IPLOCA
TOGETHER - DELIVERING SUSTAINABLE ENERGY INFRASTRUCTURE

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We need to talk about transition

The “super wicked problem” of providing affordable, dependable and sustainable energy

Jonathan Green
President, Geneva Energy Forum

Open General Meeting - 14 September 2023

We need to talk about transition

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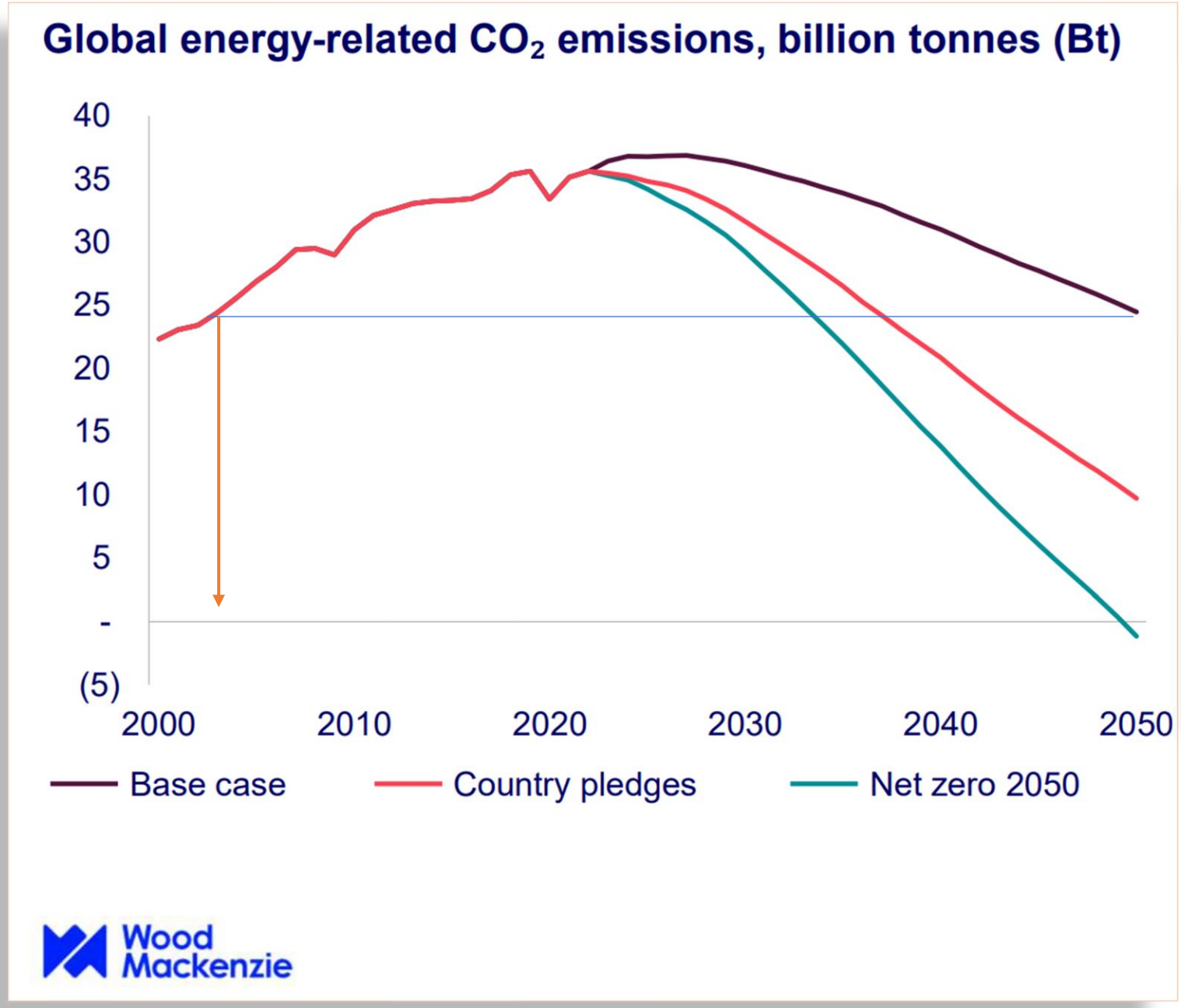
- **A super wicked problem**
- **Energy**
- **Transition metals**
- **Renewable energy**
- **Electrical transmission**
- **Biophysical word**
- **Nuclear**
- **People**
- **Conclusion**

We need to talk about transition



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We will not reach net zero by 2050 and probably never will without nuclear or some other high energy-density primary energy source

We need to talk about transition

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We will exceed 1.5°C global climate warming and probably 2°C as well

“Wicked problems” — those that are “difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize.”

Fritz Zwicky, Swiss-Bulgarian astrophysicist 1948

The global climate change community has identified climate change as a "super wicked" problem for policymakers

R J Lazarus, 2009

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If you don't know where you are going, you will probably end up somewhere else

Laurence J. Peter

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There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things

Niccolo Machiavelli, The Prince

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So what next?

Dillusional idealism

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Boiled frog syndrome

Institutional oil and gas investors "would be open to receiving lower dividends and fewer share buybacks in favor of more spending on some energy transition projects." Deloite

Dillusional idealism

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Boiled human syndrome

Energy

Energy **is** the economy

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- The energy in a barrel of oil represents the equivalent of circa **5 years** of manual labour (N.Hagens & J-M.Jancovici)
  - And it costs $80
  - Represent circ. $50,000/bbl labour equivalent [66% efficiency] (R.Norris)
  - Oil adds ~600x its value to the economy
  - **price of oil doesn't reflect its value**
  - **availability of oil is taken for granted**
  - **the need for oil is now put into question**
- Globally, energy represents circa 8% of the economy (GDP)
- Energy is embedded in everything, therefore the price of hydrocarbons impacts everything
- But without energy there is no economy
- Without energy there is no civilisation

Energy Density

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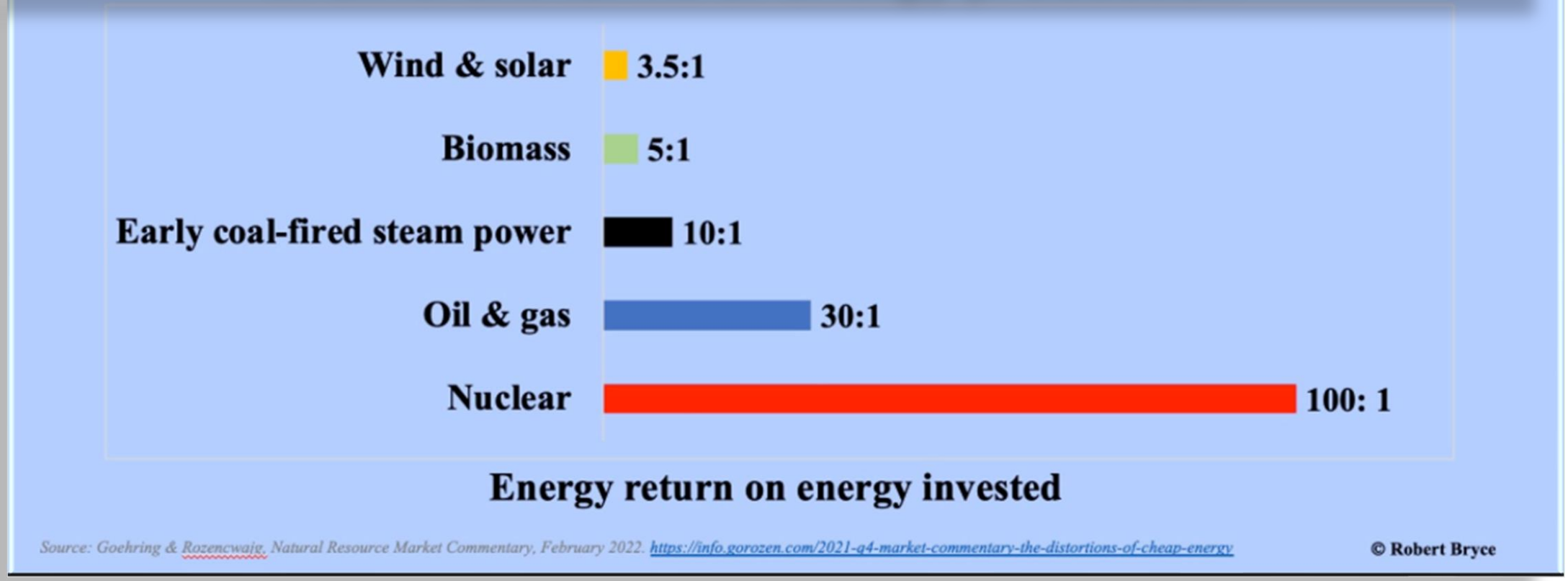
The Energy Returned on Energy Invested (ERoEI) in different forms of energy production



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Most of the public, economists, the scientific community, transition campaign groups and nearly all politicians are <u>energy blind</u>

After Nate Hagens

Energy blind transition

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The energy transition has still not yet begun

Energy transition?

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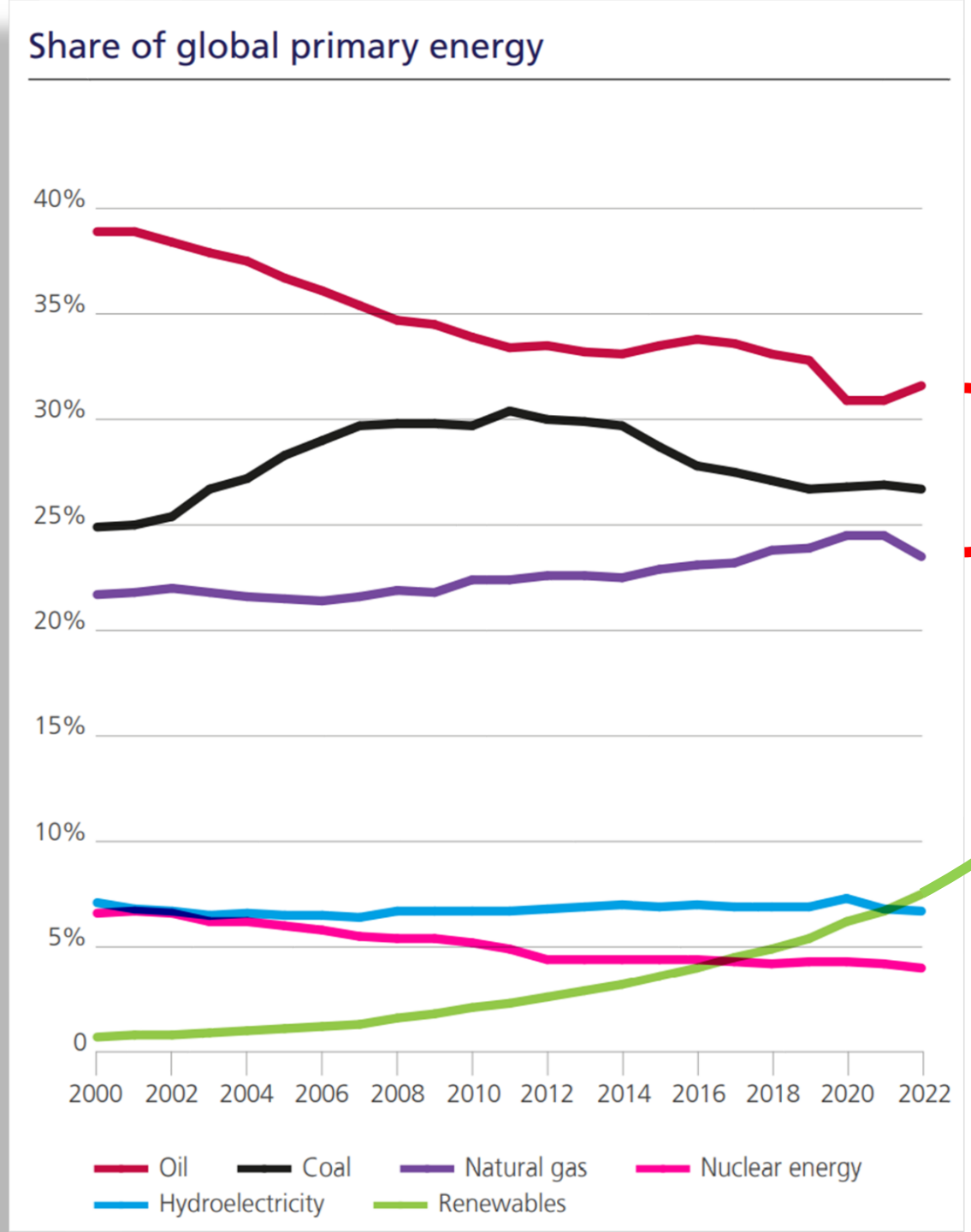

Source: Energy Institute Statistical Review of World Energy 2023

Primary energy World consumption*

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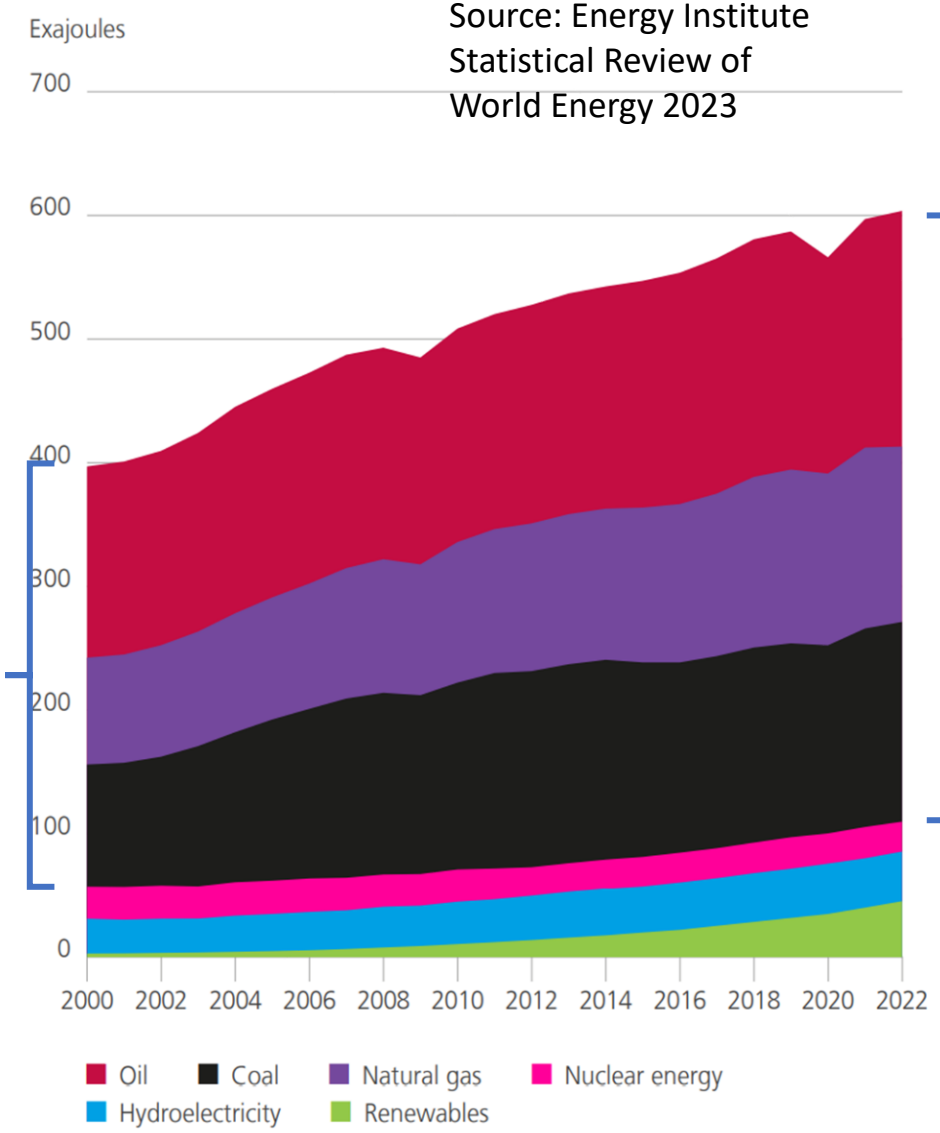
World consumption

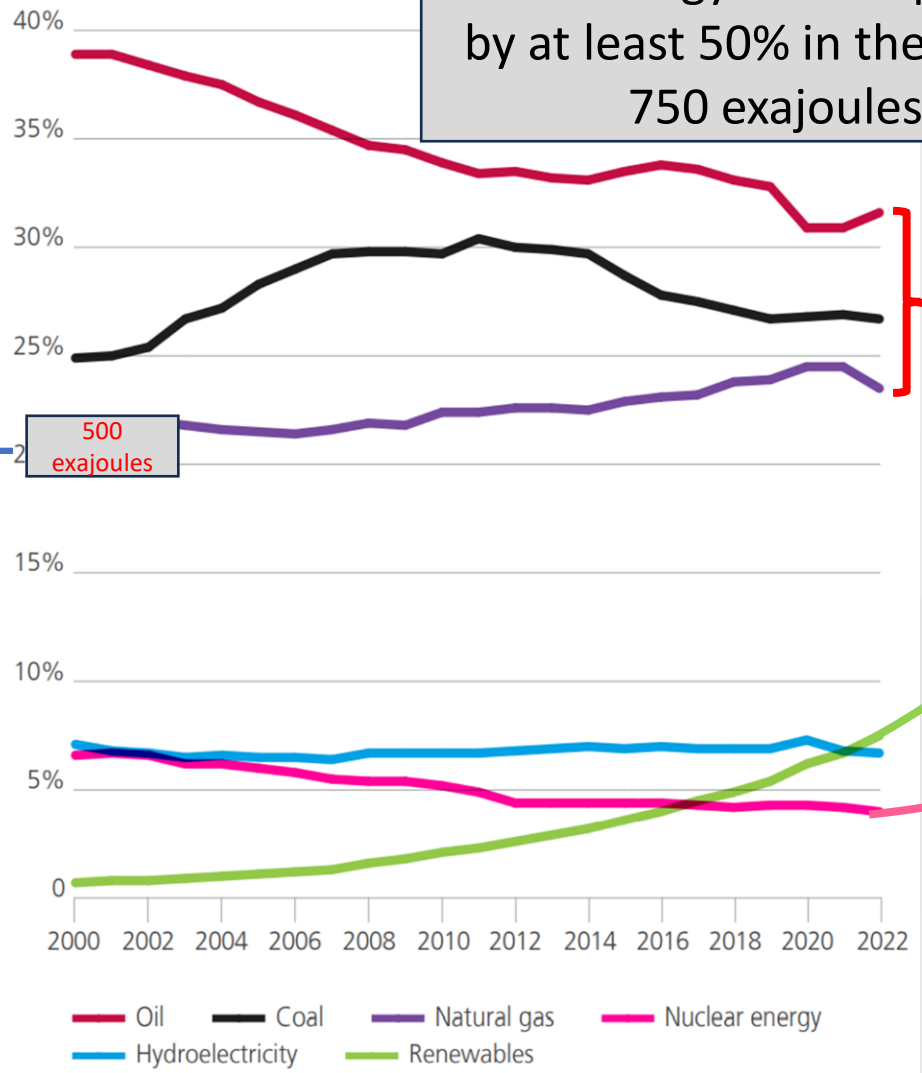
Source: Energy Institute Statistical Review of World Energy 2023



350 exajoules

500 exajoules

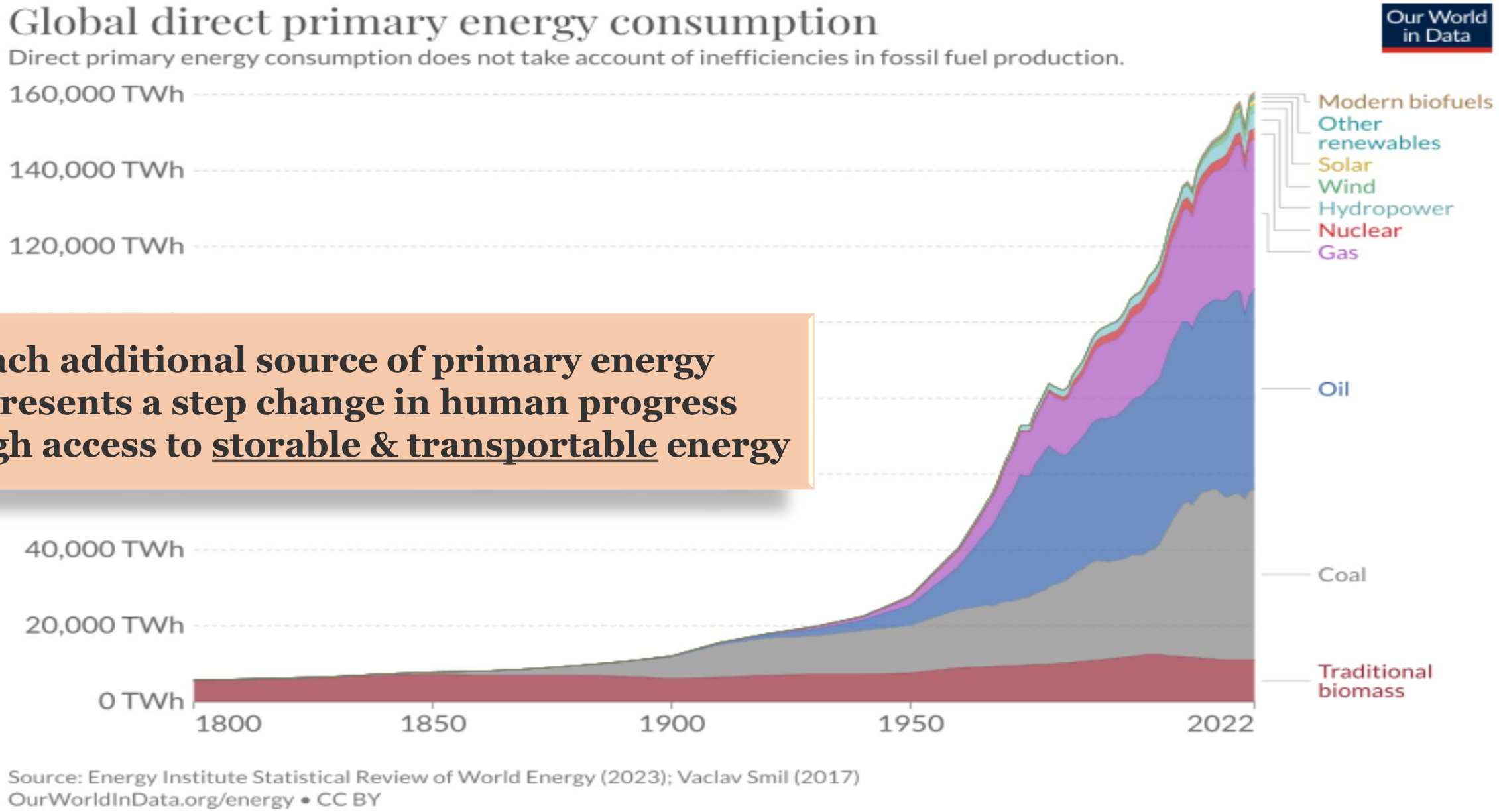
Share of global primary energy %



World energy consumption should increase by at least 50% in the next 20 to 30 years 750 exajoules fossil fuels?

%

Energy addition, not transition



Each additional source of primary energy represents a step change in human progress through access to storable & transportable energy

Exponential BS or delusional idealism

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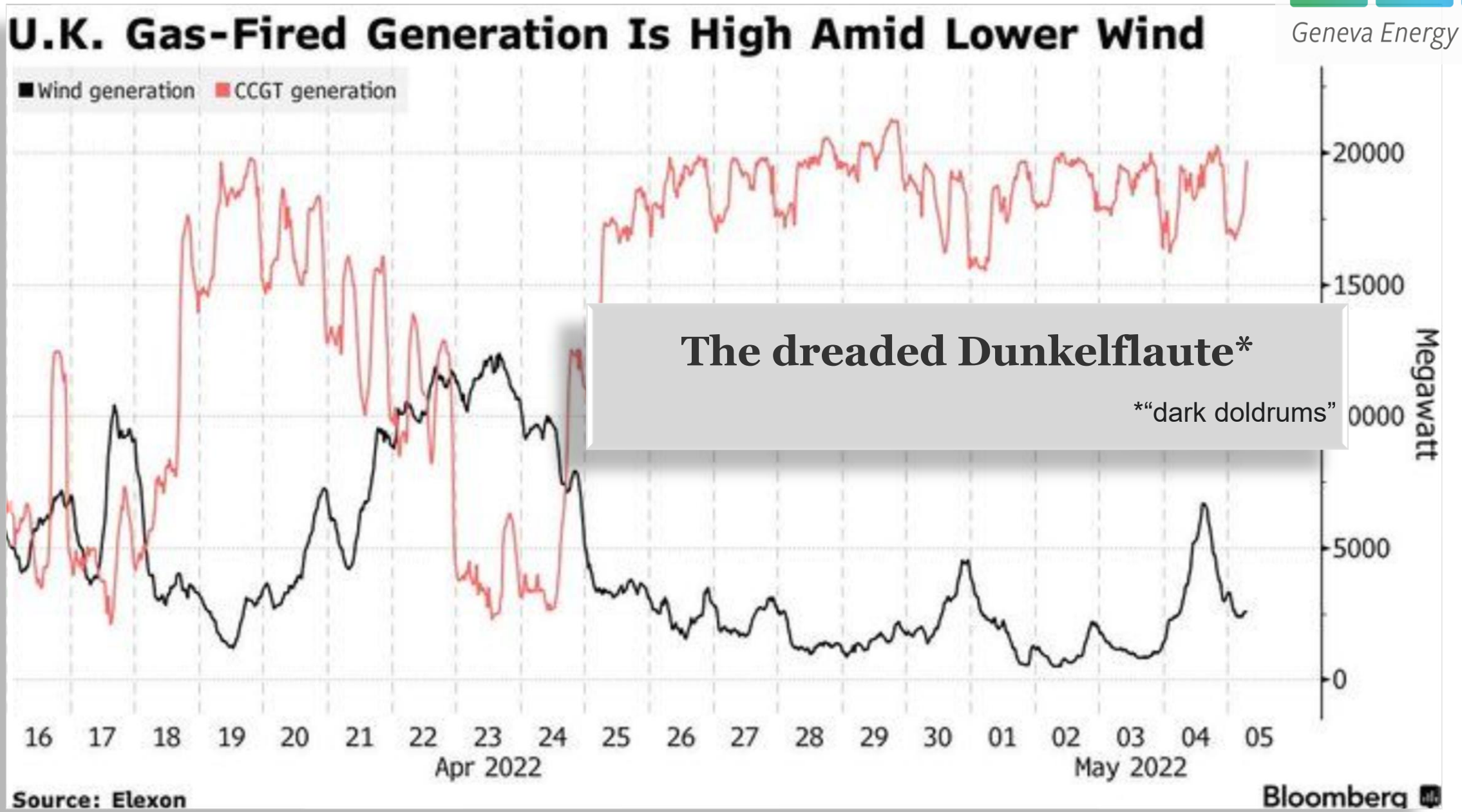

The dreaded Dunkelflaute*

*"dark doldrums"

A possible response to a super wicked problem: “I want you to panic” G. Thunberg

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Panicked solution – Just stop oil!

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The WEC's Energy Trilemma

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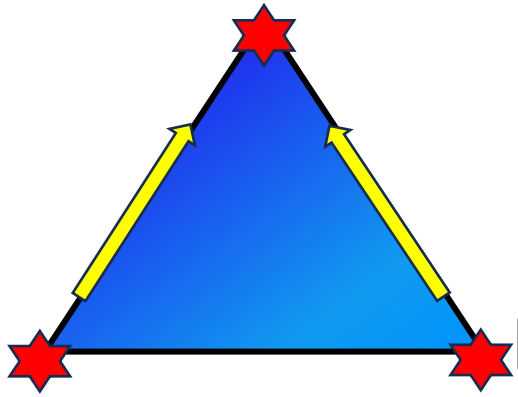
Energy security



Universal access to affordable energy supply

Environmental impacts of energy production and use

European gas price jumps almost 40% over supply disruption fears

TTF futures climb after reports of planned strike action at LNG plants in Australia

Source: FT 9 August 2023

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Iron Law of Climate: when forced to choose between economic growth and climate action, politicians and decision-makers will always choose economic growth
(…and energy security)

Prof. Roger Pielke Jr., University of Colorado

Ships beat pipes in the global gas trade

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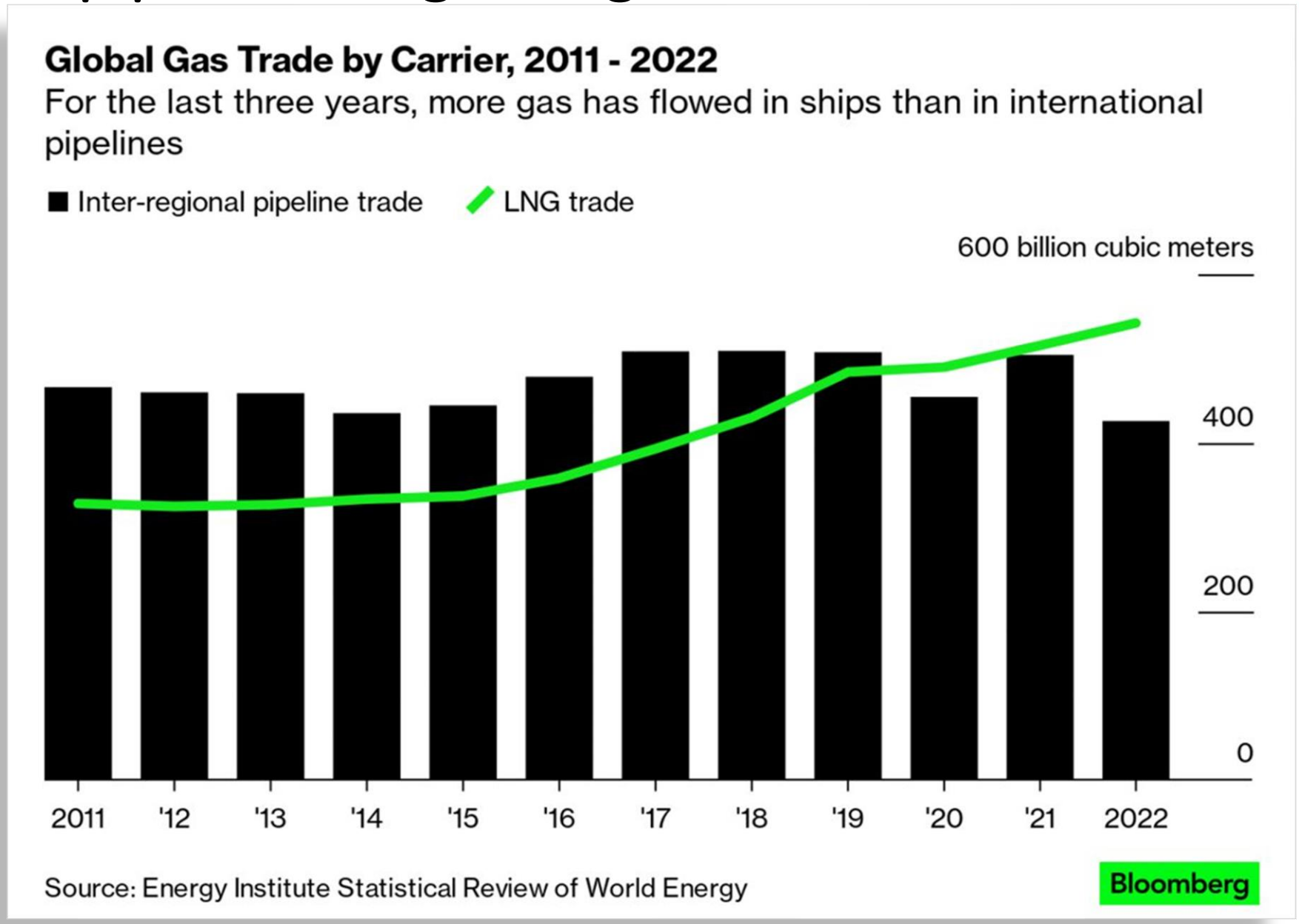

Transition metals

Transition metals

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- Hitting net zero targets by 2050 should require:
  - 35m tonnes of transition metals a year
  - 6.5bn tonnes aluminium and steel
  - 15 times today's wind-power capacity
  - 25 times more solar
  - 3 times grid size
  - 60-fold increase in the fleet of EVs

- By 2030
  - copper and nickel demand could rise by 50-70%
  - cobalt and neodymium by 150%
  - graphite and lithium six- to seven-fold

Sources: Economist, IEA & Energy Transitions Commission

Transition metals

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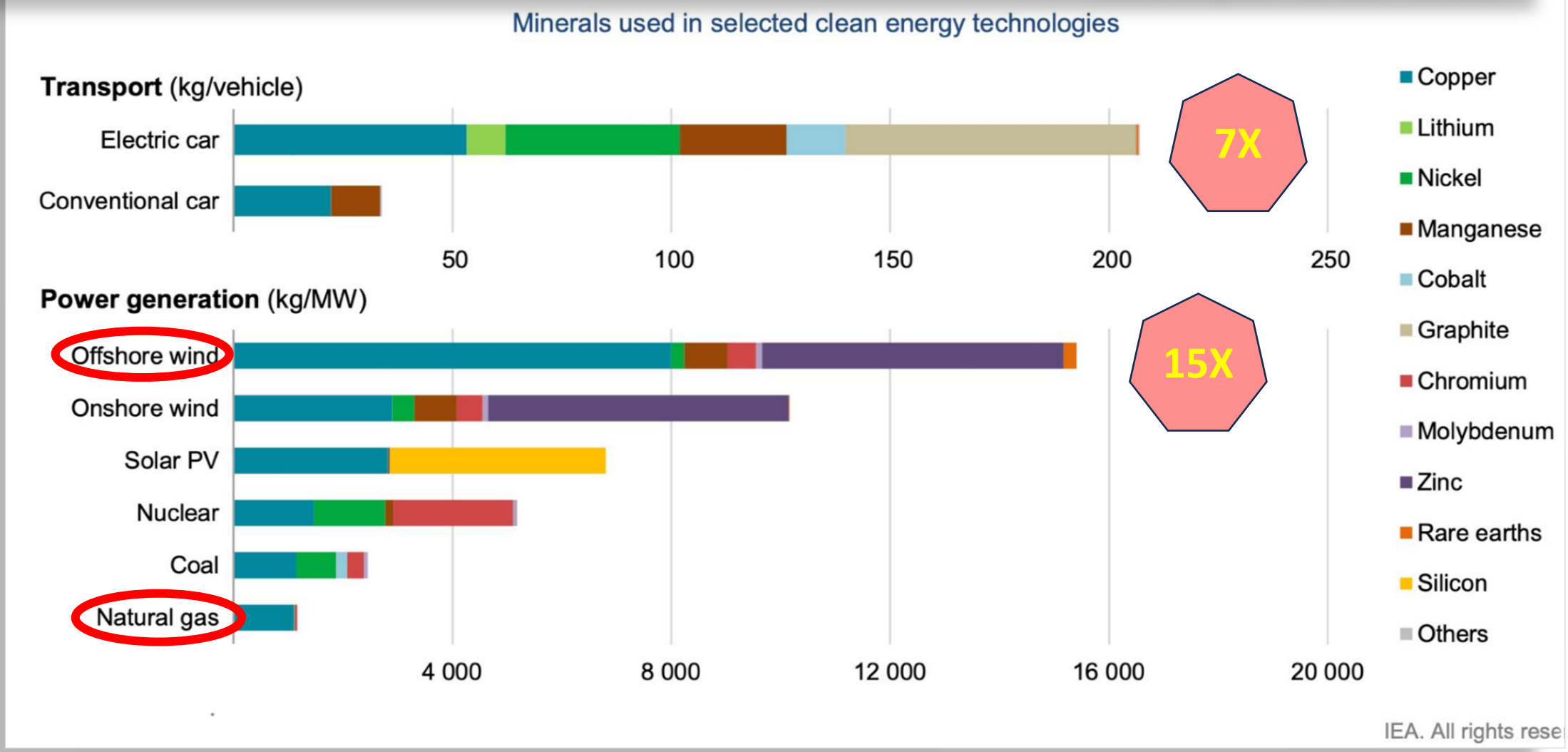
Iron Law of Declining Metals Grades: Over history the quality of ore grades has been declining ..... The world is chasing larger quantities of metals from declining ore grades

Mark Mills, Manhatten Institute for Policy Research &
Faculty Fellow, McCormick School of Engineering

Transition metals – maximum capacity

The energy sector will use five times more minerals by 2040

BloombergNEF, Net Zero Scenario



Transition metals – capacity factor

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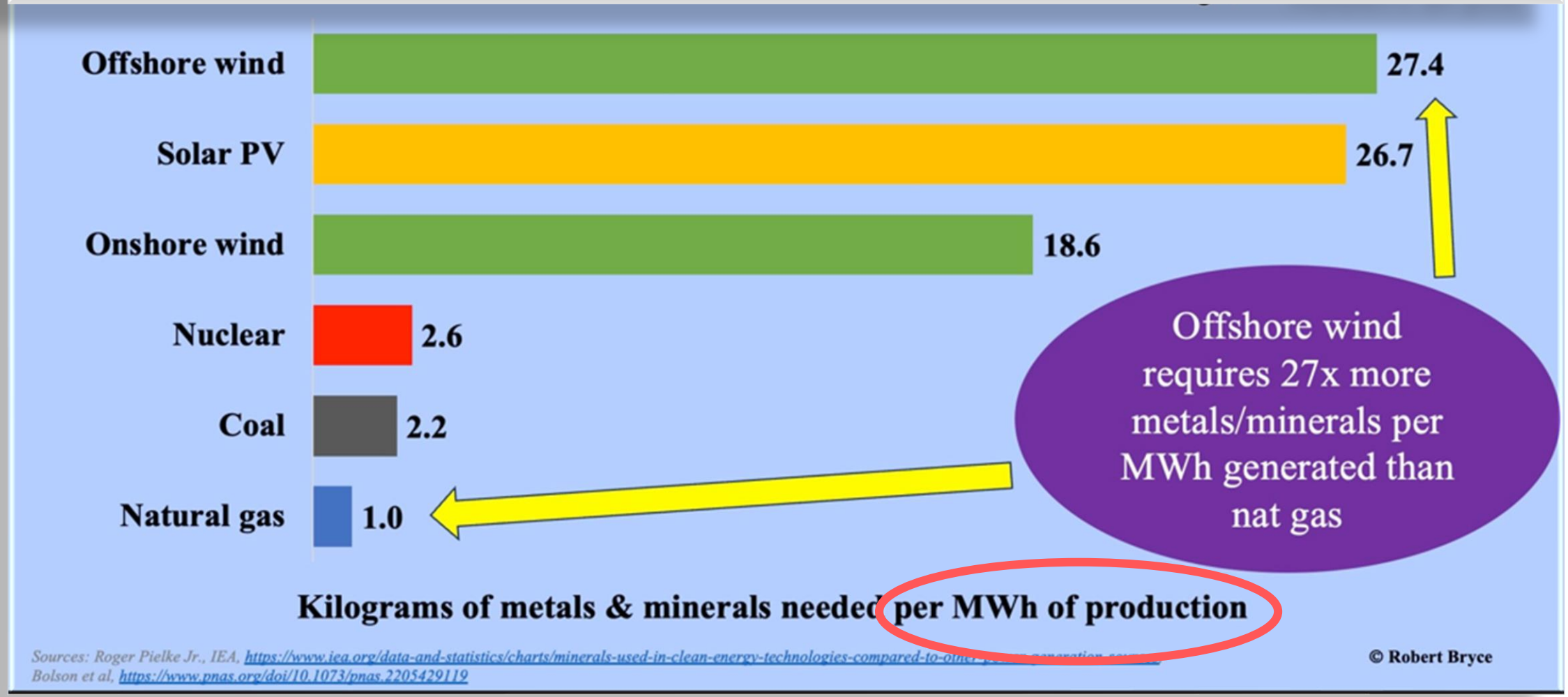
The lower the power density the greater the resource intensity

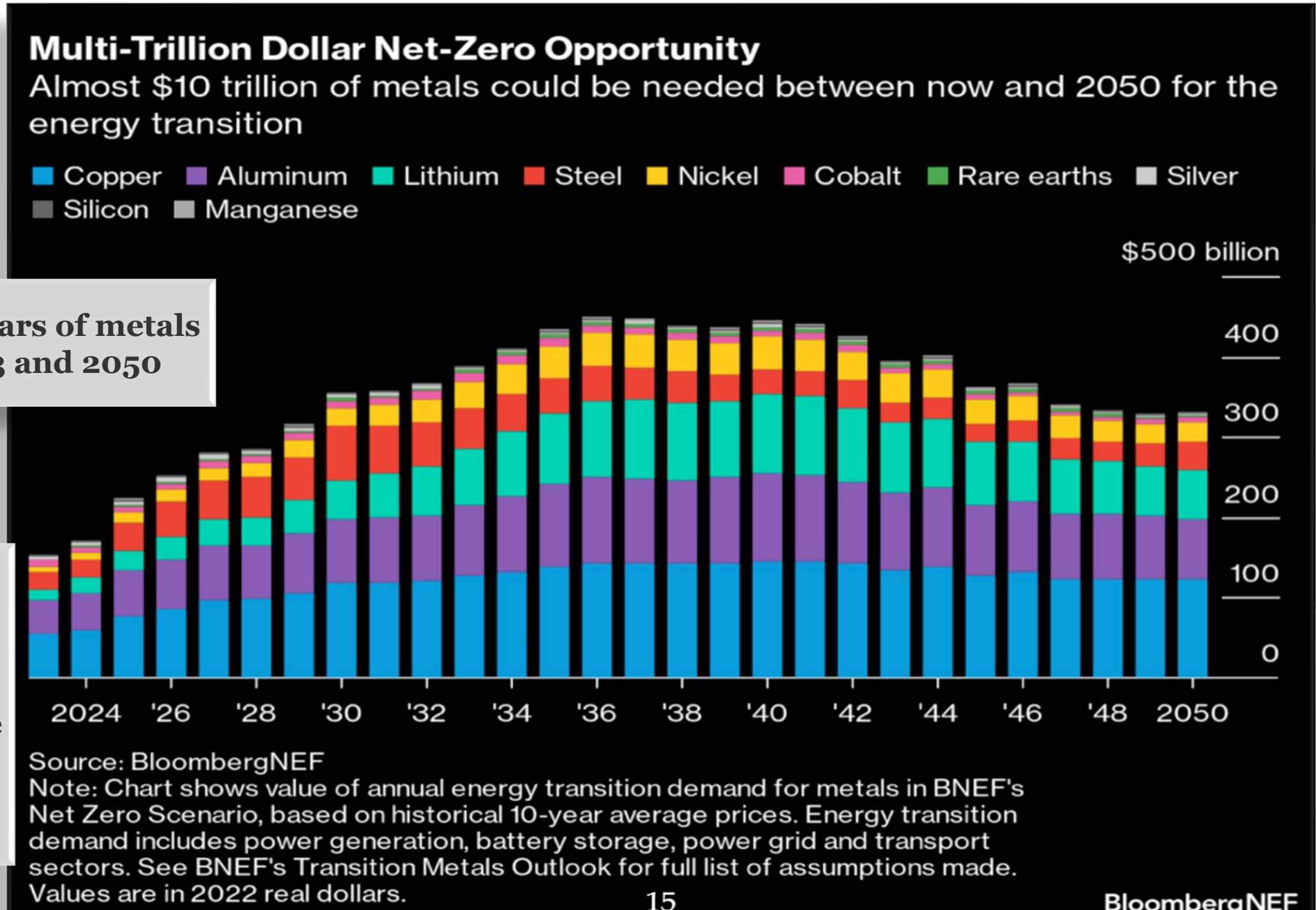
Robert Bryce



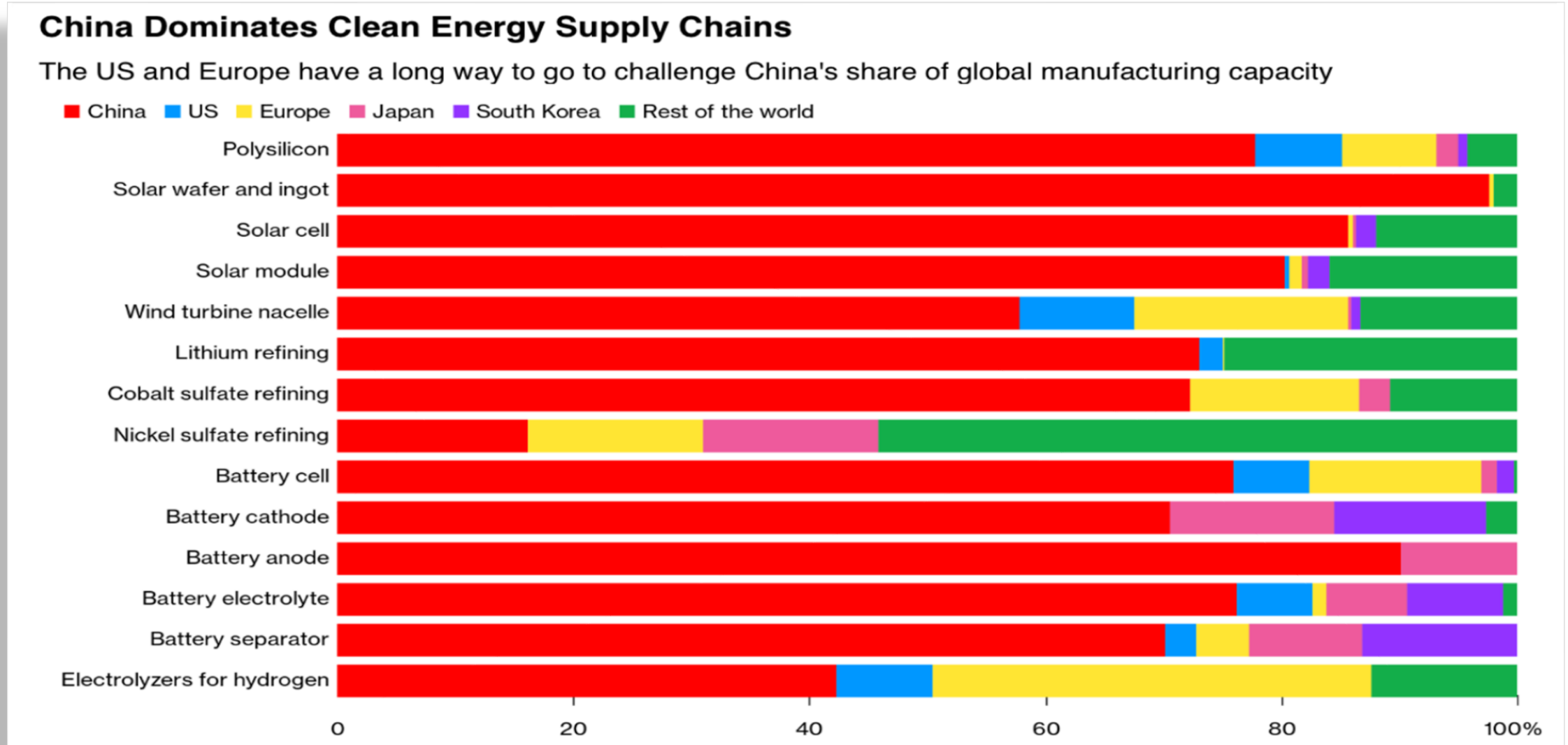
Metals

Ten trillion dollars of metals between 2023 and 2050

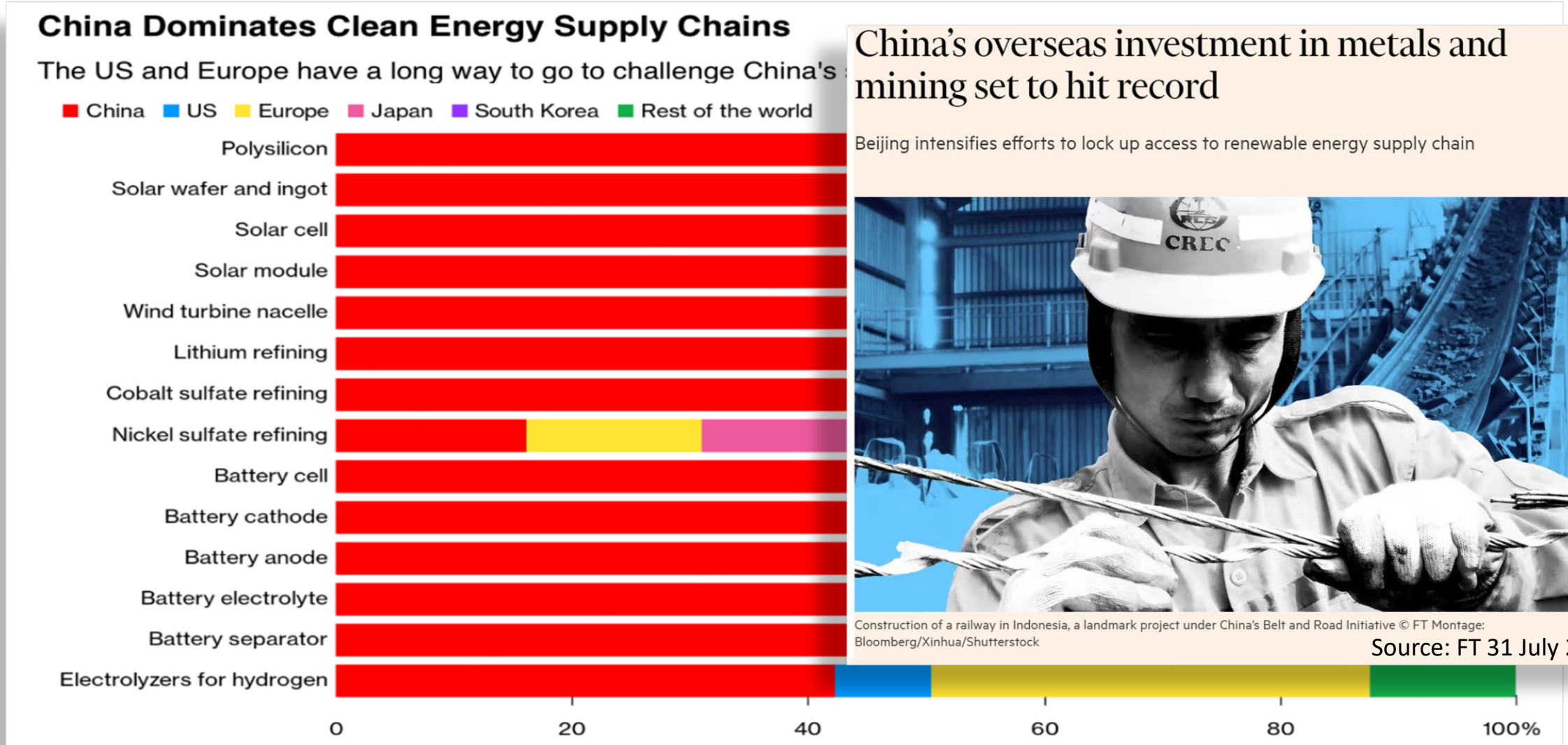
The average new mine takes more than 16 years to get from resource characterization to production



Transition metals



Transition metals



China's overseas investment in metals and mining set to hit record

Beijing intensifies efforts to lock up access to renewable energy supply chain

Construction of a railway in Indonesia, a landmark project under China's Belt and Road Initiative © FT Montage: Bloomberg/Xinhua/Shutterstock

Source: FT 31 July 2023

Metals transition?

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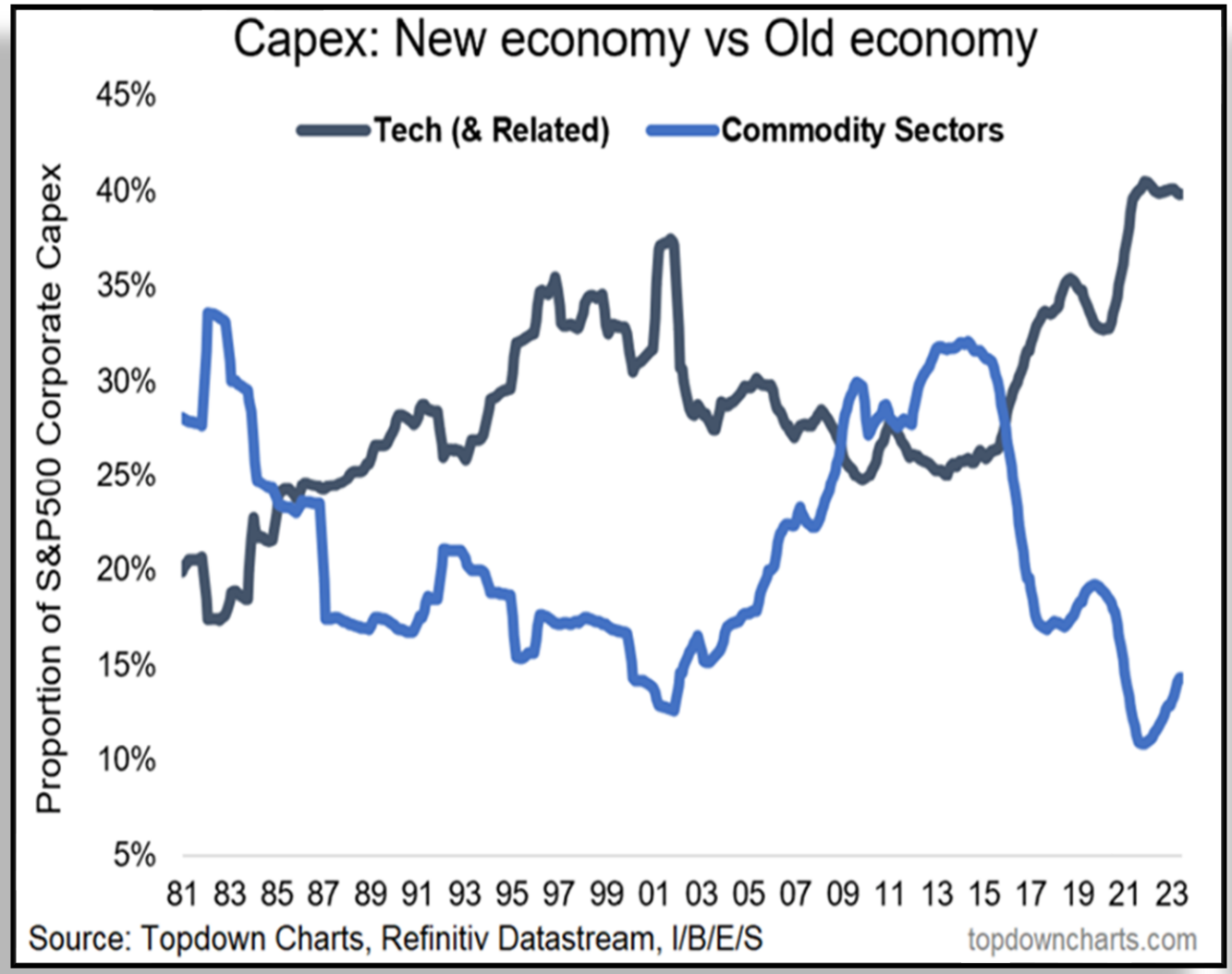

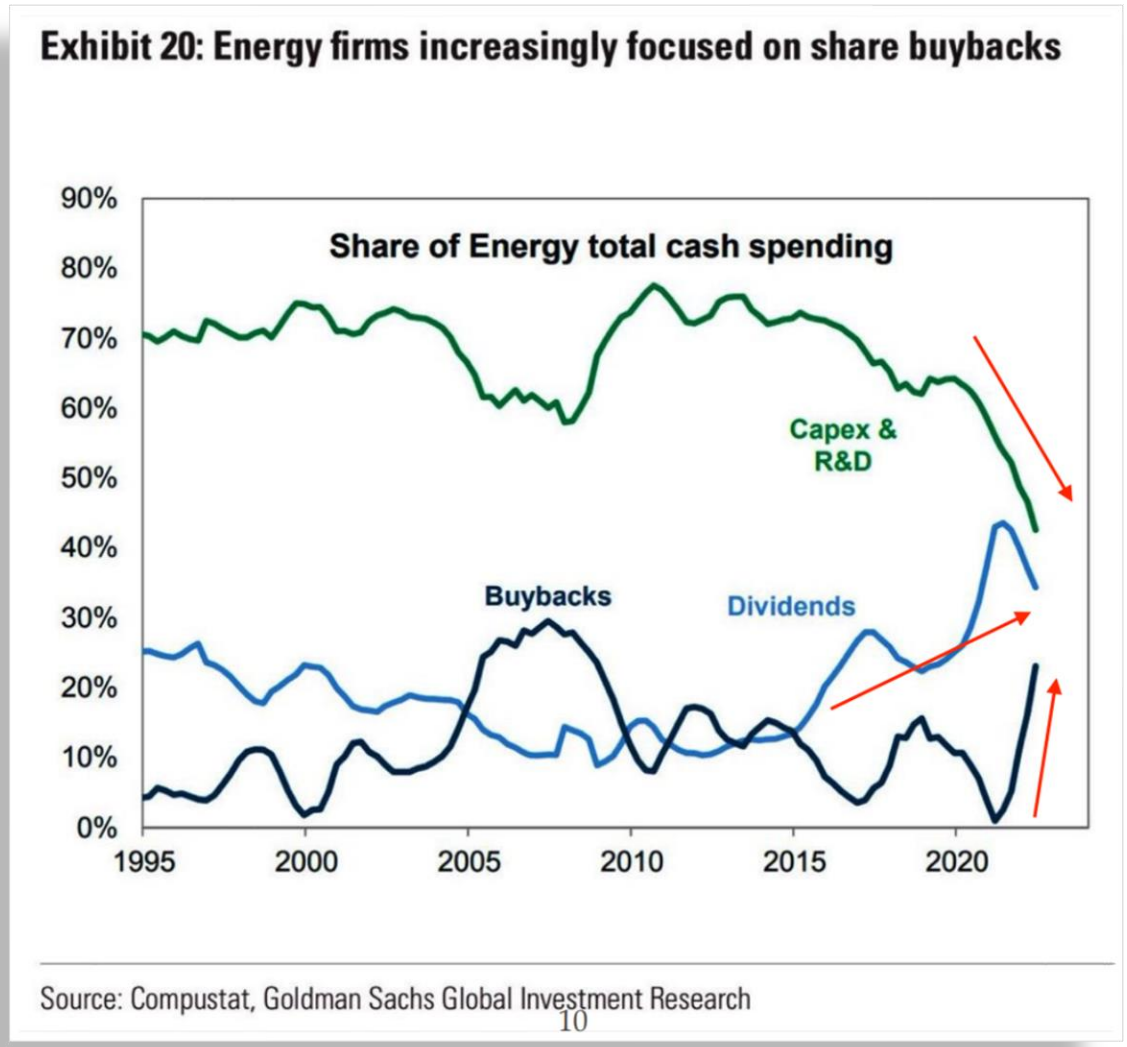

Metals transition?

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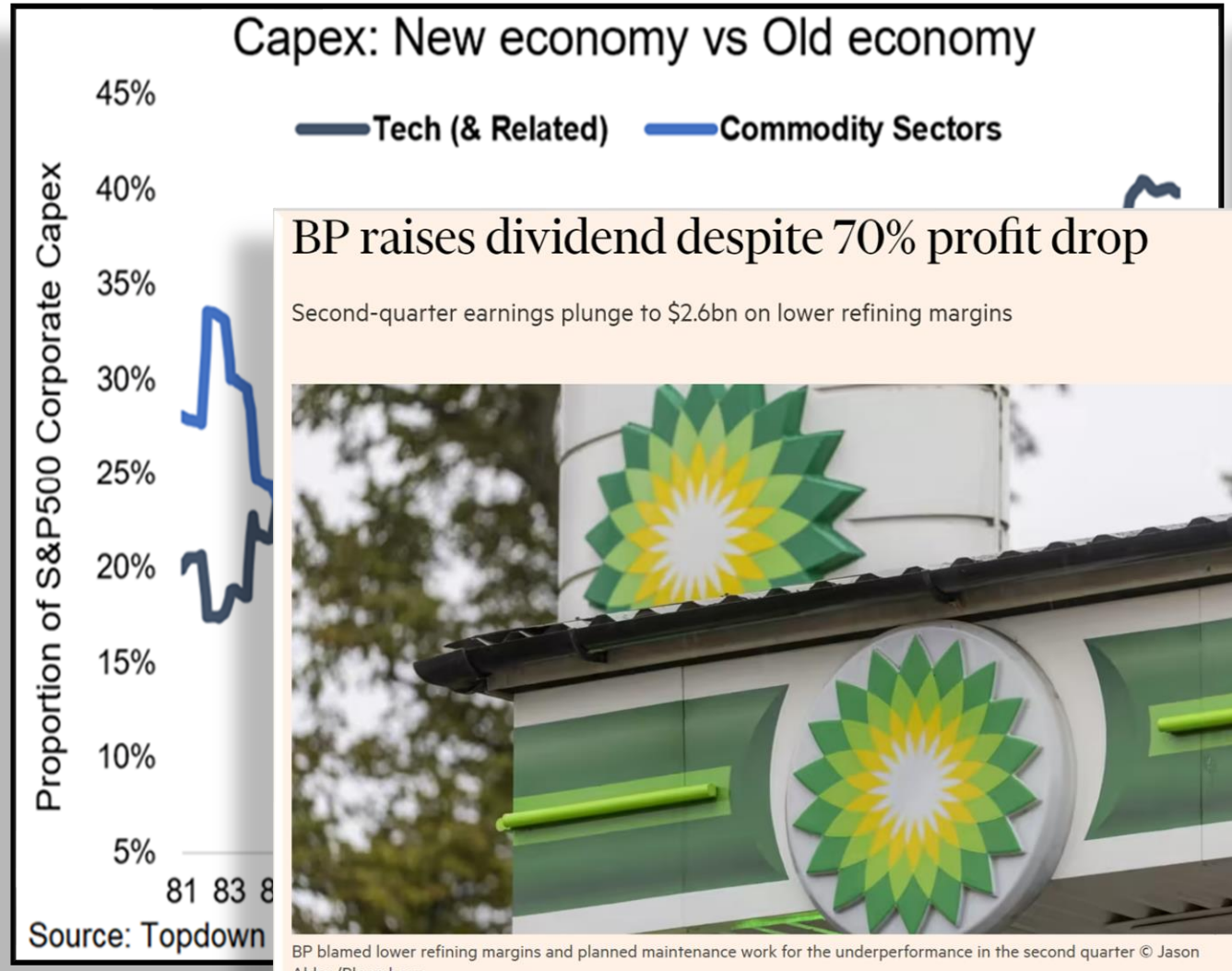
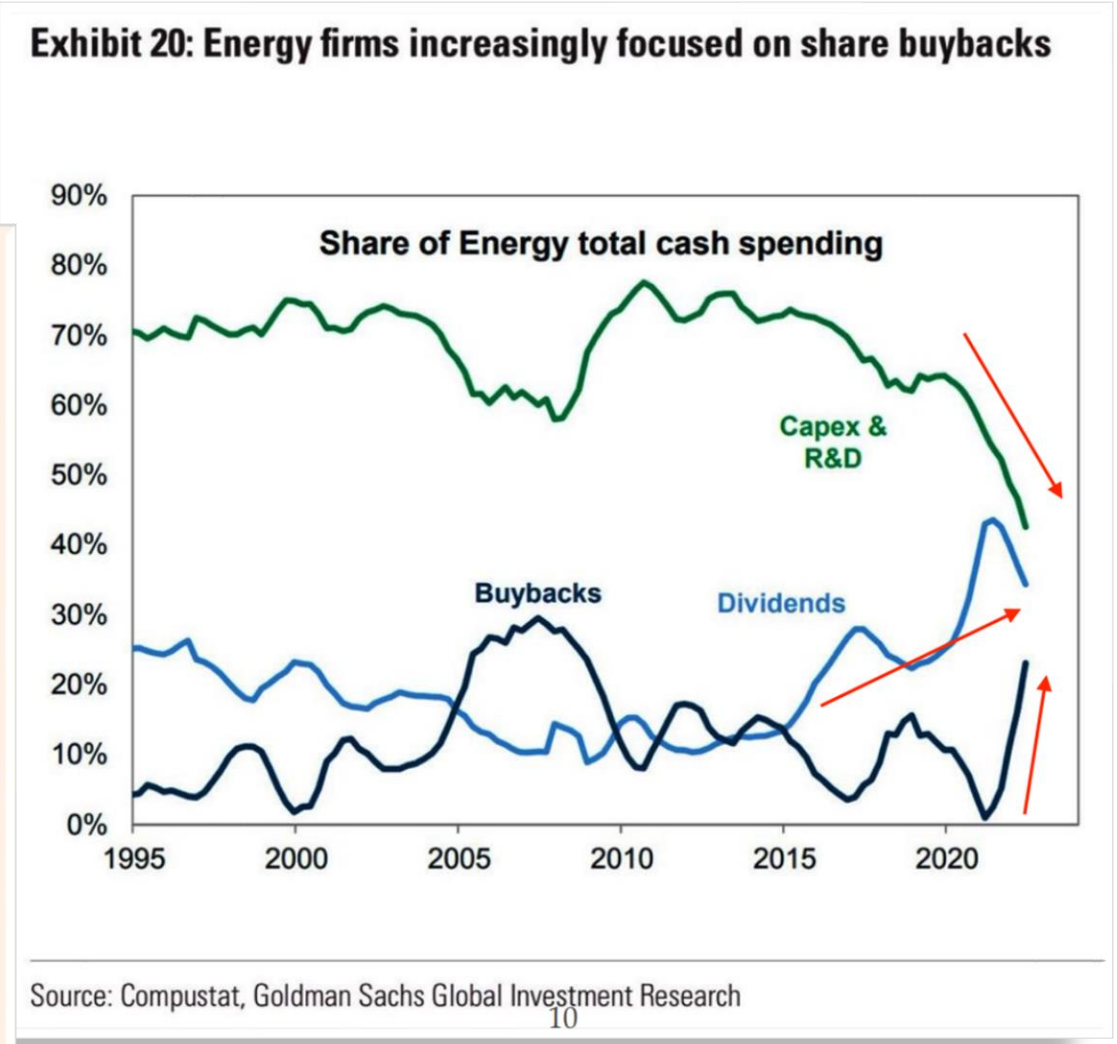


BP raises dividend despite 70% profit drop

Second-quarter earnings plunge to $2.6bn on lower refining margins

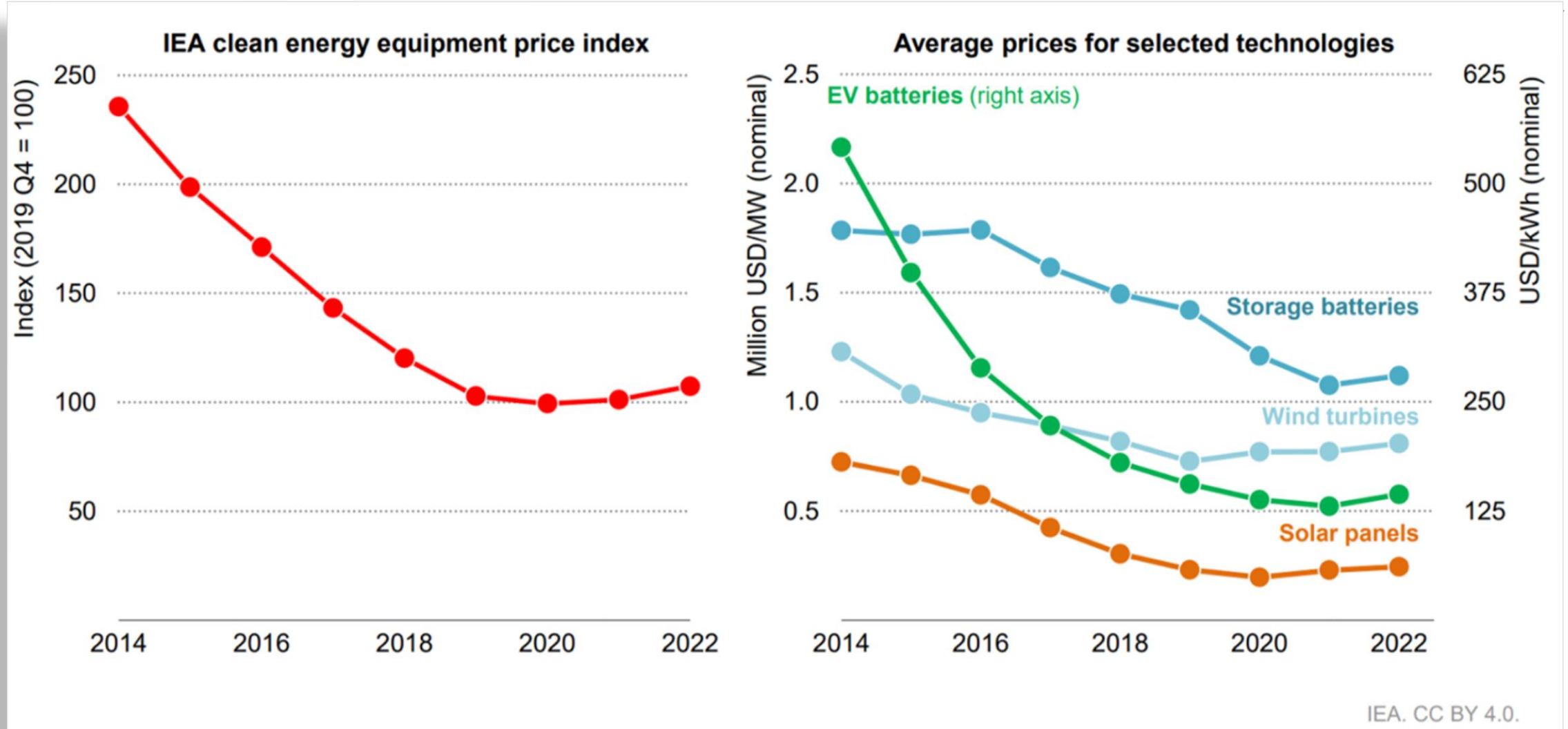
BP blamed lower refining margins and planned maintenance work for the underperformance in the second quarter © Jason Alden/Bloomberg

Source: FT 31 July 2023



Renewable energy

Renewable cost reductions are not exponential



Note: The IEA clean energy equipment price index tracks price movements of a fixed basket of solar PV panels, wind turbines and lithium-ion batteries (for EVs and energy storage). Prices are weighted based on the shares of global average annual investment.

Source: IEA analysis on company financial reports, Bloomberg and BNEF.

Renewable energy investment headwinds

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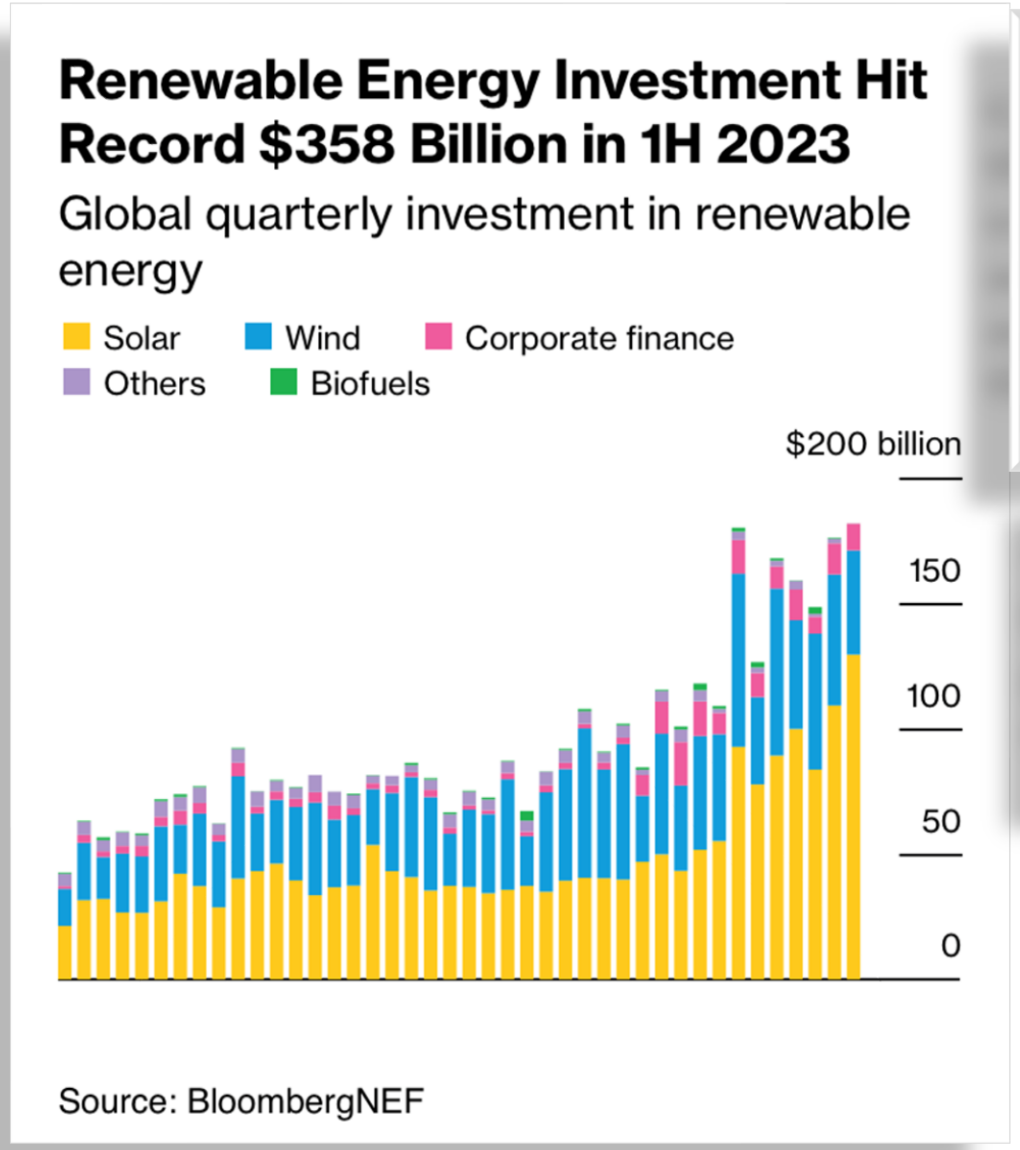

Green businesses are still "project financing and therefore extremely sensitive to interest rates, extremely sensitive to the discounted future cash flows and extremely sensitive to the cost of commodities that are going to be used to build the turbines or to build the offshore wind farms."

Renaud Saleur, Anaconda Invest

"..pretty much all new wind projects currently being built will be unprofitable without stupidly high power prices to compensate," as the cost of debt increases by about 5% on average for UK offshore wind projects.

Barry Norris, Argonaut Capital Partners

August 30th, Orsted A/S shares plunged the most on record after the renewable energy company warned of impairments of as much as $2.3 billion to its US portfolio because of supply-chain issues and soaring interest rates.

Source: BloombergNEF

Renewable energy investment headwinds

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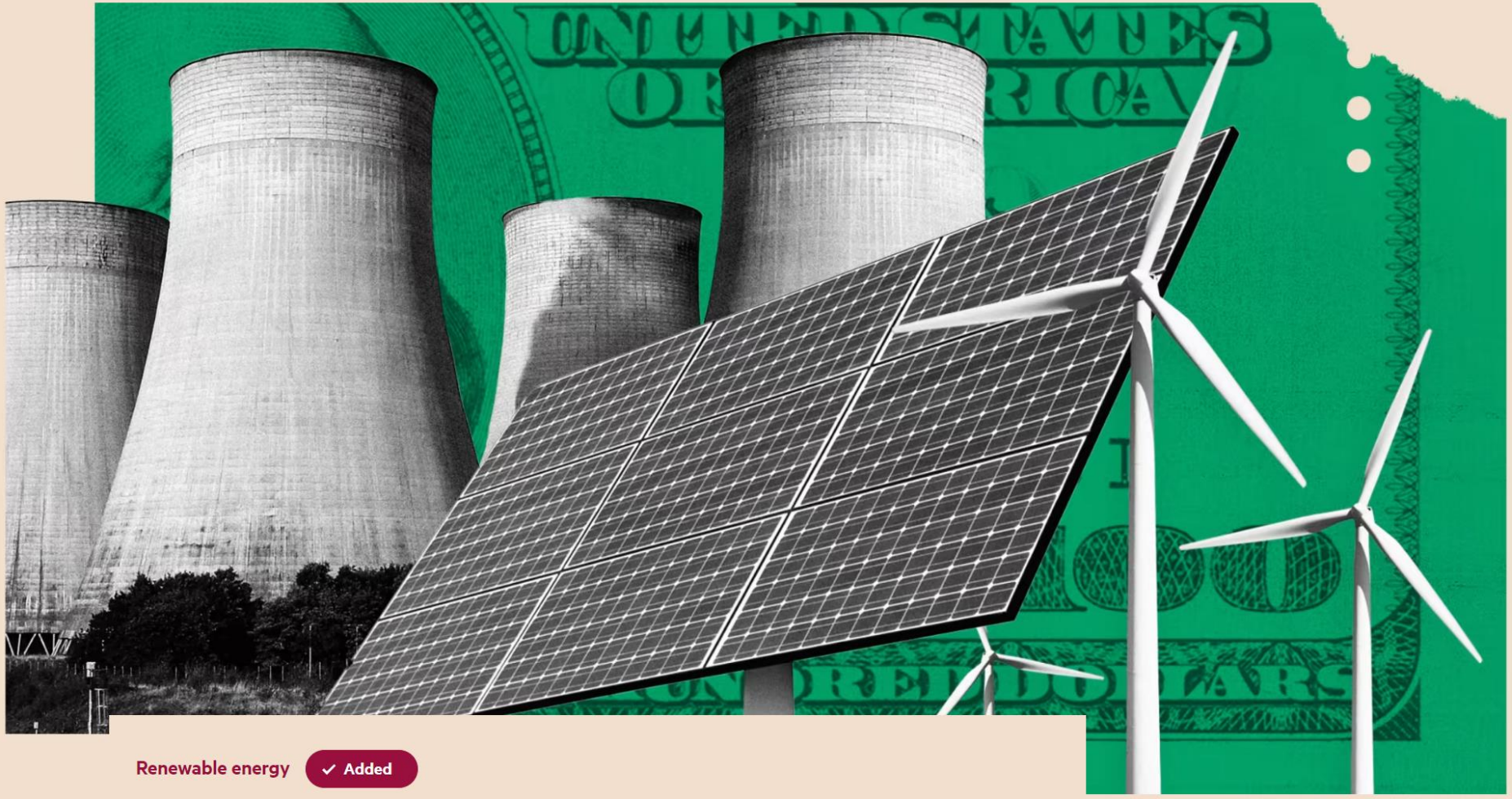
FT Series **The Return of Big Government**



Renewable energy ✓ Added

The $100tn path to net zero

In the absence of a global carbon tax, the green transition could prove politically expensive

Renewable energy investment headwinds

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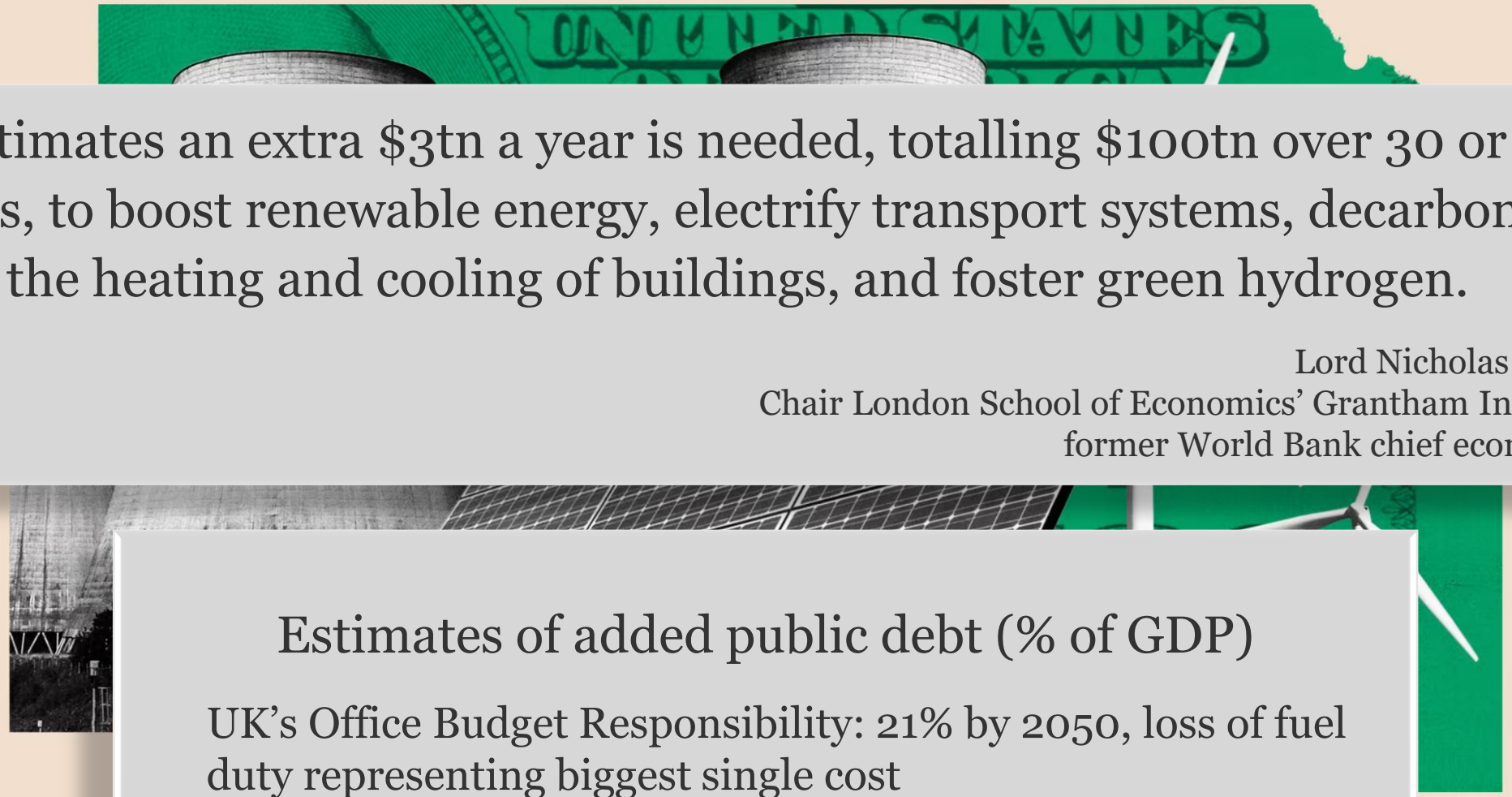
FT Series **The Return of Big Government**



…estimates an extra $3tn a year is needed, totalling $100tn over 30 or 40 years, to boost renewable energy, electrify transport systems, decarbonise the heating and cooling of buildings, and foster green hydrogen.

Lord Nicholas Stern,
Chair London School of Economics' Grantham Institute
former World Bank chief economist

Estimates of added public debt (% of GDP)

UK's Office Budget Responsibility: 21% by 2050, loss of fuel duty representing biggest single cost

French government report: 25% by 2040

In the absence of a global carbon tax, the green transition could prove politically expensive

Renewable energy investment headwinds

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Cheap renewables are only cheap if you have access to cheap capital

Transmission

We need a bigger grid

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Without transmission, there is no transition

Allan Andersen, associate professor, University of Oslo

We need a bigger grid

- Electricity will power 70% of any future net-zero economy compared to 20% today
- The global electrical infrastructure must double (or even treble) in the size
- Expansion will cost $21.4 trillion
- Connection backlog:
  - Europe: 600 gigawatts of wind & solar projects, equivalent to 130% of installed capacity
  - US: > 1.4 terawatts, equivalent to 120% of installed capacity.
- The power engineering supply chain simply cannot cope – it is short of
  - cables
  - transformers
  - project managers
  - engineers
- Planning process for additional transmission on new routes often languishing in regulatory limbo for well over a decade.

Source: BloombergNEF

Biophysical world

Biophysical boundary overshoot

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Infinite growth on a finite planet

Jevon's Paradox

Haber-Bosch nitrogen fixation

Biophysical boundary overshoot

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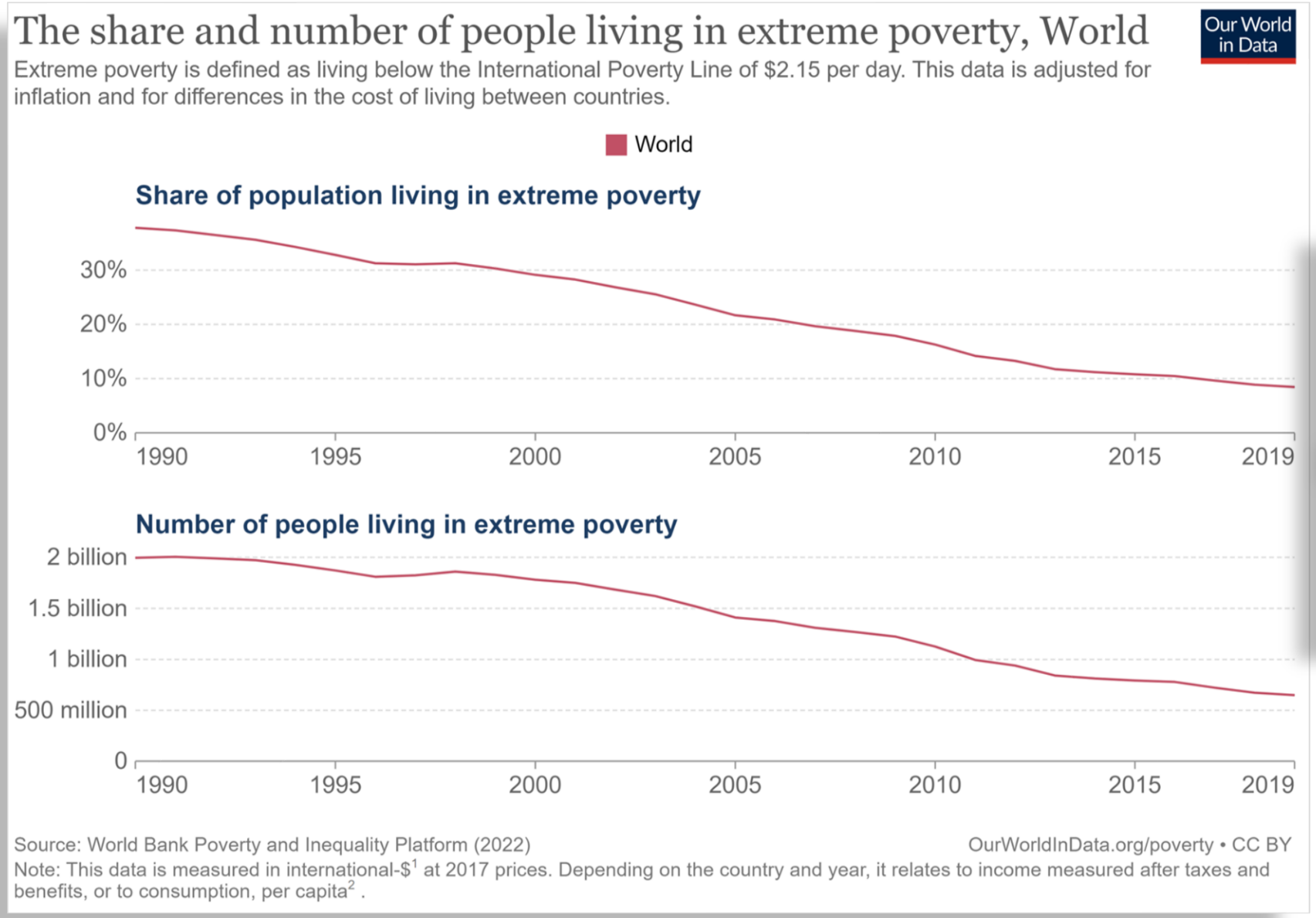

During this 30-year period global population increased from 5 billion to 8 billion

Biophysical boundary overshoot

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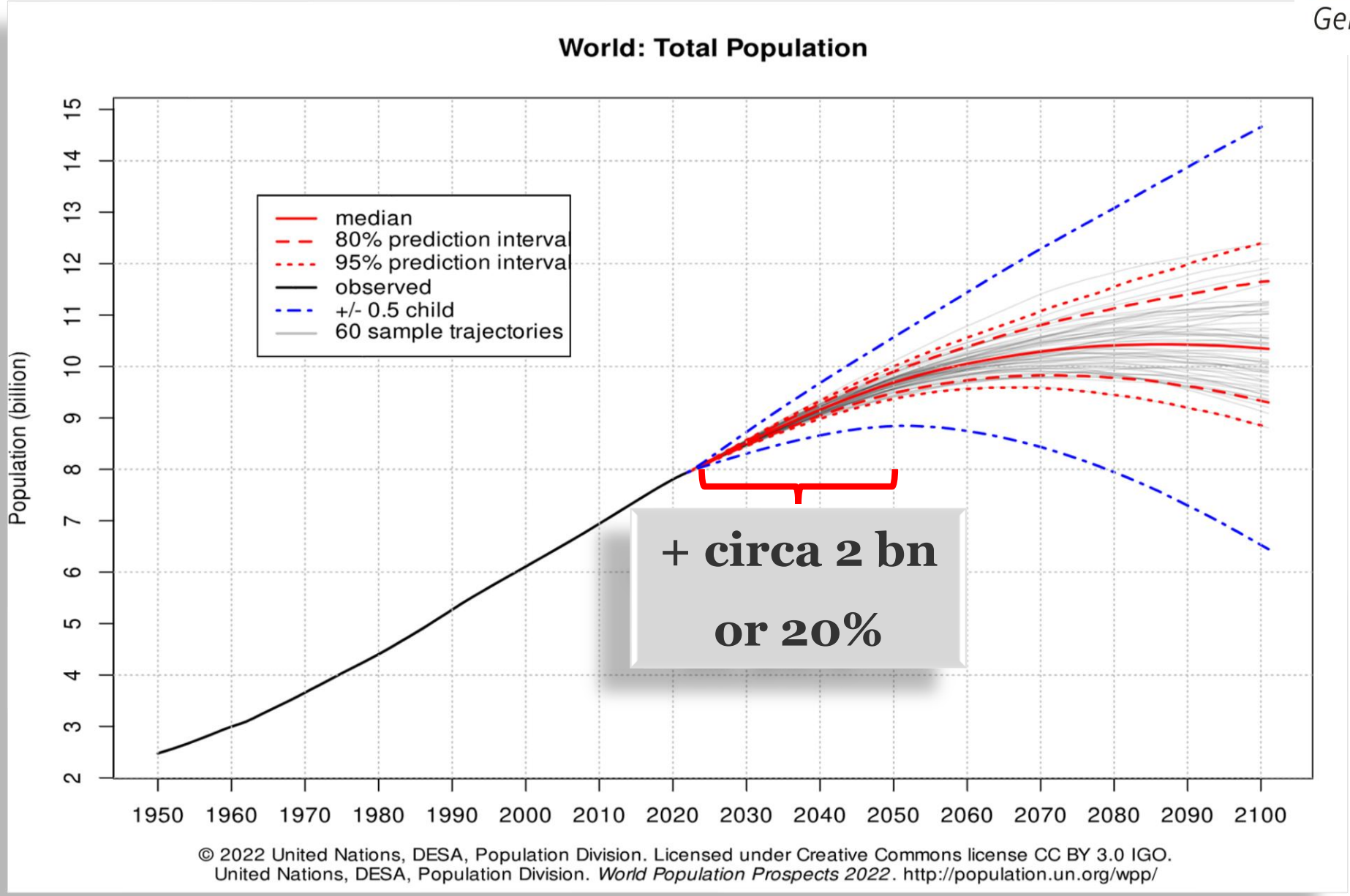

Biophysical boundary overshoot

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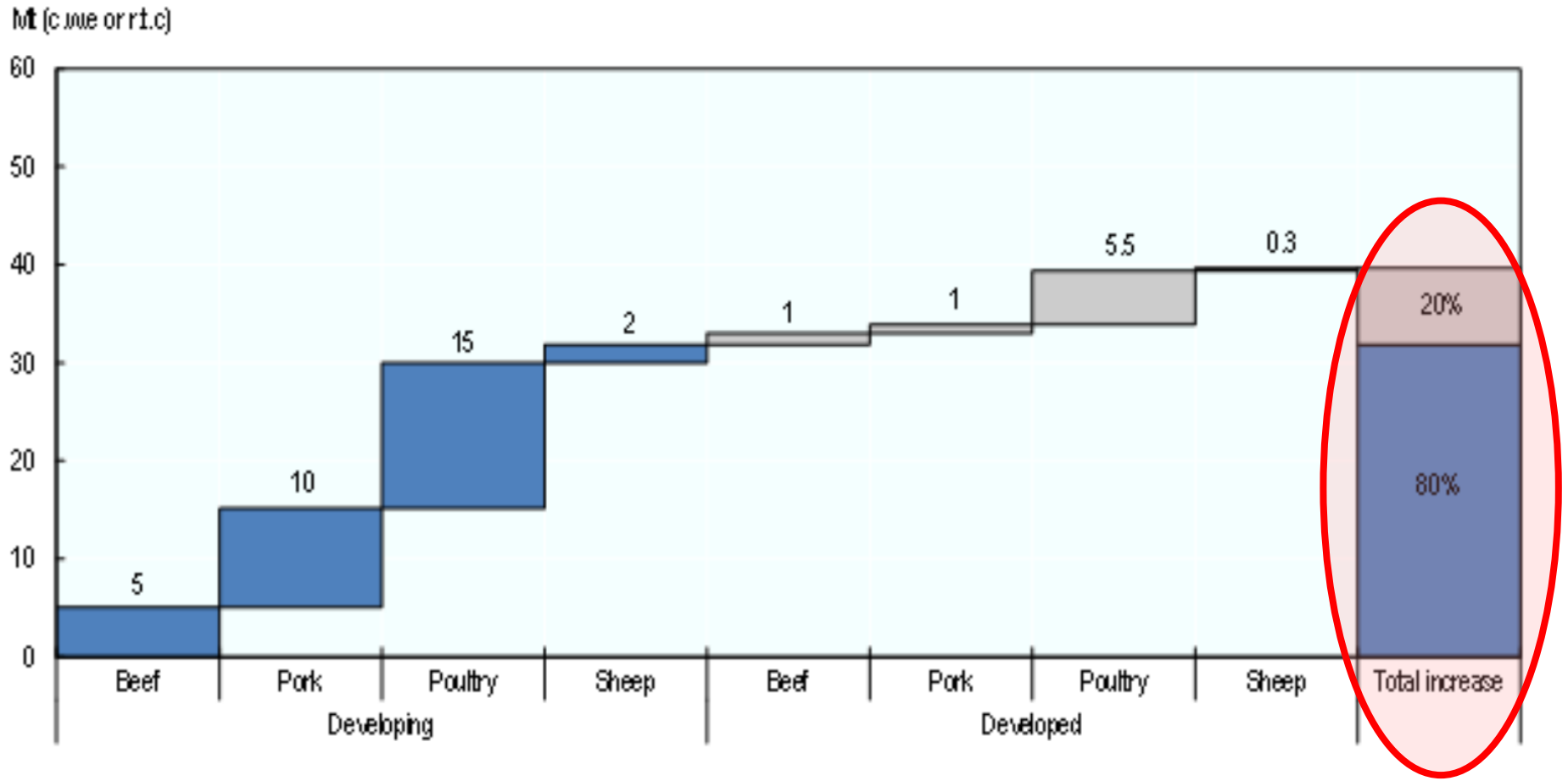
Figure 6.3. Growth of meat production by region and meat type

2029 vs 2017-19



Note: c.w.e. is carcass weight equivalent, r.t.c. is ready to cook equivalent.
Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Biophysical boundary overshoot

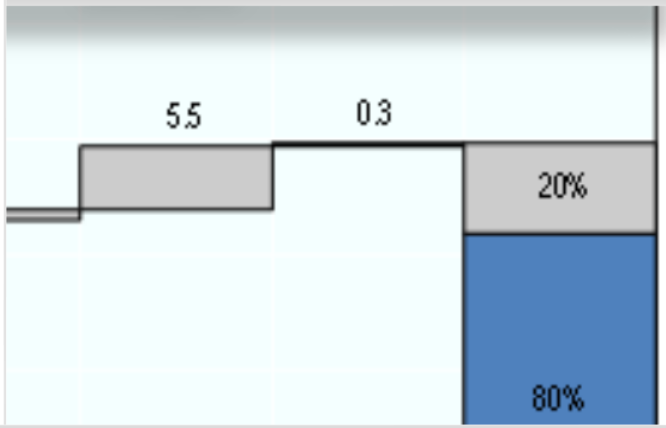
Livestock make up 62% of the world's mammal biomass; humans account for 34%; and wild mammals are just 4%

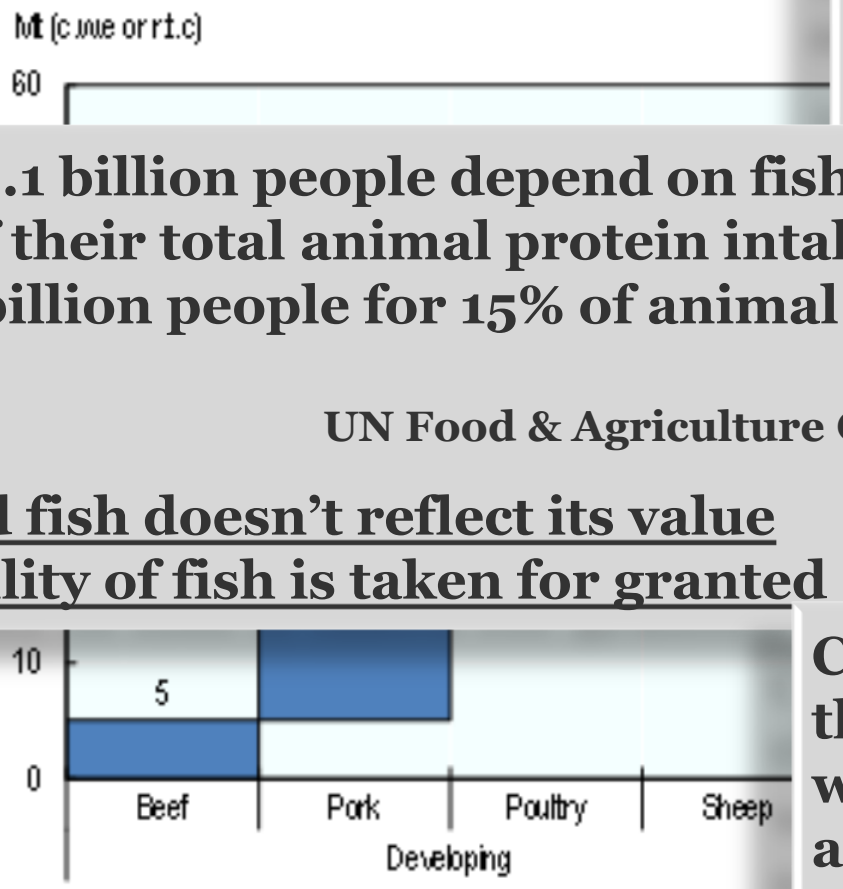
https://ourworldindata.org/wild-mammals-birds-biomass

More than 3.1 billion people depend on fish for at least 20% of their total animal protein intake, and a further 1.3 billion people for 15% of animal protein intake.

UN Food & Agriculture Organisation

Price of wild fish doesn't reflect its value
The availability of fish is taken for granted





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Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook"
http://dx.doi.org/10.1787/agr-outl-data-en.

China is running out of arable land to produce the high-protein food demanded by its wealthier population as official statistics show a downward trend in grain consumption and growth in meat, dairy and seafood

Caixin Global

Biophysical boundary overshoot

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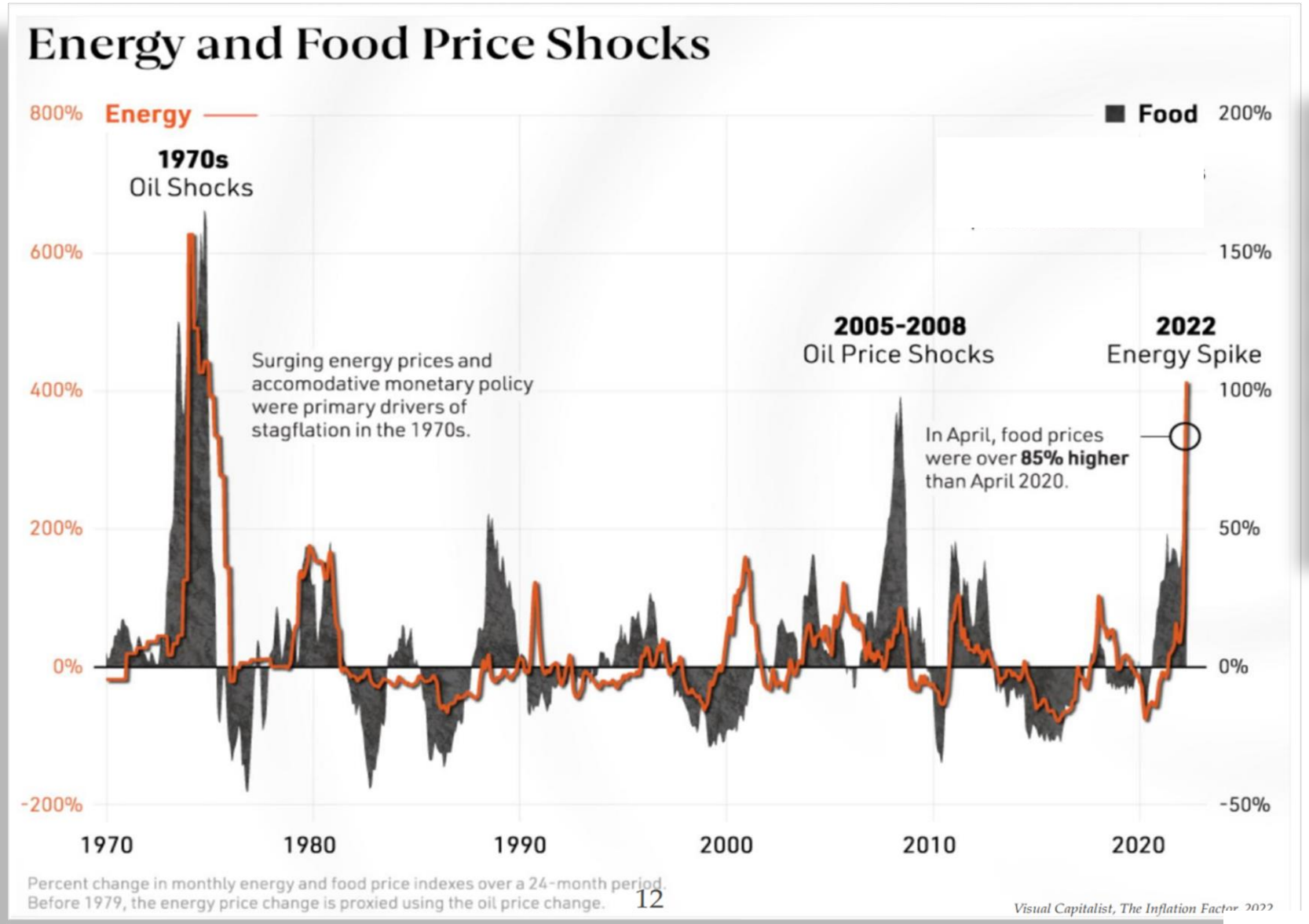

The price of oil influences as much as 64% of food price movements

Visual Capitalist, The Inflation Factor 2022

Biophysical boundary overshoot

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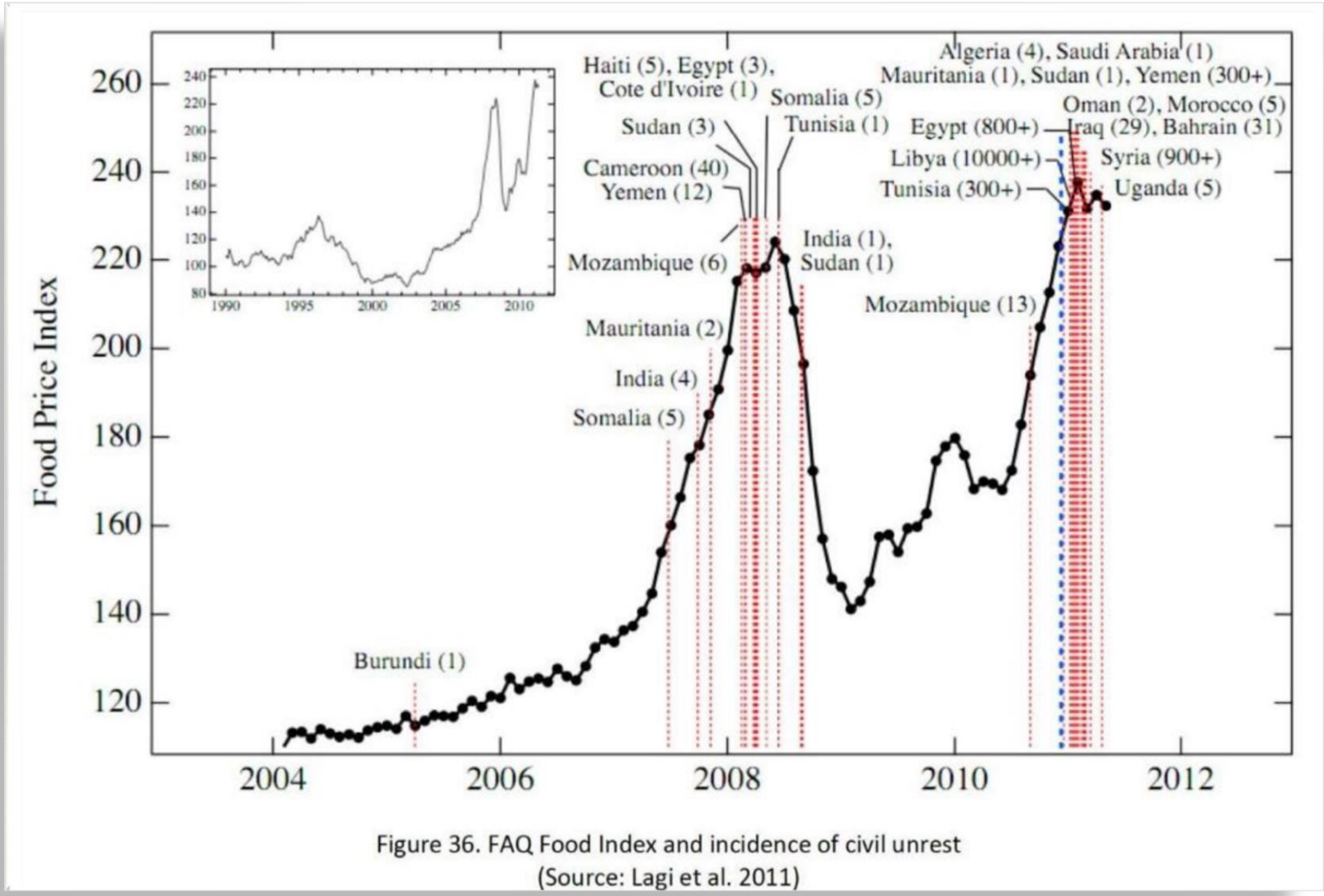

Figure 36. FAQ Food Index and incidence of civil unrest
(Source: Lagi et al. 2011)

The only barrier between us and anarchy is the last nine meals

Alfred Henry Lewis (1896)

Biophysical boundary overshoot

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Biophysical boundary magic

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Nuclear

The Power of Physics EROEI = 100:1

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$E = mc^2$ tells us exactly how much energy you get from converting mass

- **1 kg of mass if turned into energy yields 9 × 1016 joules**
- **equivalent of 21 Megatons of TNT**
- **40% the energy of the largest nuclear explosion**

Small and medium sized nuclear reactors (SMRs)

- **50 SMR designs and concepts globally**
- **4 in advanced construction stages in Argentina, China & Russia**

Oklo aims to build 'Aurora' fast reactors that could economically use the spent fuel from conventional nuclear reactors to operate

People

People

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People care about climate change, but they care more about immediate priorities*

- **Pew Research Center: 75% people consider climate change a major threat**
- **IPSOS: climate change comes ninth, far behind inflation, poverty, unemployment, crime, corruption, health care and taxes**

*Multi-country surveys

Conclusions

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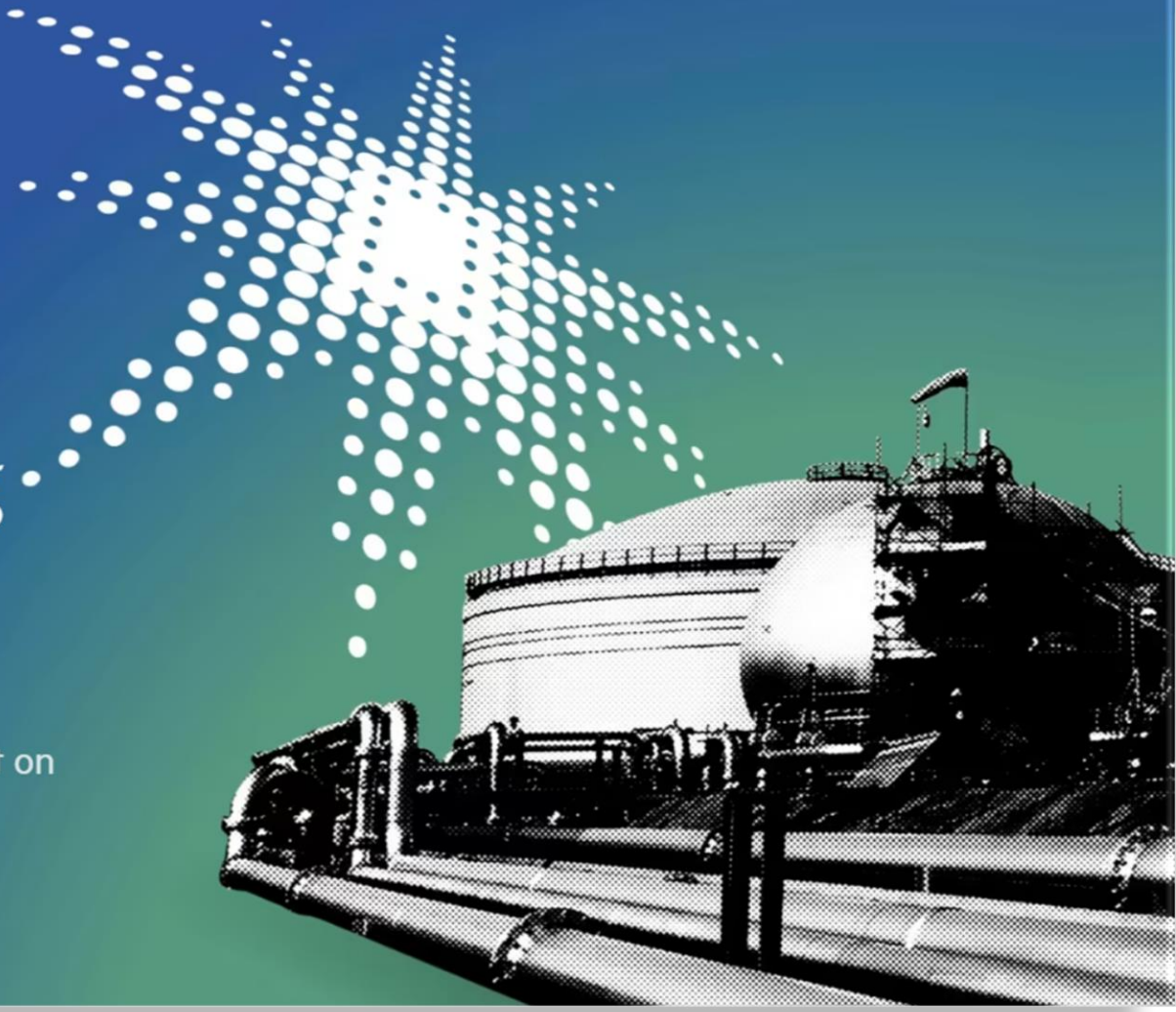
The Big Read Oil & Gas industry ✓ Added

Saudi Aramco bets on being the last oil major standing

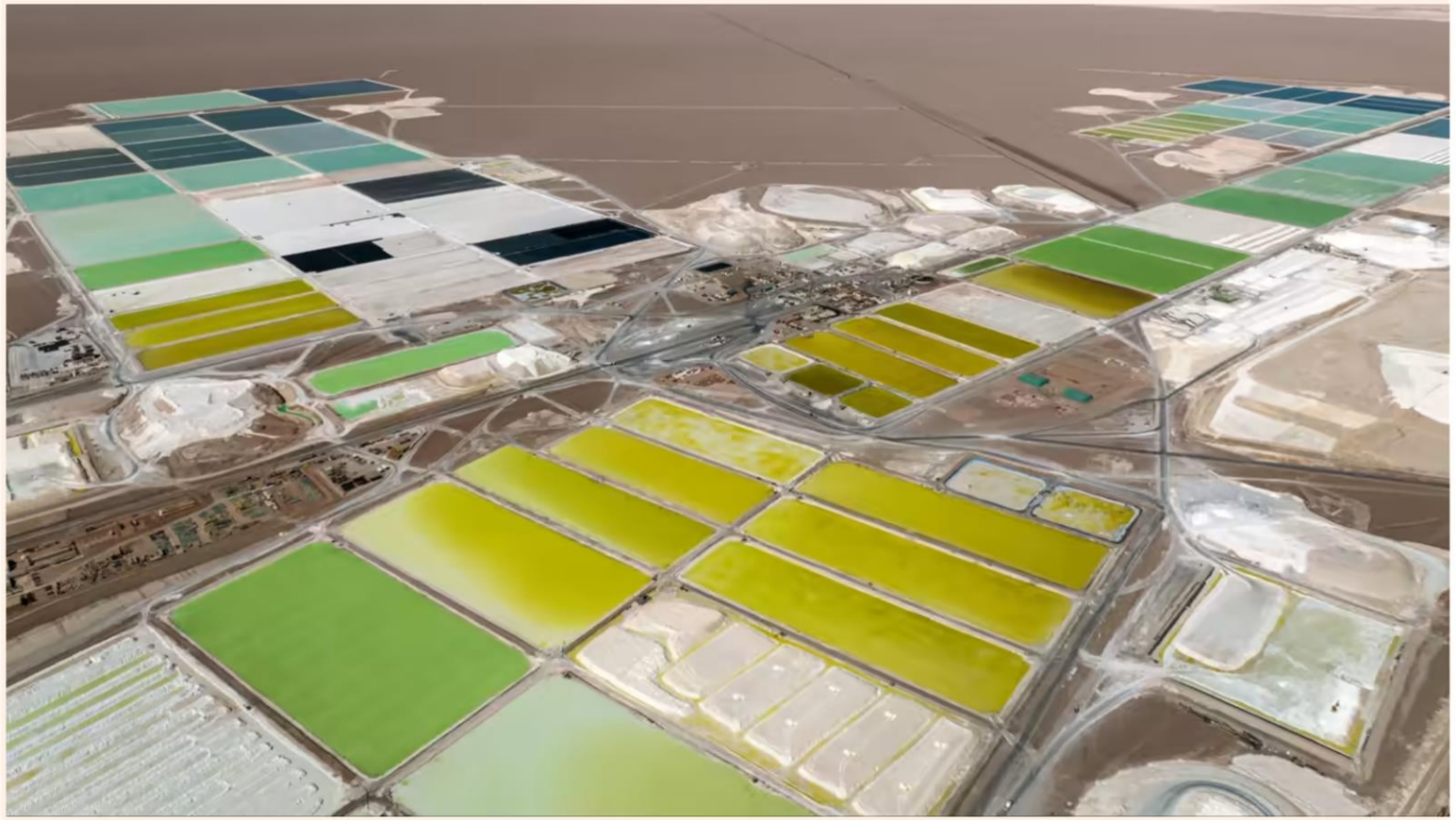
While some western energy companies prepare for a future less reliant on fossil fuels, the world's biggest supplier is doubling down



Source: FT

China pushes to dominate trading in clean energy metals

Beijing aims to wrest benchmark contracts for minerals such as lithium carbonate away from the west



Pools of brine containing lithium carbonate stretch across a lithium mine in Chile. The proliferation of futures contracts on crucial elements of electric-vehicle products such as lithium carbonate reflects the growing importance of the industry © Getty Images

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Source: FT

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Moral Money

The green treasure chest buried in Ukraine Premium

Up to $11.5tn worth of minerals needed for the energy transition are located in the country

….. the country had “commercially relevant deposits of 117 of the 120 most-used industrial minerals across more than 8,700 surveyed deposits”.

Source: FT

Adaptation – time to get real!

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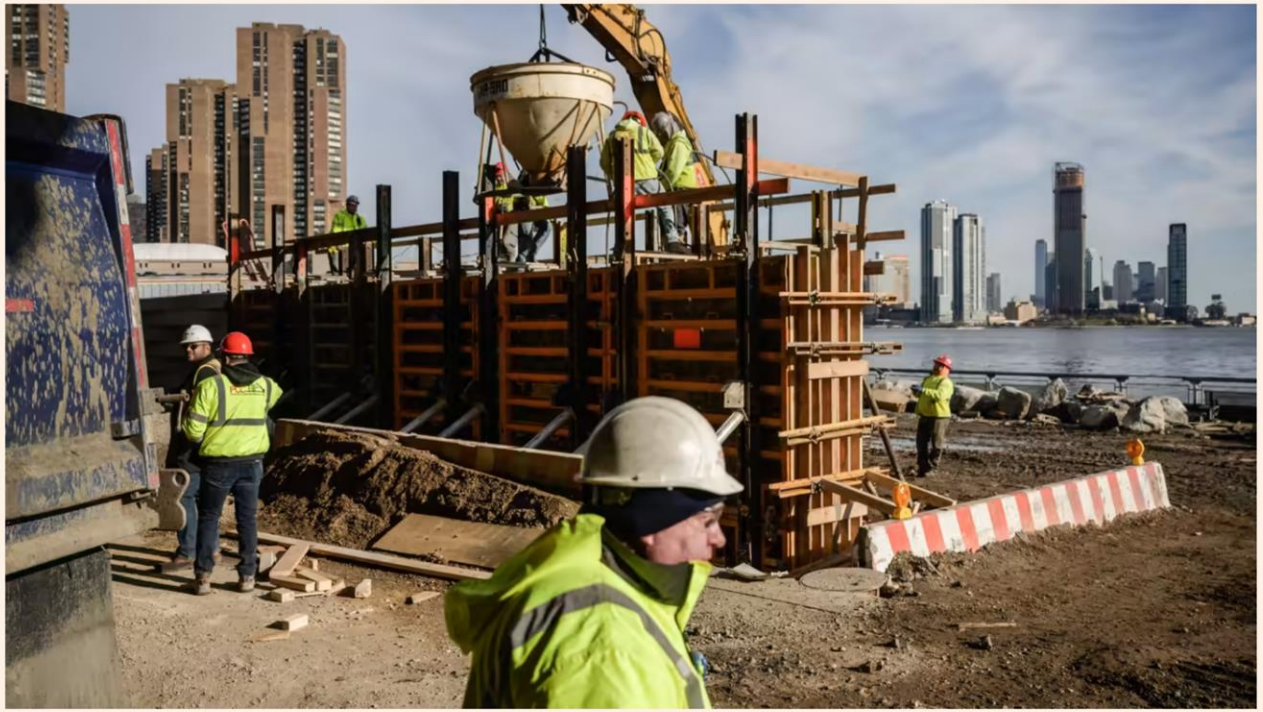
Why it's time to prepare for the worst on climate change

Business and society must invest in adaptation now despite uncertainty about the impact

ROBERT PINDYCK + Add to myFT



Stemming the tide: Construction work on a sea wall to protect New York City from storm surges amid rising sea levels © Ed Jones/AFP via Getty Images

Concluding opinions

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AN important part of the solution to the very wicked problem of global climate change lies with honest energy education

Deaths of the fossil and nuclear industries are greatly exaggerated

Insufficient investment in oil, gas and critical 'transition minerals'

Dependence on future oil and gas supply from Gulf States and dependence on transition metals from China

Energy and commodity security will be fiercely contested - history is littered with negative examples

Concluding opinions

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Adaptation and mitigation are essential and will need strong governance and global leadership in a time of civil disruption:

- Pakistan & Bagladesh LNG, Indian rice, Chinese urea
- Australian refining

Energy efficiencies, recycling, lifestyle changes and technology will not "save us" but should have a significant impact

Energy & commodity 'real' economics will dominate financial economics as the world transitions from energy abundance to energy scarcity

"We will know when wind and/or solar has hit the big time when they provide both electricity and tax revenues" Richard Norris

A nuclear renaissance is inevitable given nuclear's unparalleled zero carbon, high energy density – this needs to happen now!

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How we live is so different from how we ought to live that he who studies what ought to be done, rather than what is done, will learn the way to his downfall rather than to his preservation.

Niccolo Machiavelli, The Prince

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We need to talk about transition

The “super wicked problem” of providing affordable, dependable and sustainable energy

Jonathan Green
President, Geneva Energy Forum

Thank you