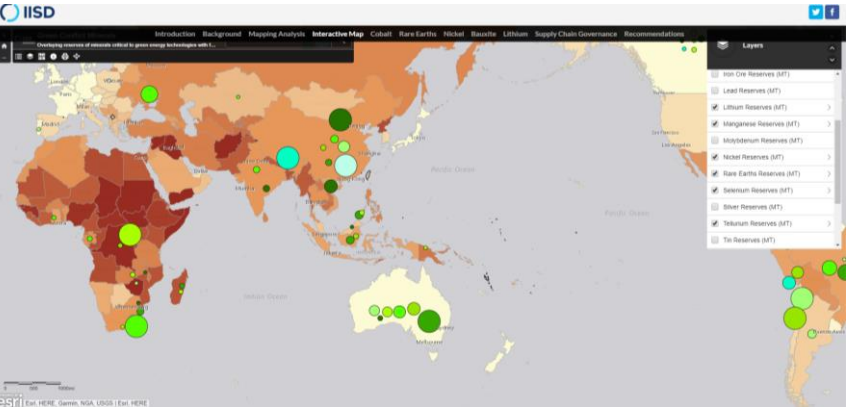


Table 2
Cobalt production and reserves (metric tons) (Drexhage et al., 2017 based on USGS, 2016).

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

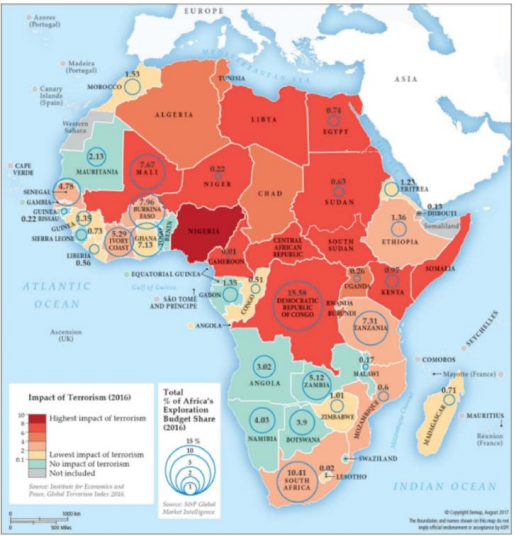
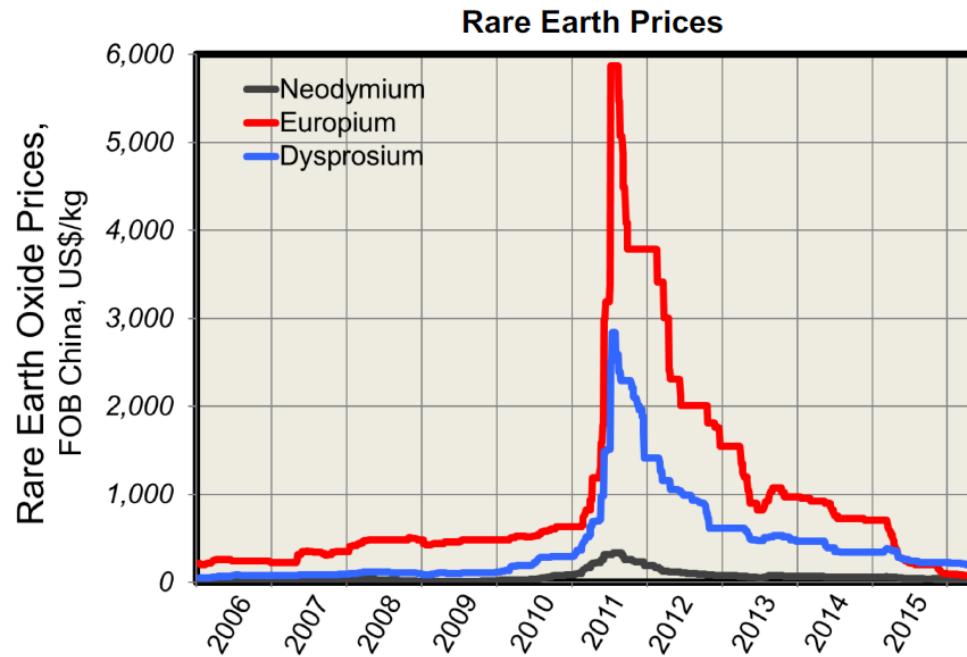
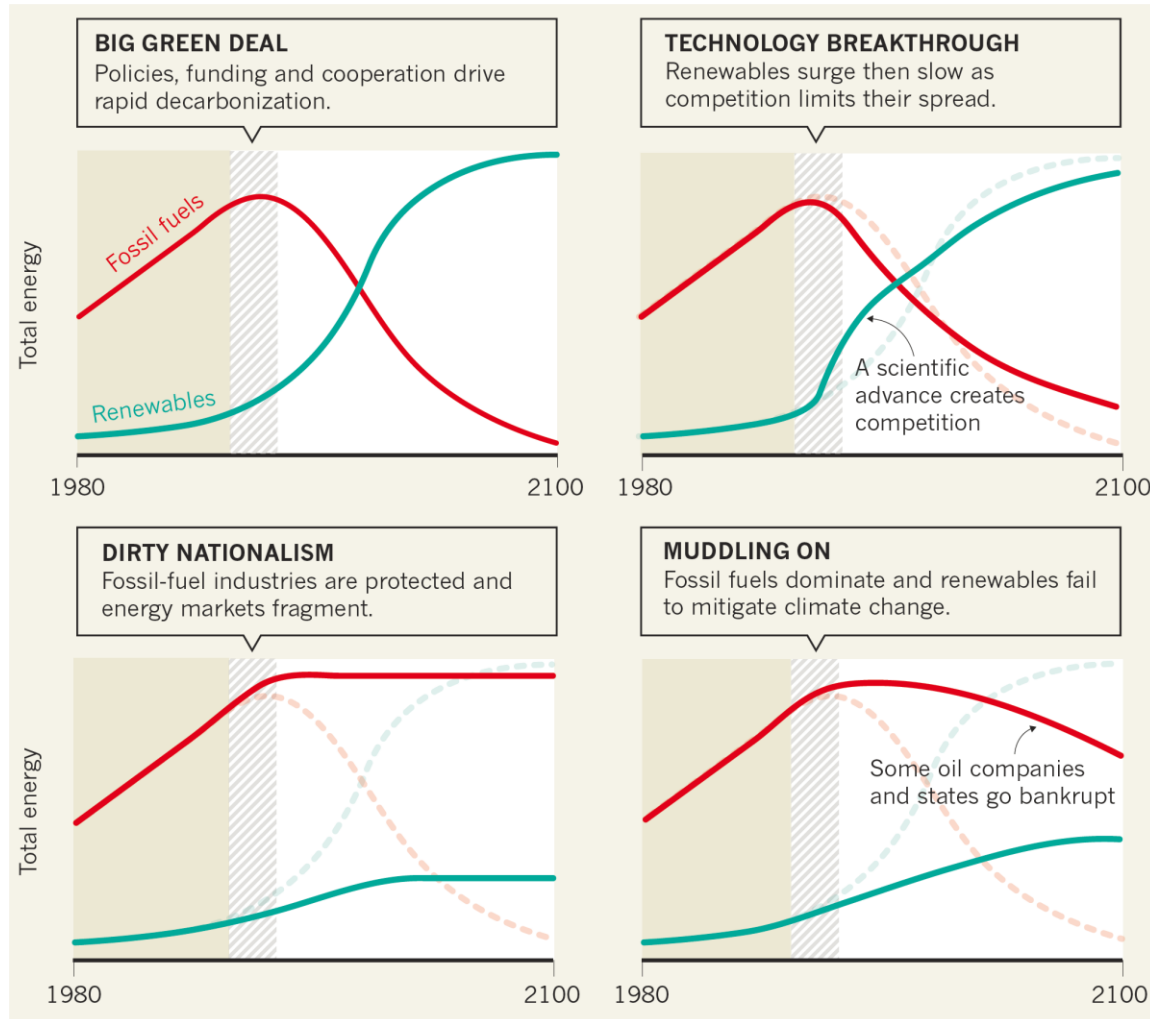


Fig. 3. Mining exploration budget and terrorism impact (Sharland et al., 2017).

Motivation to start CMI



Global energy transition: four alternative futures

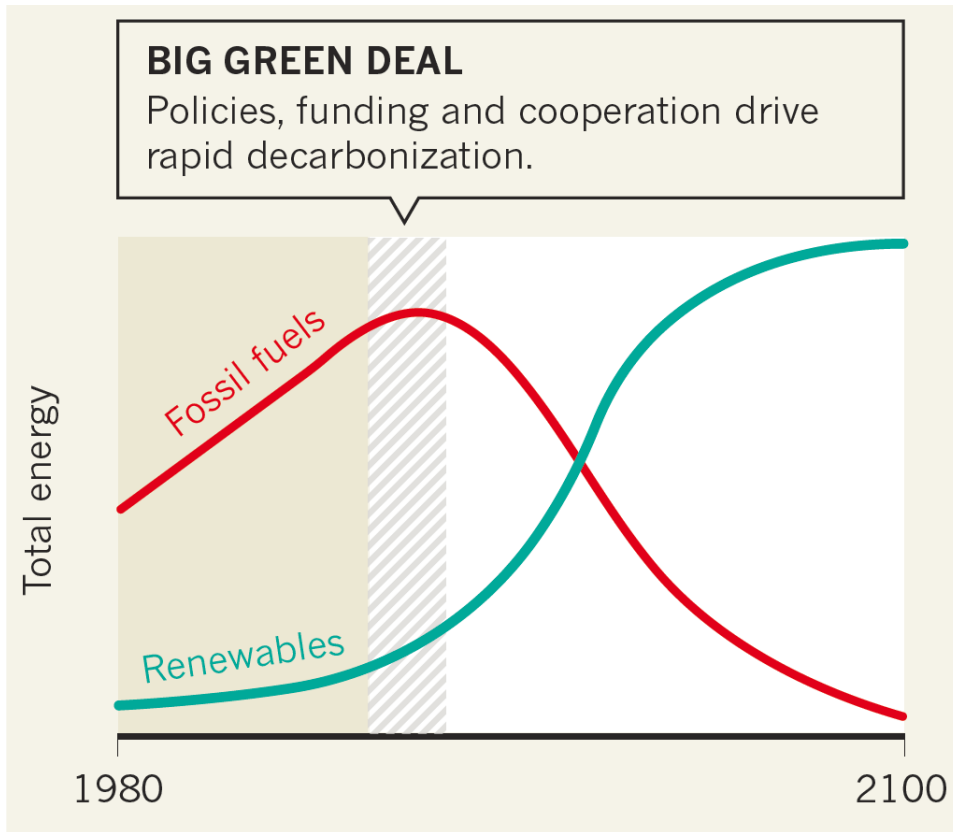


GET drivers:

- Policy
- National politics
- Technology
- Markets

Source: Goldthau, Bazilian et al,
Nature 2019

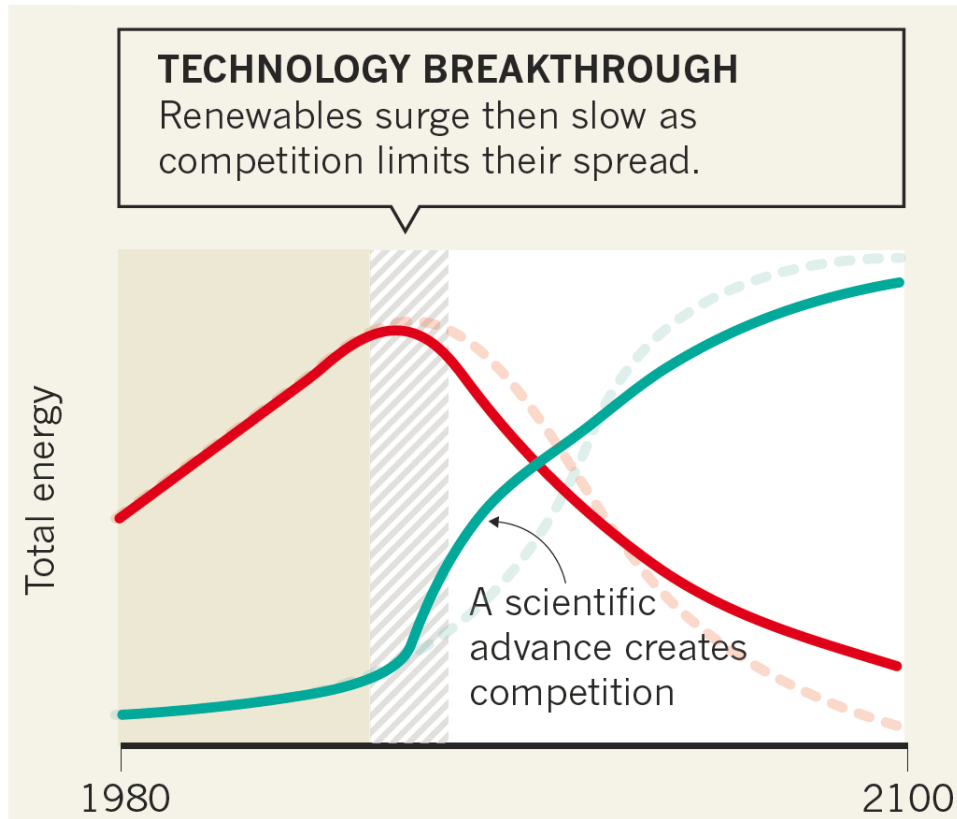
Big green deal



- Global consensus on CC action & strong international policy push
- Financial markets reallocate capital to low carbon firms
- Generous Green Climate Fund compensates petro-states
- Wave of green globalization follows
- All countries to share in the benefits of decarbonisation

→ Low geopolitical friction; Just Transition/ SDGs achieved

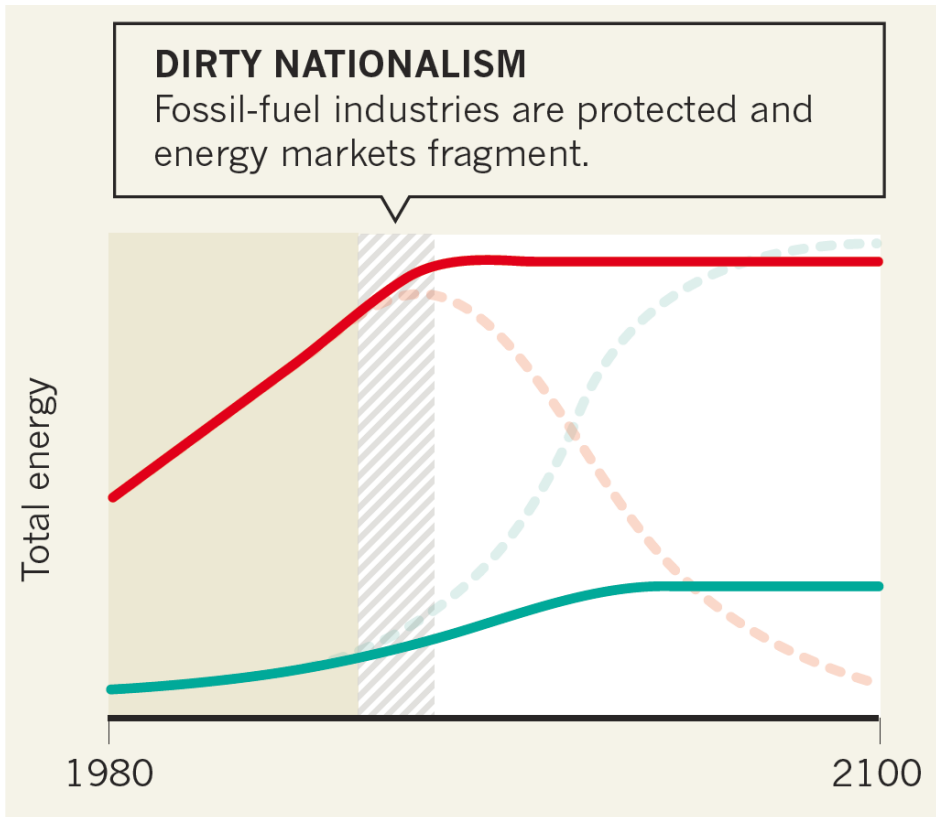
Technology breakthrough



- US and China take the lead
- Google & State Grid of China emerge as dominant players
- World fractures into 2 rivaling camps led by tech leaders
- Blocs control rare earth metals & LCT access for outsiders
- Renewables race helps climate mitigation but not all regions profit
- Developing nations excluded from advanced energy know-how

→ Oil producers falter; clean tech cold war; tensions due to uneven transition

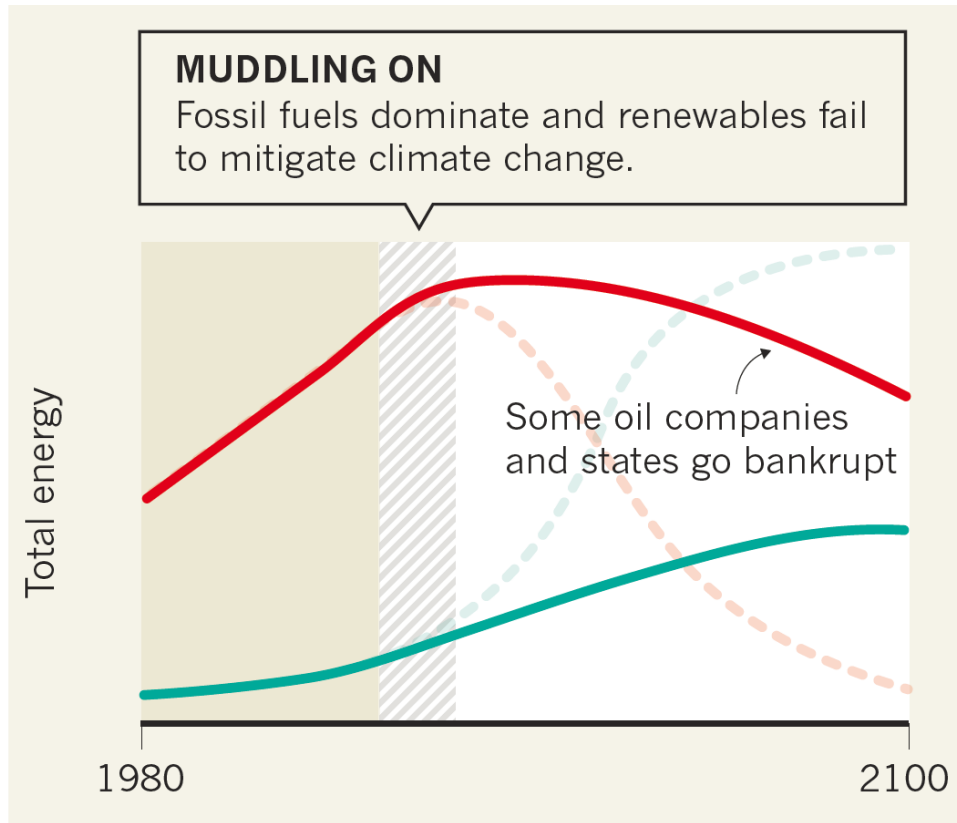
Dirty nationalism



- Elections bring populists to power
- Nation-first policies drive both domestic fossil fuels & renewables
- States ringfence their industries, zero sum logics return
- Protectionism limits RES economies of scale
- Fossil fuel producers panic & pump
- Power rivalries undermine multilateral institutions incl. UNFCCC & Paris Agreement

→ **Unmitigated CC as stress amplifier; conflict over water and other resources**

Muddling on



- Unit costs keep declining but fossil fuels remain dominant
- GET too slow to mitigate CC but too fast for FF industry to adapt
- Few producers compete on exports
- NOCs go bust or consolidate
- MENA producer countries and Russia see political turmoil
- Europe goes for like-minded partnerships, US on the sidelines
- Some regions fail to benefit from partnerships, energy inequality rises

→ Global North-South imbalances reinforced; BAU results in 'energy clubs'

Geopolitics of the global energy transition

Scenario	Key Drivers	Pace of Change	International Political Architecture	Carbon Consequences & SDGs
Big Green Deal	Concerted, multilateral policy drive	Fast and even	Multilateralism	Green globalization meets SDGs & Climate targets
Dirty Nationalism	Nation-first policies	Slow if not stalling	Zero-sum, anarchy	Unmitigated climate change acts as a stress amplifier (SDGs fail)
Tech Breakthrough	Disruptive advancement in energy technology	Fast but uneven	Regional hegemony	Successful climate change mitigation (but not all SDGs)
Muddling on	Falling costs, but slow progress	Slow	Clubs	Mitigation too slow to meet CC targets (SDGs compromised)

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.

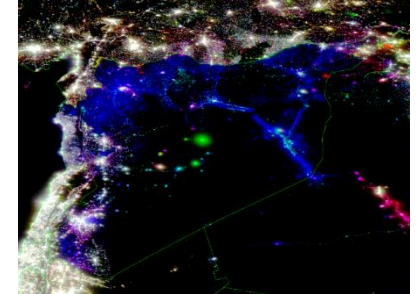
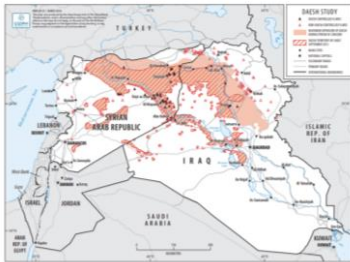
→ ***Acknowledge abating carbon creates losers & prepare for it***

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

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

New ways to monitor the transition

Figure 1: Iraq and Syria Oil Production, Fields, and Daesh Control, March 2016



Parting thoughts

- Many analogies between minerals criticality and energy security
 - Social license
 - Security of supply
 - Not just a supply risk!
 - Both public and private elements
 - Importance of developing economies
 - Resource and reserve frameworks
- Need to think across many different supply chains
 - Each supply chain has several uncertainties
 - Each has a very different “market” profile
 - Deeply interconnected, not independent.
- The energy transition looks sure to be mineral and metal-intensive
- Mining investments and development can take decades



The Payne Institute *for* Public Policy



COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT