

# The political economy of the energy transition

Jan Osička

# Transition effects

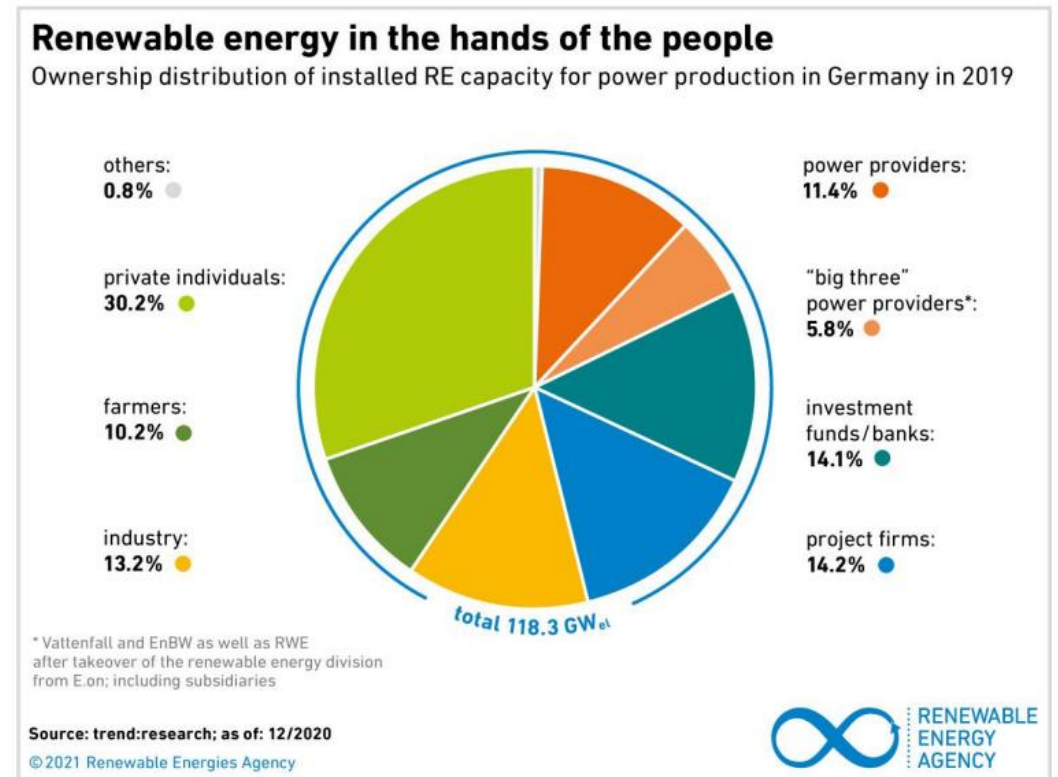
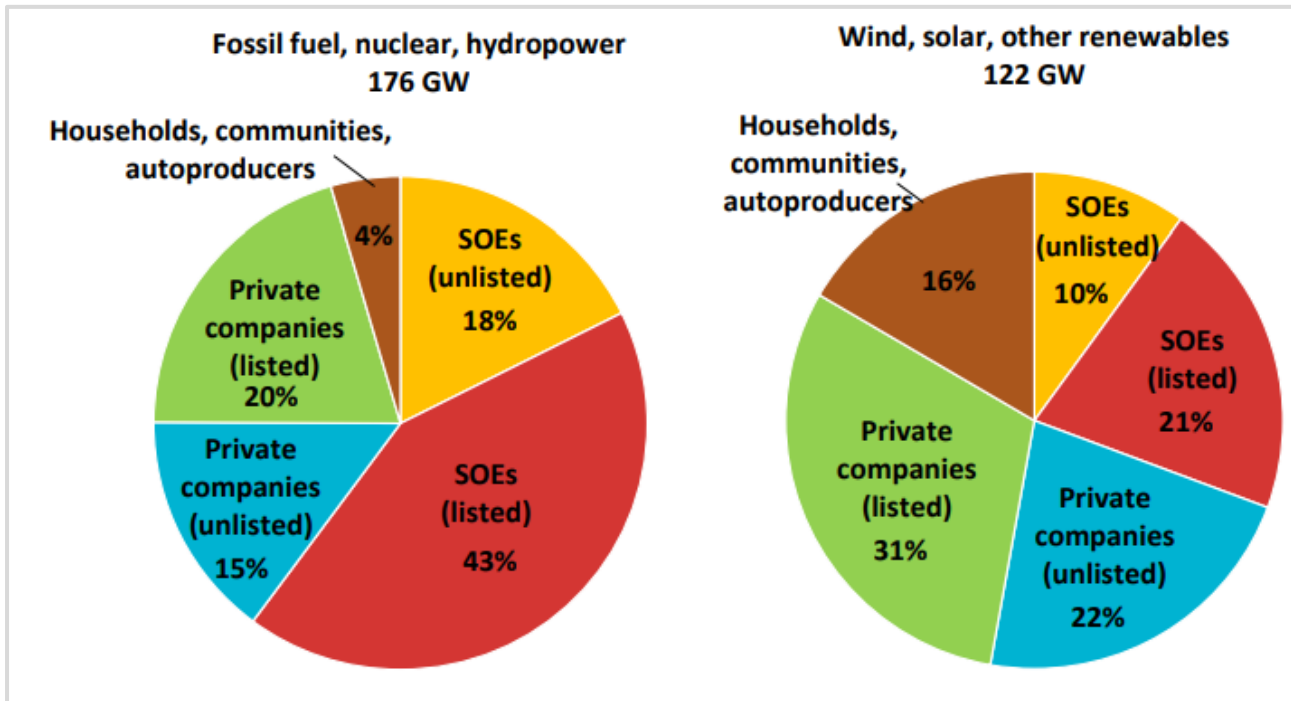
Transition Studies	Political Economy	International Political Economy	International Relations	Security Studies
Systemic change in the economy	Domestic winners and losers	International winners and losers	Power & Influence implications	Security implications

Domestic winners and losers

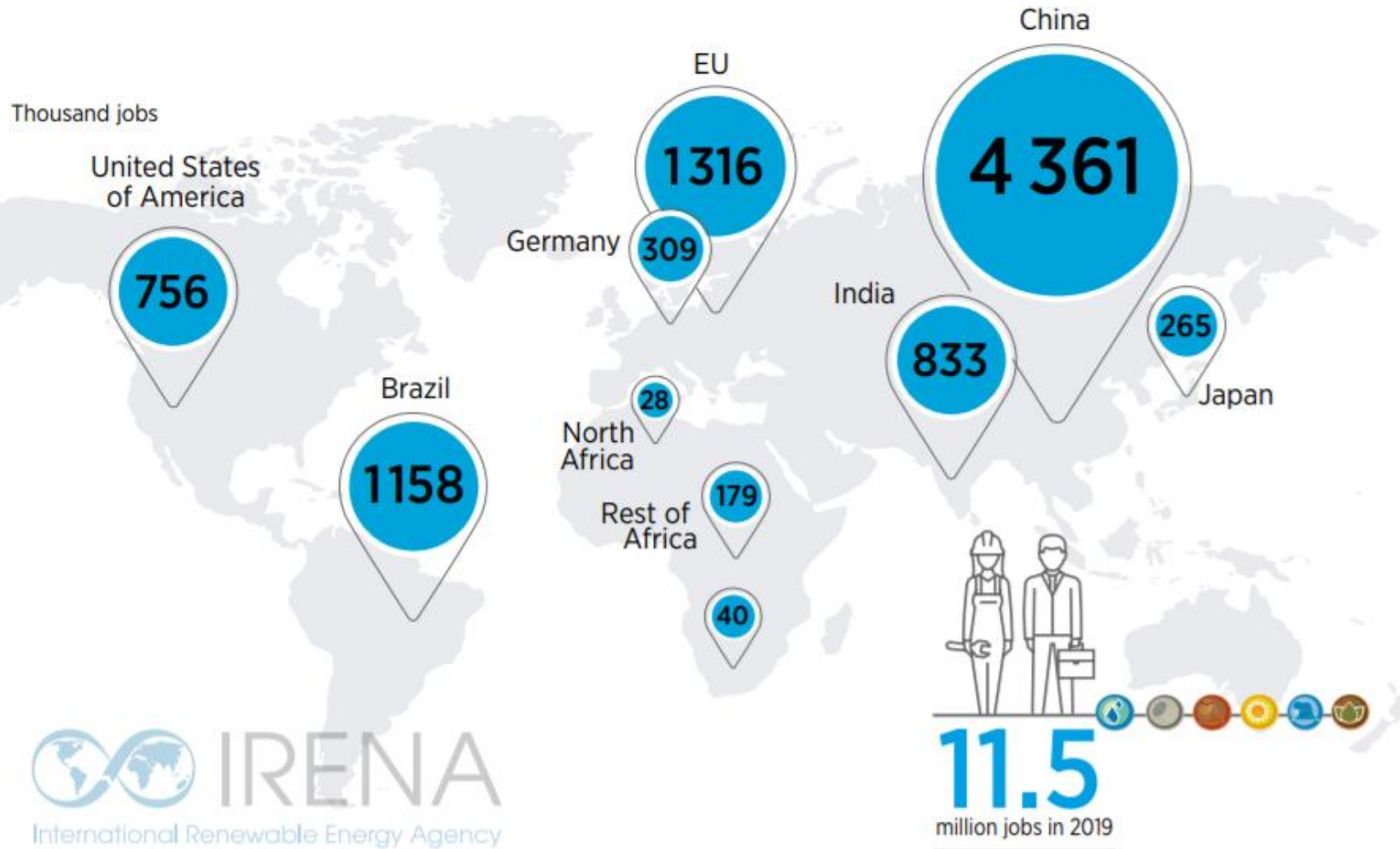
# Democratization of the energy system ownership

Ownership of global power generation capacity commissioned in 2015

Ownership of installed RE capacity in Germany (2020)



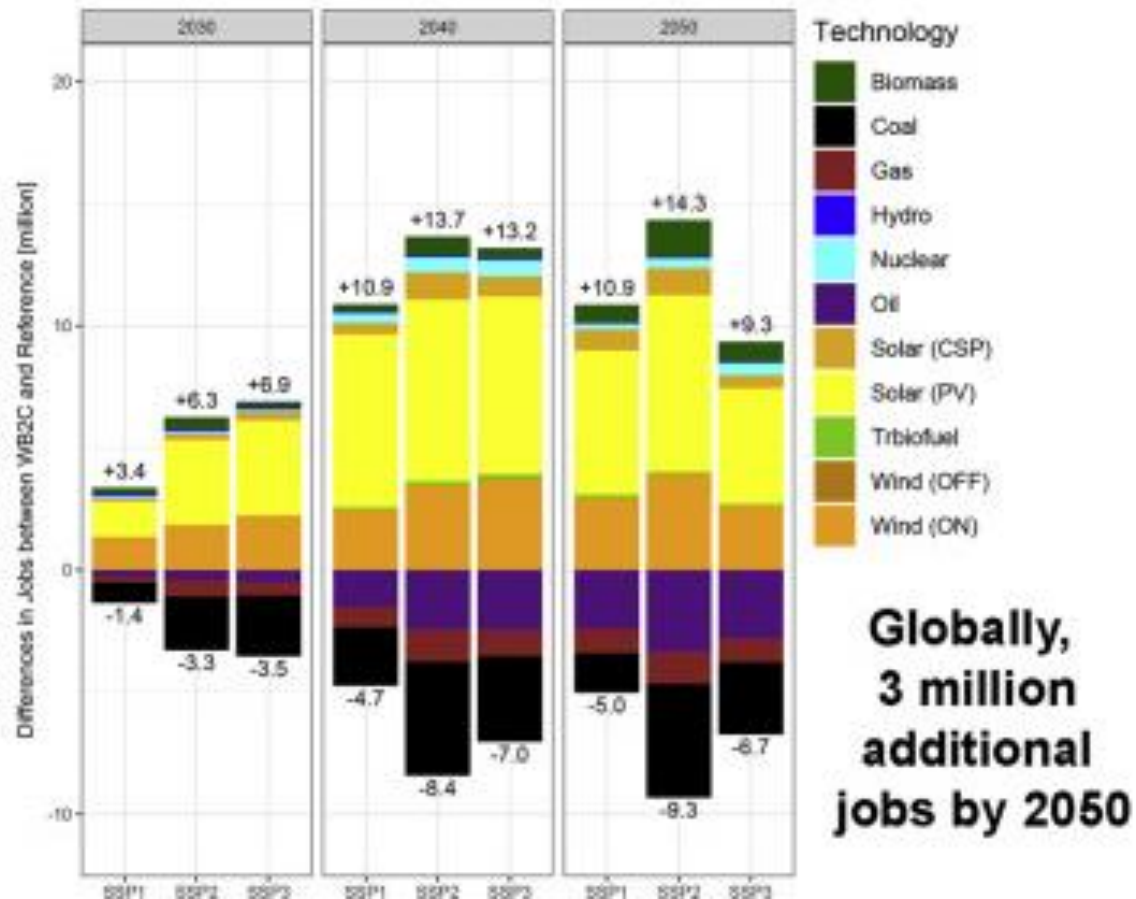
# Changes in employment structure



- 11.5 M jobs in RE as of 2019
- 1 M USD invested (USA)  
=> 7.5 jobs in RES  
=> 2.6 in fossil energy

Sources: [IRENA](#),  
[Garret-Peltier 2017](#)

# Changes in employment structure



RES jobs additions to outweigh fossil fuels job losses

Source: [Pai et al. 2021](#)

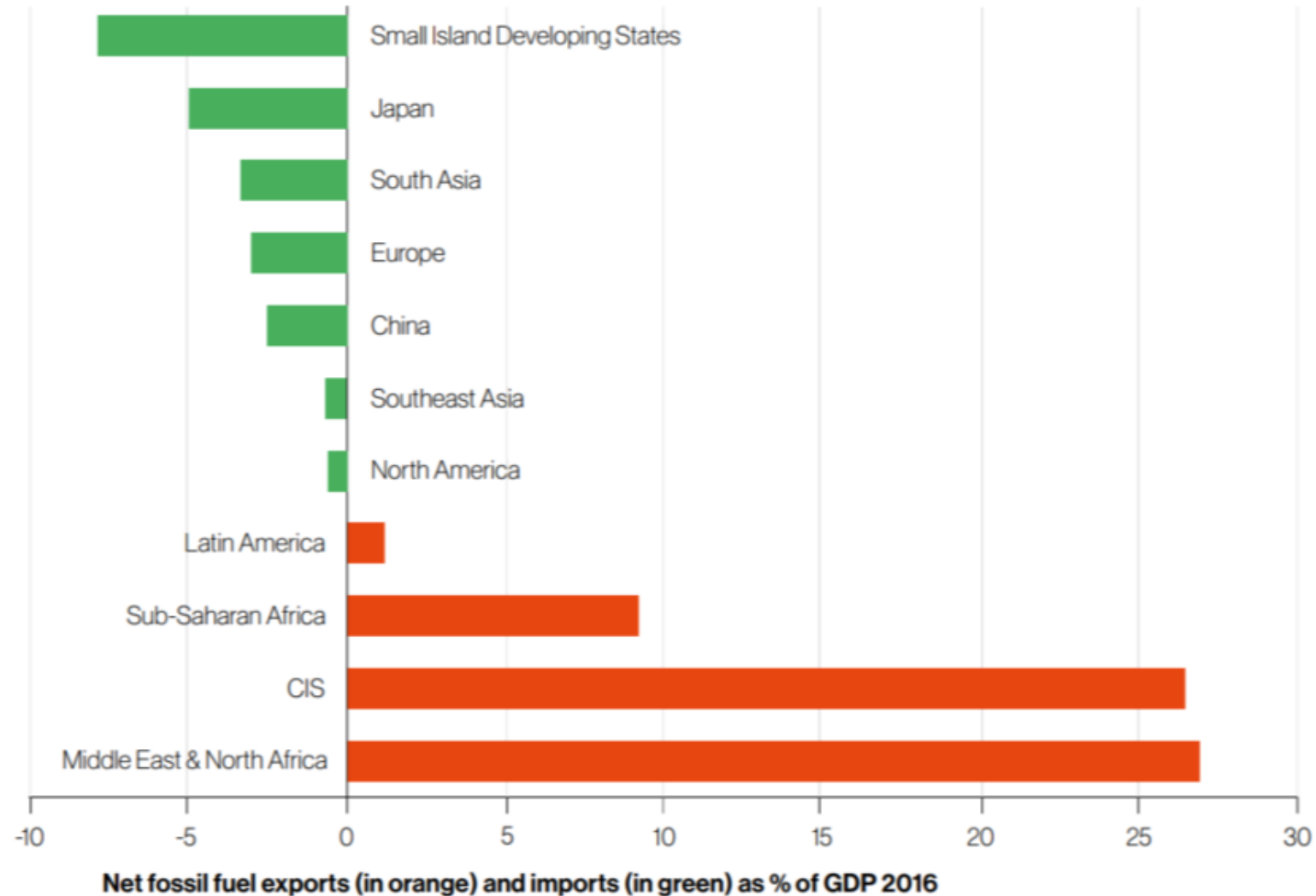
International winners and losers

# Winners: the greentech race

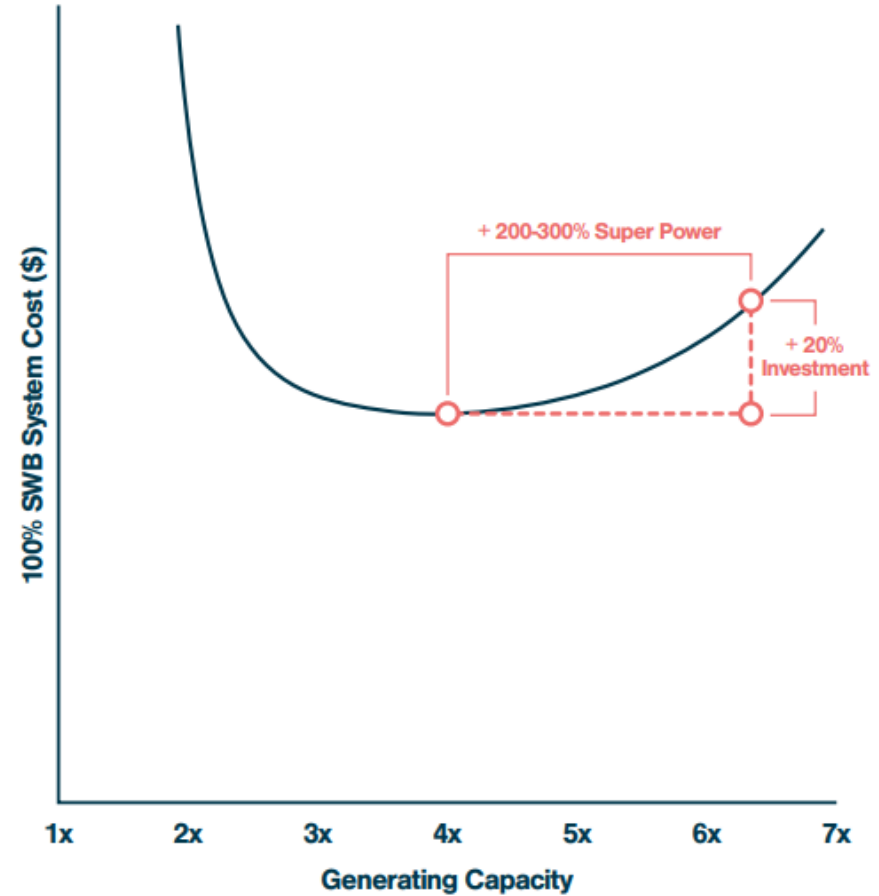
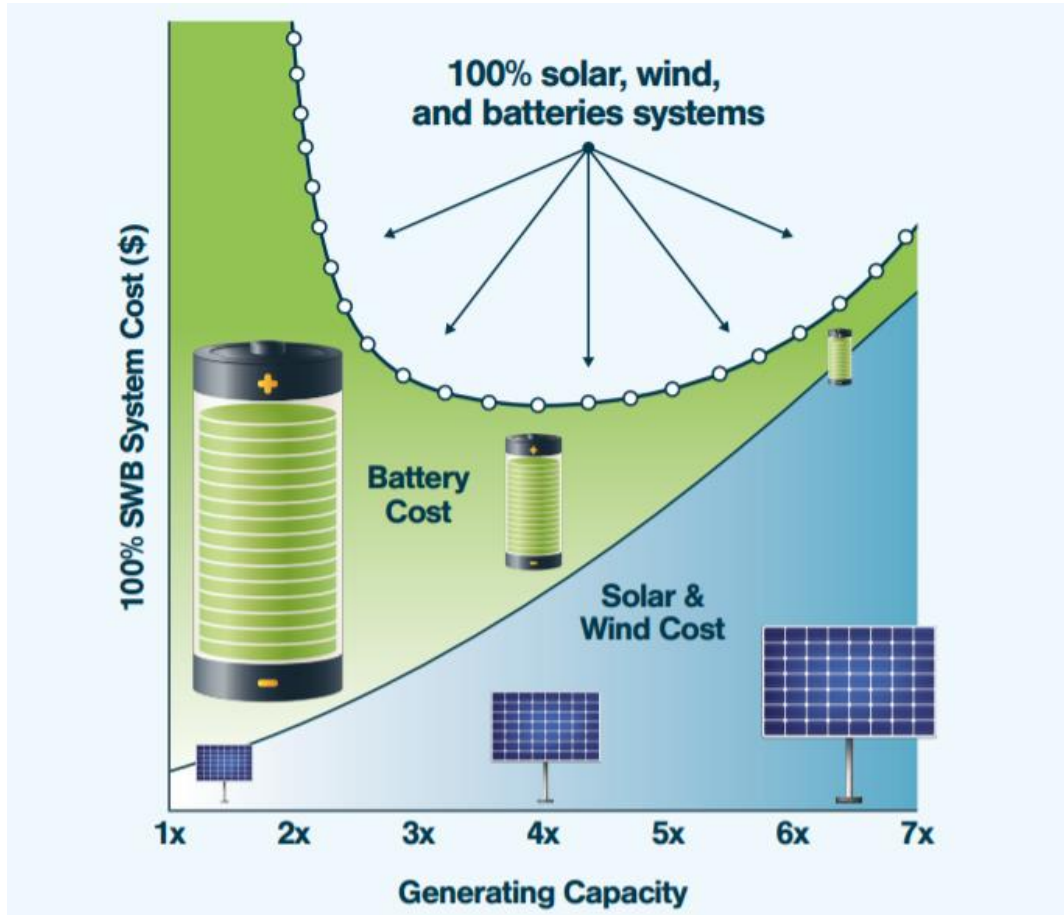
<b>Oil</b>	<b>Solar</b>
Exploration and production	Raw materials production
Refining	Manufacturing and assembly
Transportation	Transportation
Retail and distribution	Installation
	Operation and maintenance



# Winners: the implementation race



# Winners: the implementation race



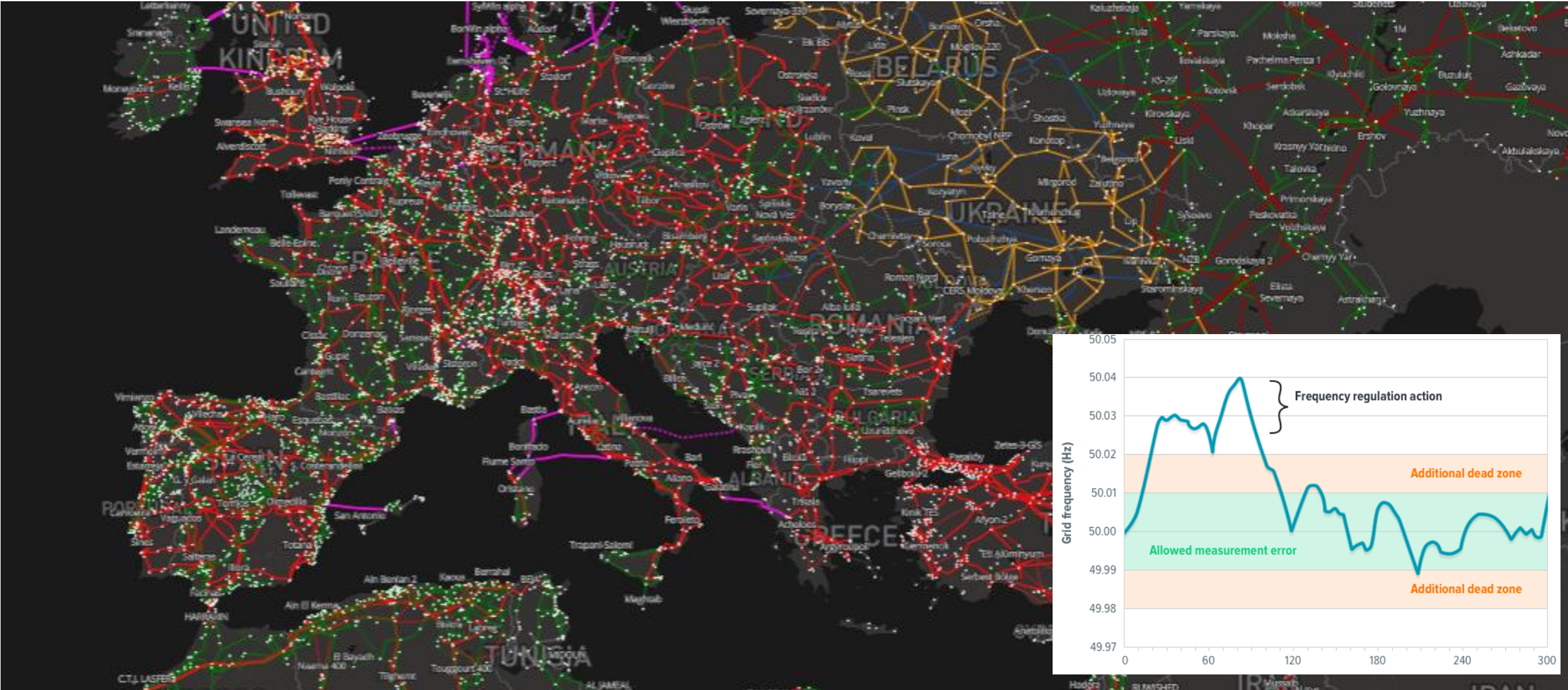
Power, influence, and security implications

# (Anti)fragility of the all-electric system

**Sector coupling** – an integrated energy system based on renewable electricity

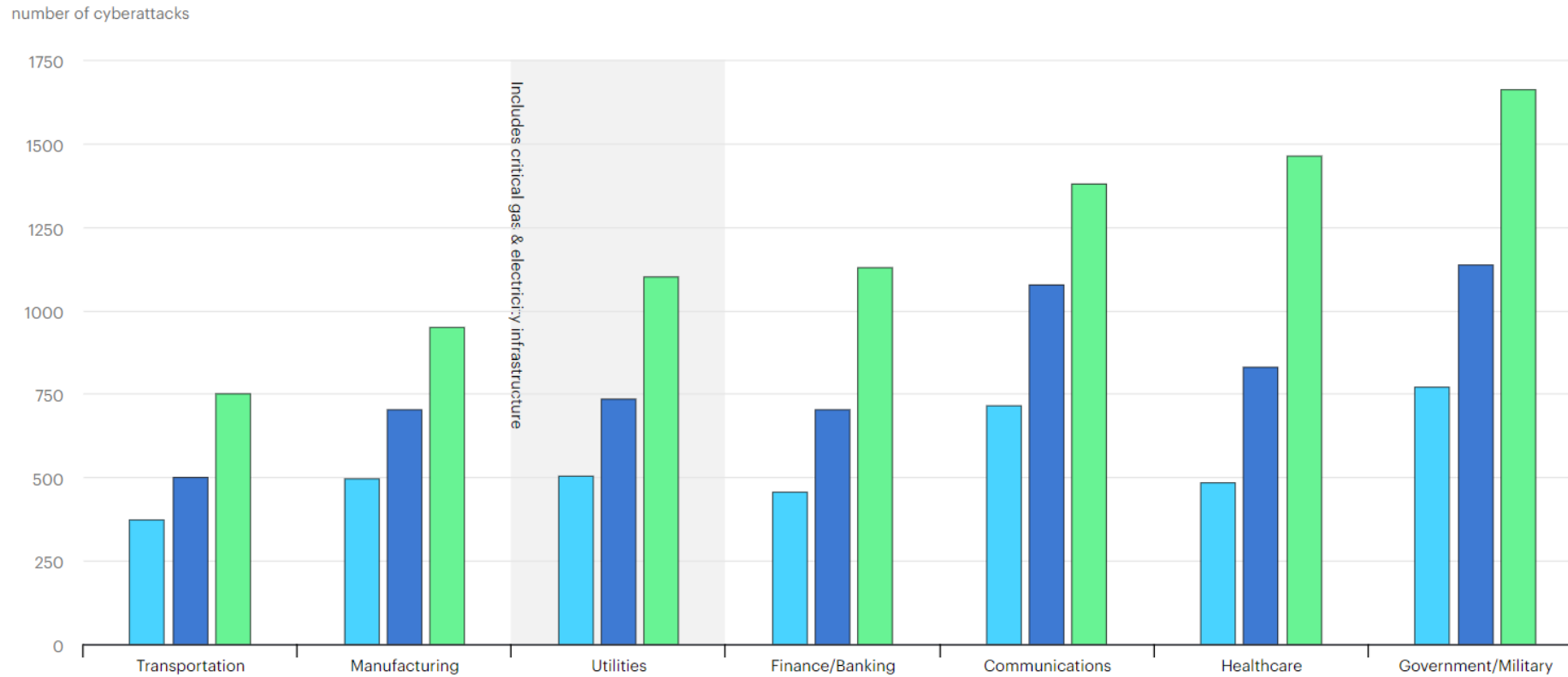


# New security challenges



# Cyberattacks

Average number of weekly cyberattacks per organization in selected industries, 2020-2022



Will there be enough transition materials?

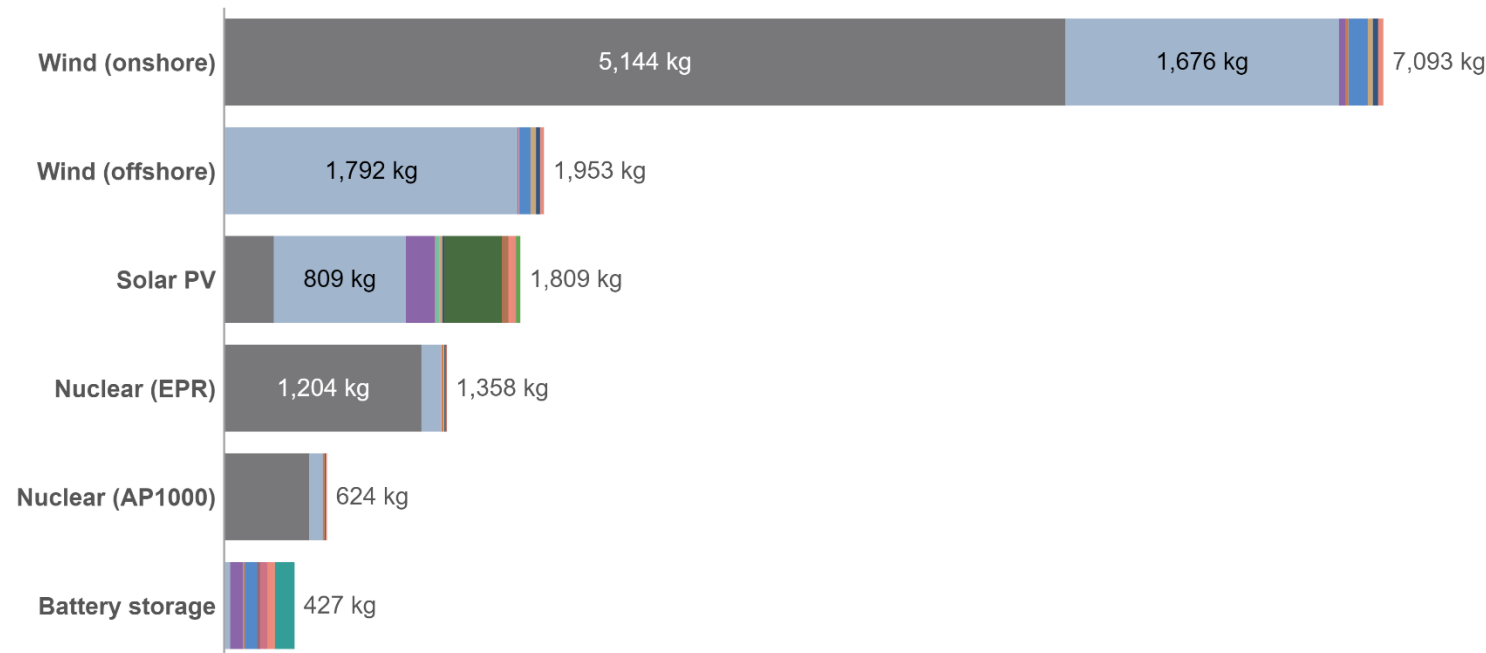
# RES are material-intensive

## Materials used for low-carbon electricity sources



Measured in kilograms per gigawatt-hour (GWh) of power generation. Waste rock produced from mining is not included.

Concrete Steel Aluminum Chromium Glass Iron Lithium Manganese Nickel  
Phosphate Solar PV cover glass Silicon Copper Niobium Molybdenum Magnesium Lead  
Graphite Silver Tin Cobalt Boron Rare earths Uranium Titanium Tungsten Zinc



Data source: Seaver Wang et al. (2024). Updated Mining Footprints and Raw Material Needs for Clean Energy. OurWorldinData.org/metals-minerals | CC BY

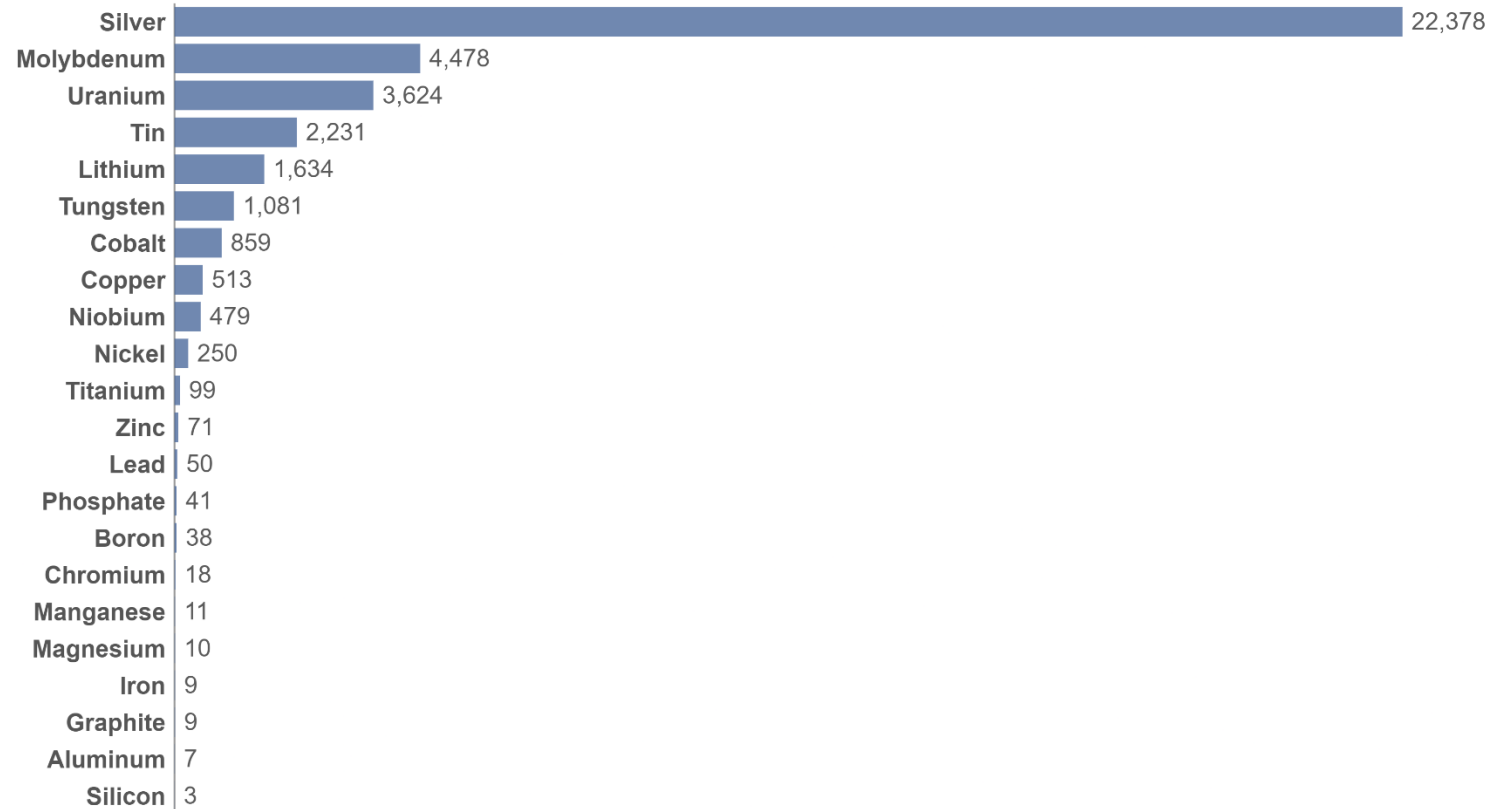


# And mining-intensive

## Rock-to-metal ratios of mined materials

Our World  
in Data

The quantity of rock that has to be mined to produce one unit of metal. For example, a ratio of 50 means that 50 kilograms of rock has to be mined to produce one kilogram of that metal.



# And yet they will need less mining than fossil fuels

## Mining requirements of different electricity sources



Measured in kilograms of material per gigawatt-hour (GWh) of electricity generated. Metals and minerals include all of the materials used for manufacturing and construction. Rock includes mined coal and the amount of rock that has to be mined for the extraction of minerals.

■ Metals and minerals ■ Rock



Data source: Seaver Wang et al. (2024). Updated Mining Footprints and Raw Material Needs for Clean Energy. OurWorldinData.org/metals-minerals | CC BY



# ALL THE METALS WE MINED

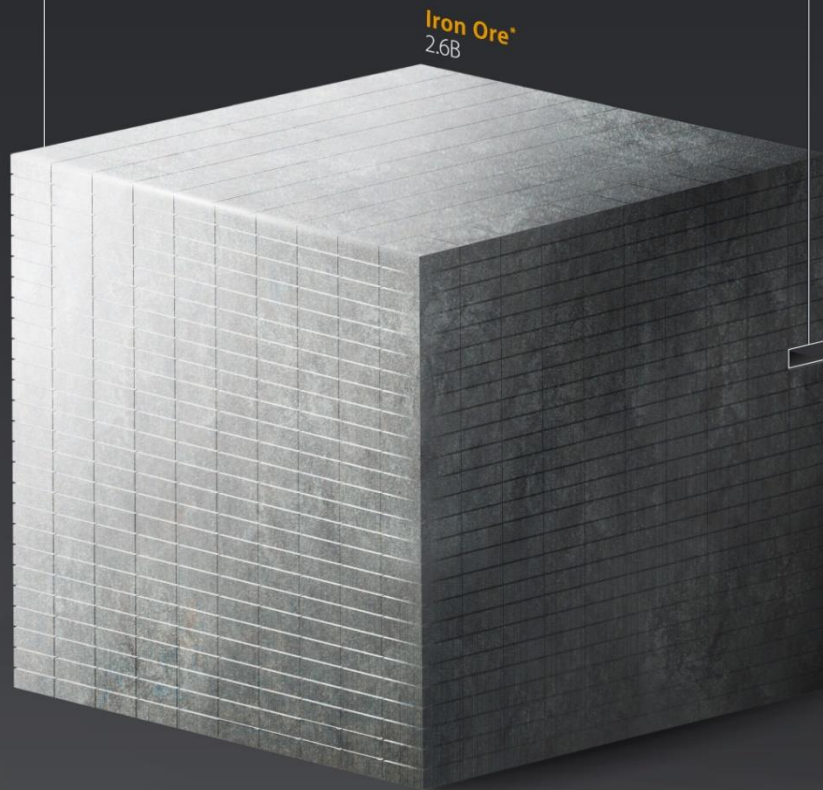
IN 2021

The world produced roughly **2.8 billion tonnes** of metals in 2021. Here are all the metals we mined, visualized on the same scale.

## IRON ORE

2,600,000,000 tonnes\*

 = 1,000,000 tonnes



## LARGEST END-USE



Steelmaking



Construction



Chemicals



Alloying Agents



Energy/Batteries



Magnets



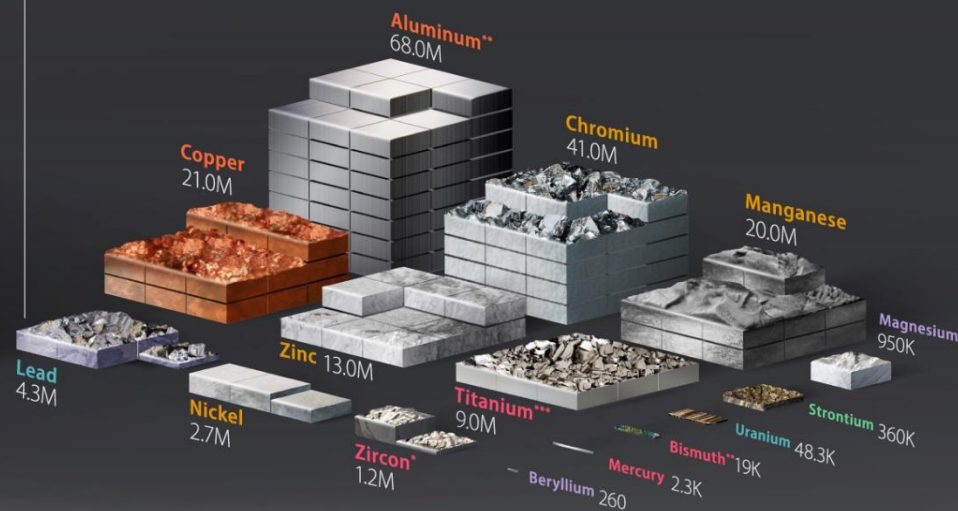
Electronics



Other

## INDUSTRIAL METALS

181,579,892 tonnes

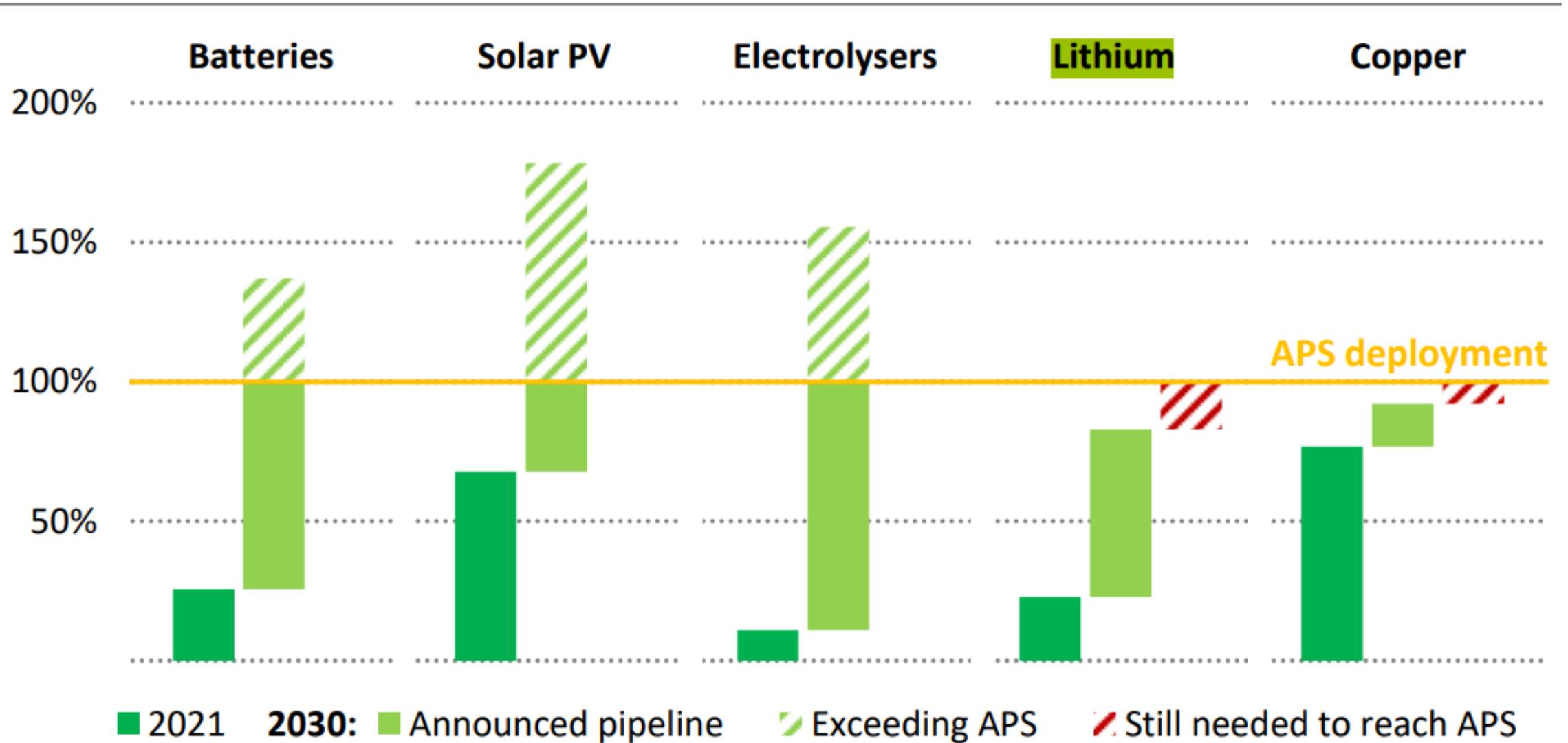


## TECHNOLOGY AND PRECIOUS METALS

1,474,889 tonnes

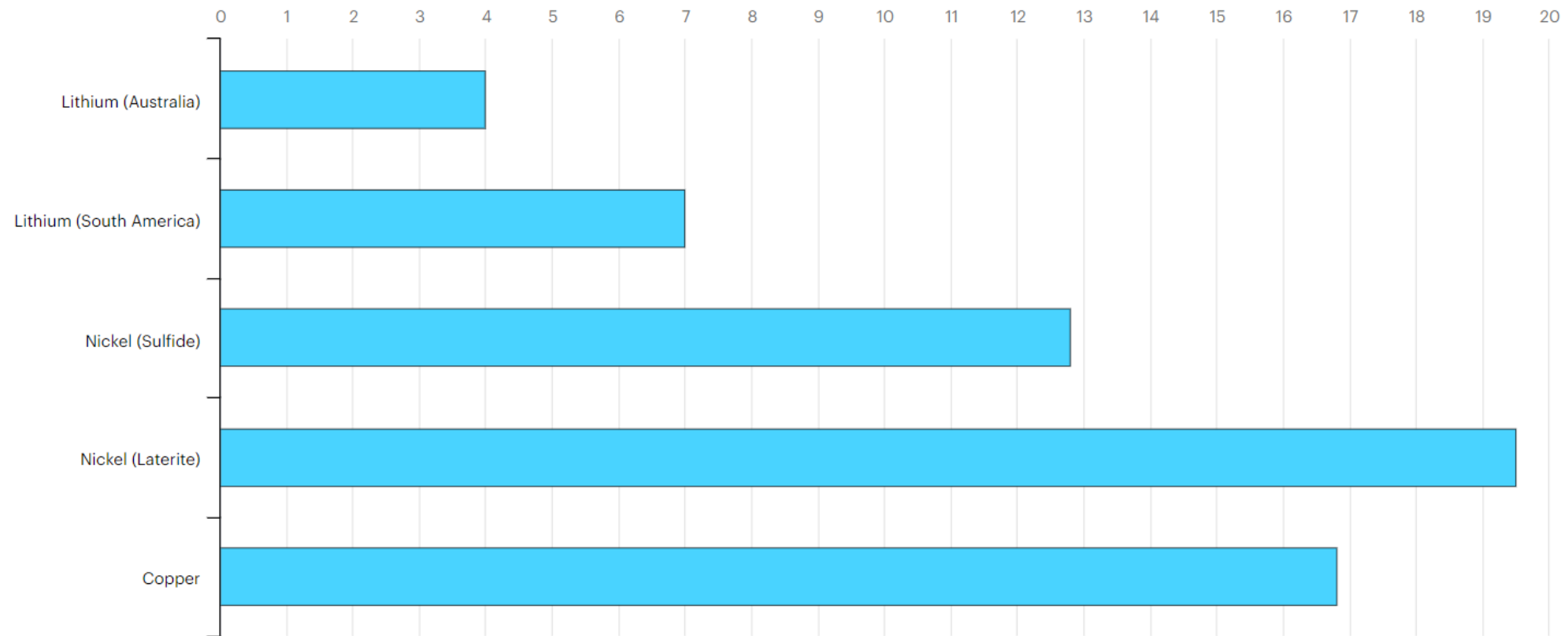


**Figure 1.25** ▶ Announced manufacturing capacity for selected energy technologies relative to deployment in the APS, 2021 and 2030



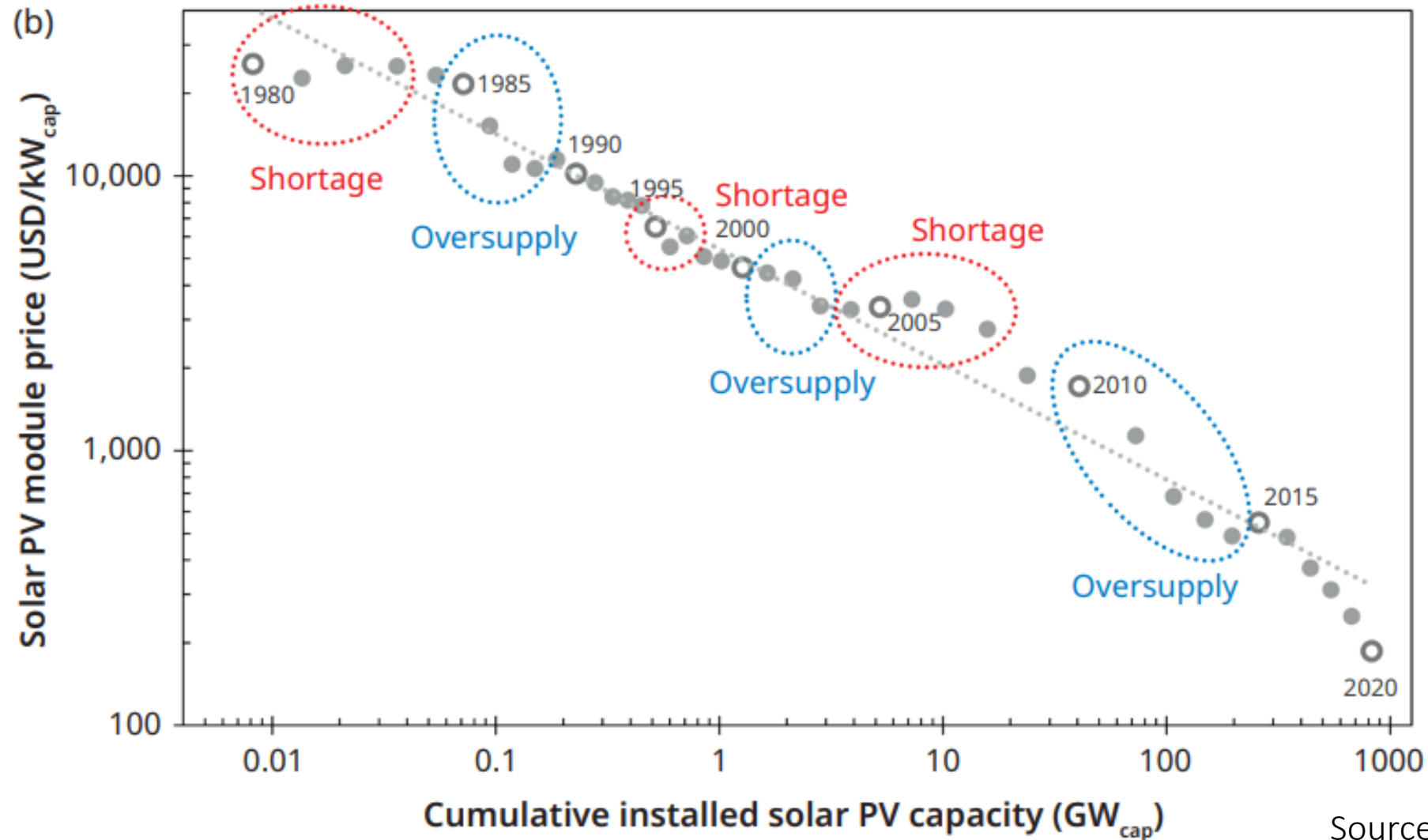
# Getting the timing right: boom and bust cycles

Lead times from discovery to production, 2010-2019



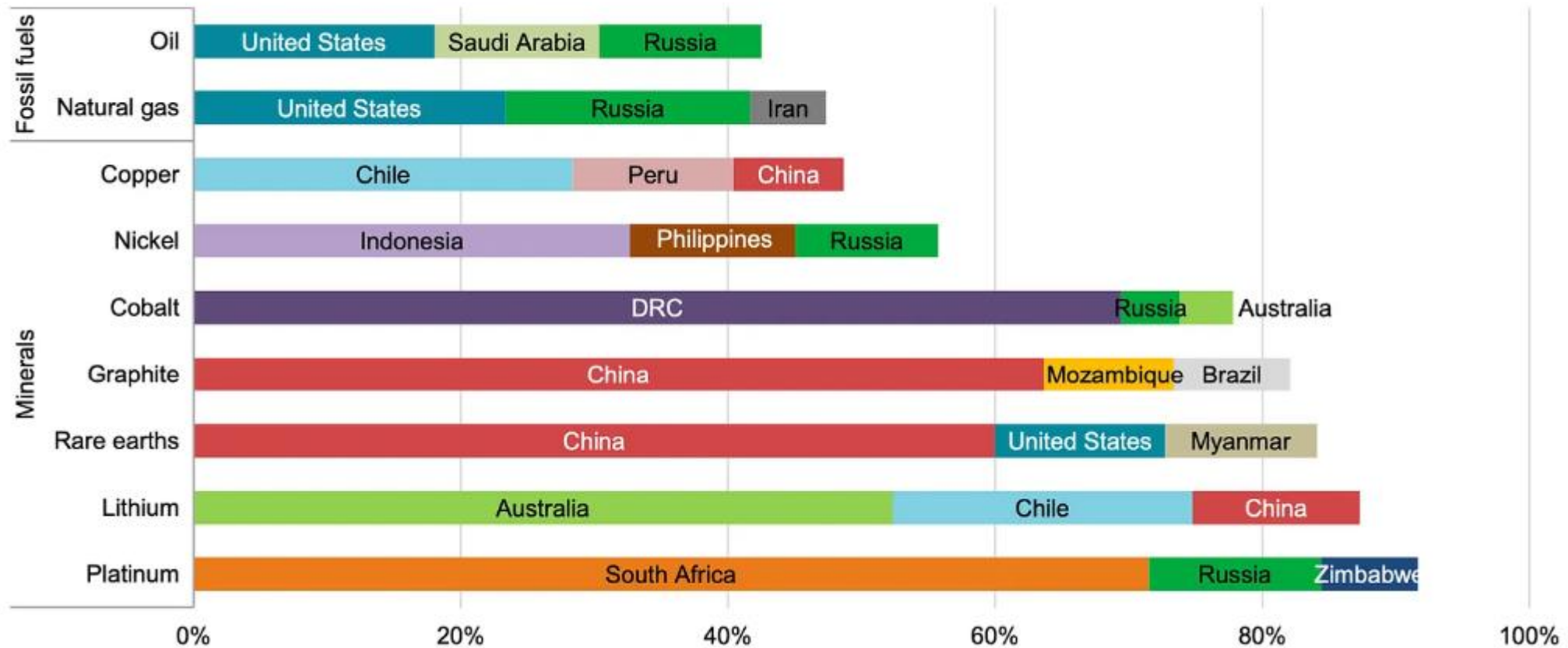
Source: [IEA 2021](#)

# Getting the timing right: boom and bust cycles

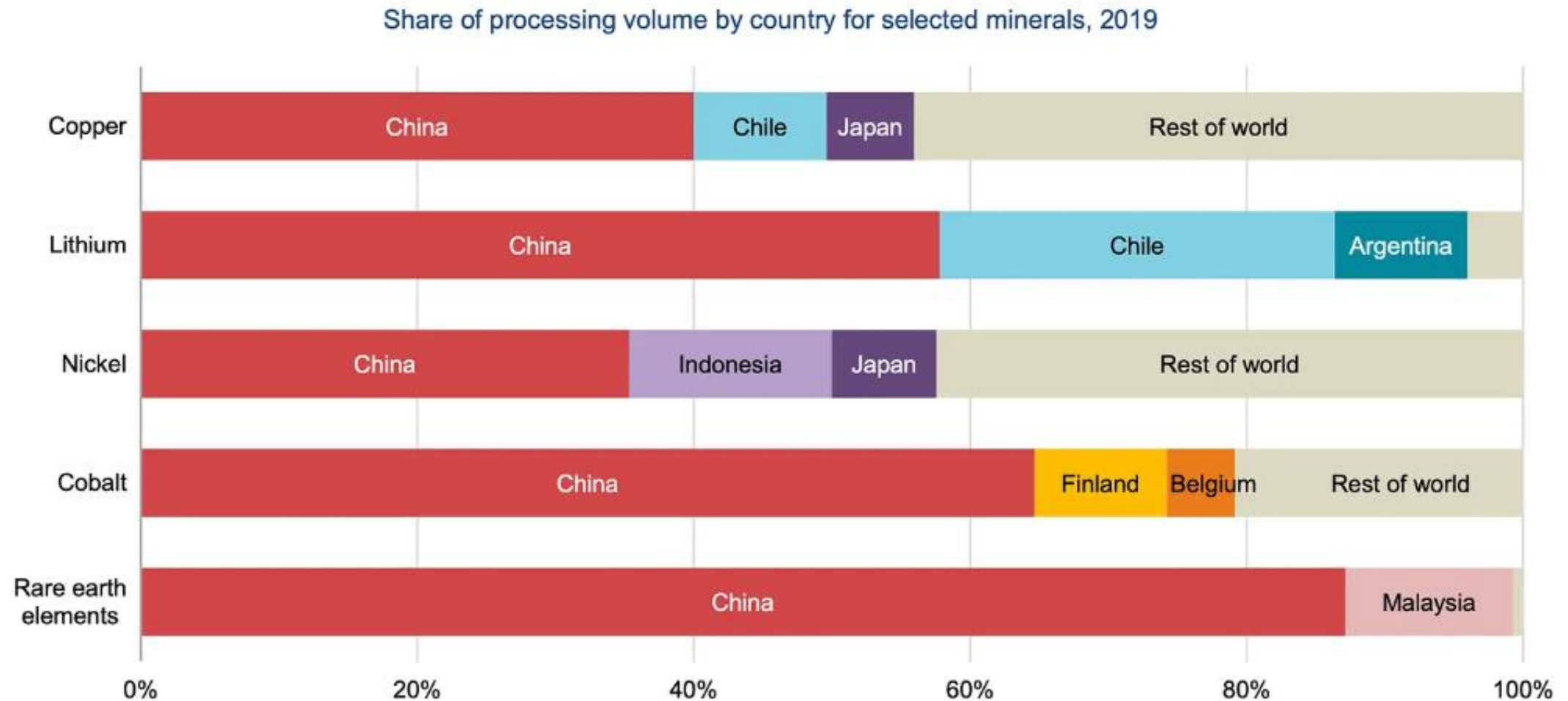


# Will new energy materials breed new Saudi Arabias?

Share of top three producing countries in total production for selected minerals and fossil fuels, 2019



# Will new energy materials breed new Saudi Arabias?



Sources: [IEA 2021](#), [Volts 2022](#)



# Fossil fuels and critical materials are different



## FOSSIL FUELS

### Large mining quantities

In 2021, 15 billion tonnes of fossil fuels were extracted.<sup>a</sup>



### Generate huge rents

Oil and gas exports alone represented a value of USD 2 trillion in 2021.<sup>c</sup>



### Combusted as fuel

Fossil fuels are primarily burned as fuel, accounting for approximately 94% of their usage.<sup>e</sup>



### Energy security risk

A disruption in the supply of fossil fuels can lead to immediate energy shortages and price spikes.



### Not recyclable

Fossil fuels are primarily consumed through combustion and cannot be recovered or repurposed.



## CRITICAL MATERIALS



### Low mining quantities

Some 10 million tonnes energy transition minerals were produced in 2022 for low-carbon technologies.<sup>b</sup>



### Generate smaller profits

Exports of copper, nickel, lithium, cobalt and rare earths generated 96 billion in 2021.<sup>d</sup>



### Input to manufacturing

Critical materials are housed within energy assets that typically have a 10–30 year lifespan.



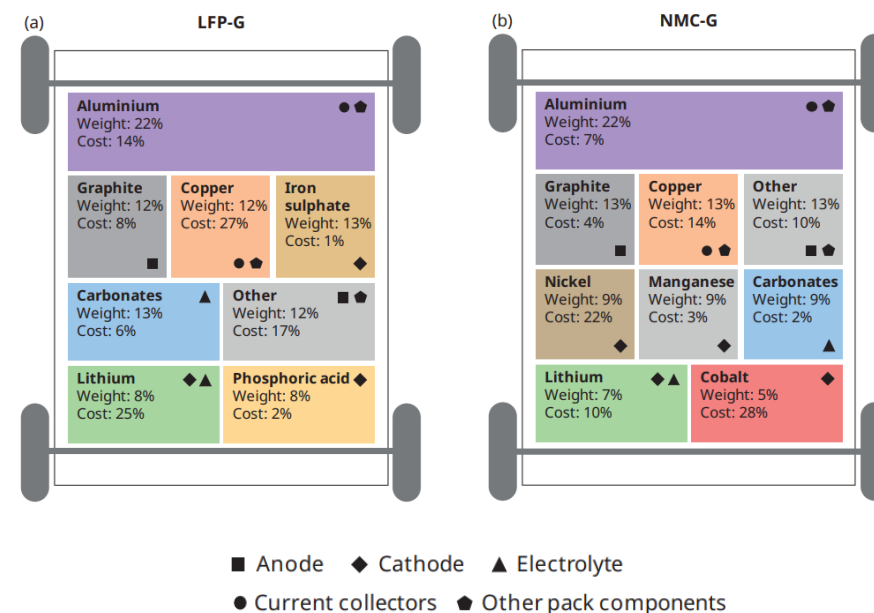
### Energy transition risk

Disruptions in the supply of critical minerals can delay the construction of new clean energy assets, but do not affect current energy prices or supply.



### Reusable and recyclable

High potential for reducing use, reusing and recycling.



Material shortages: prices and substitution

