



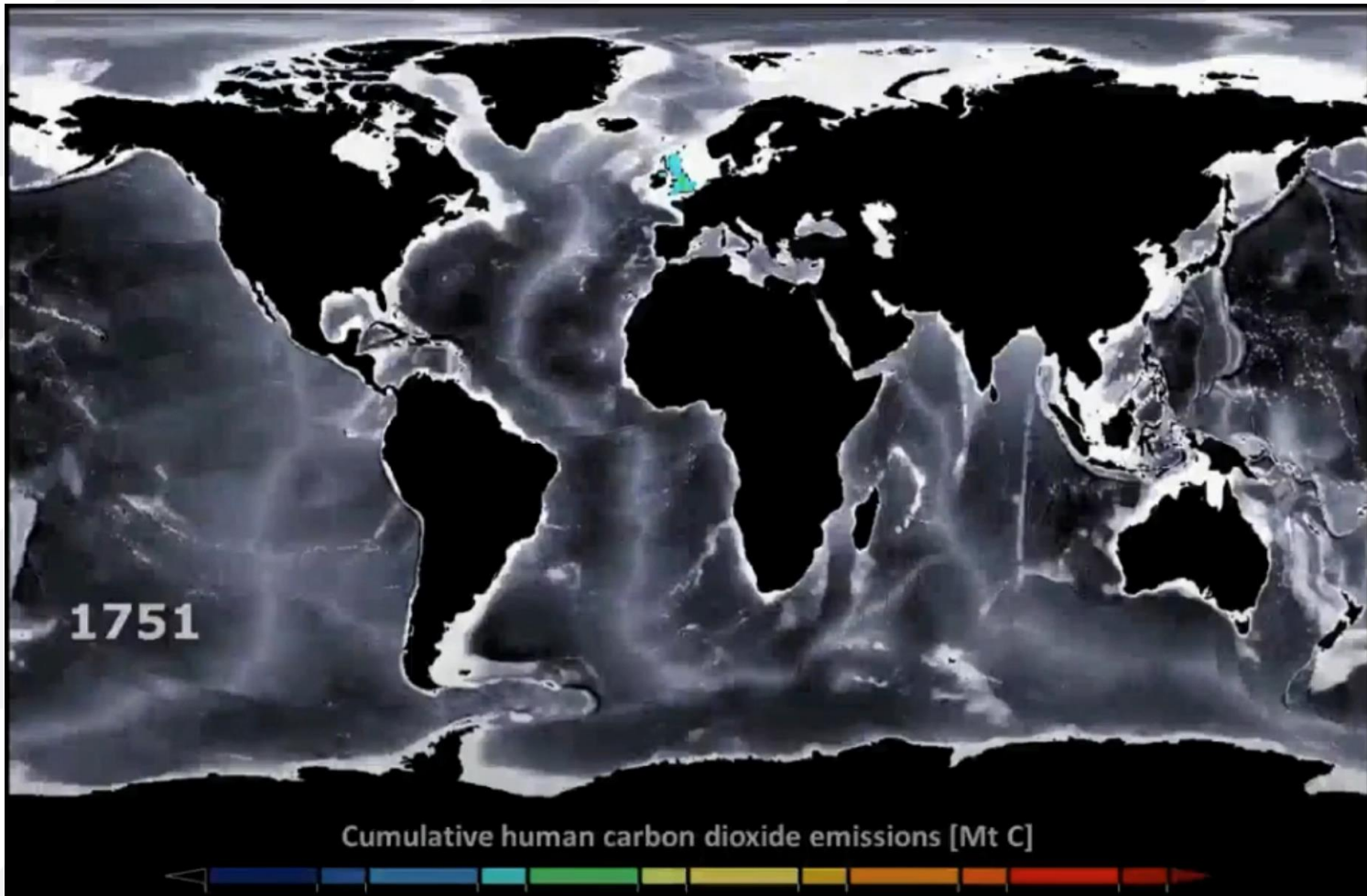
Critical Mineral Resources for the Green Energy Transition: Are They Available?

Adam Simon

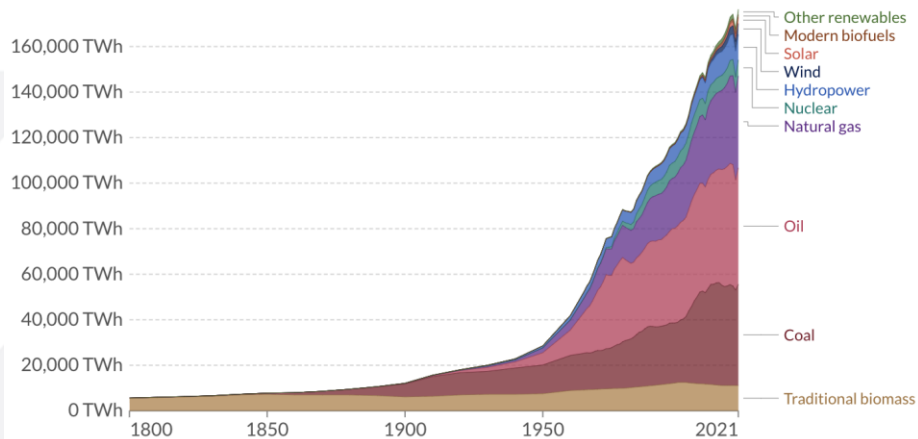
VectOres PROVIDING CRITICAL SOLUTIONS FOR SOCIETY



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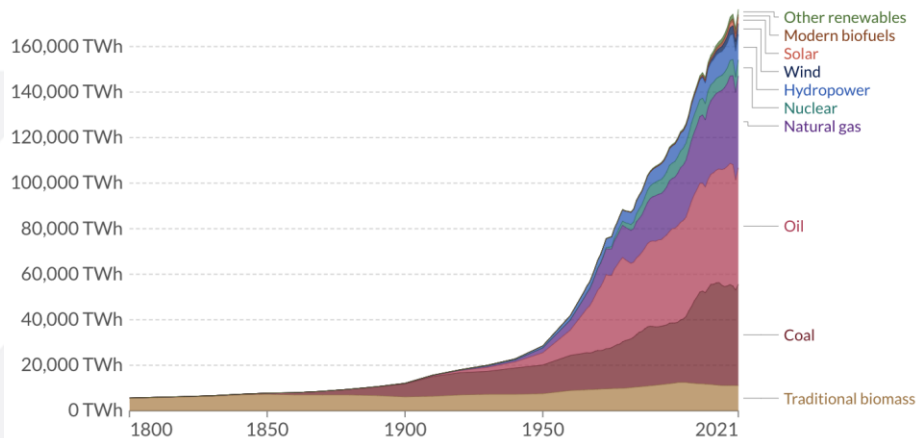


Primary energy consumption



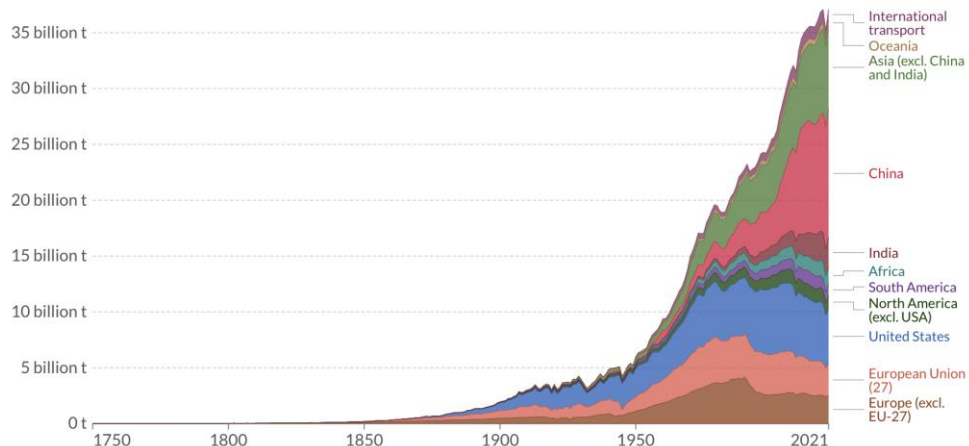
**coal + oil + natural gas = 85%
of primary energy consumption**

Primary energy consumption



**coal + oil + natural gas = 85%
of primary energy consumption**

CO₂ emissions

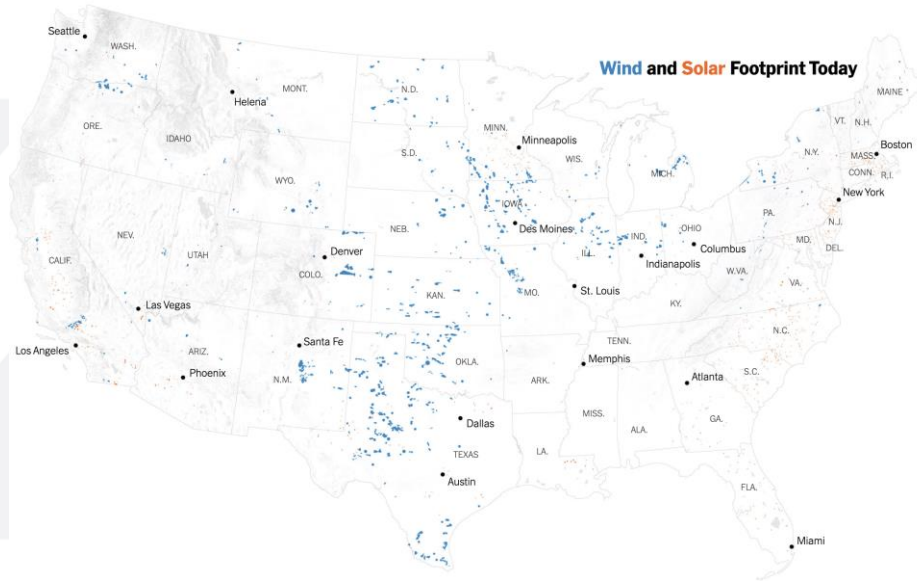


coal + oil + natural gas + O₂ = CO₂ + ENERGY

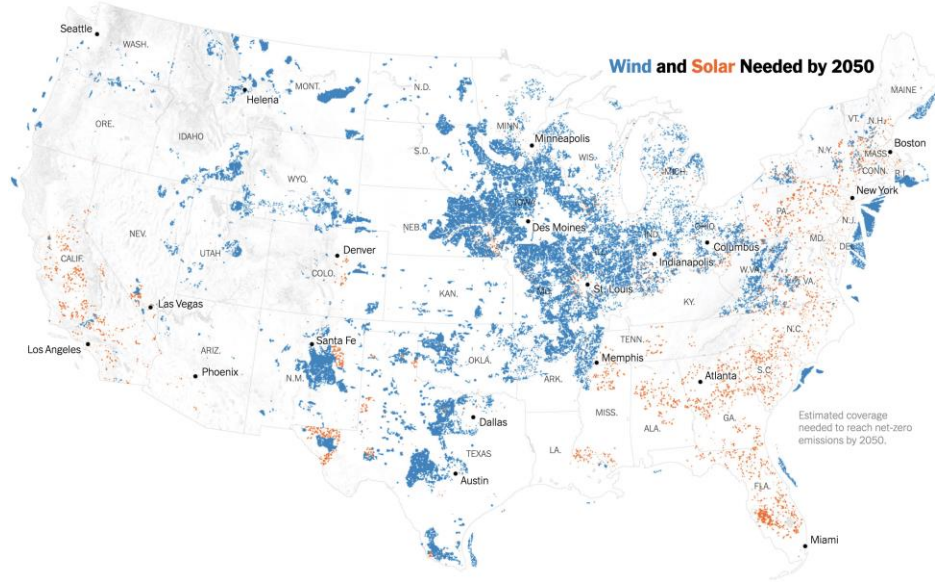
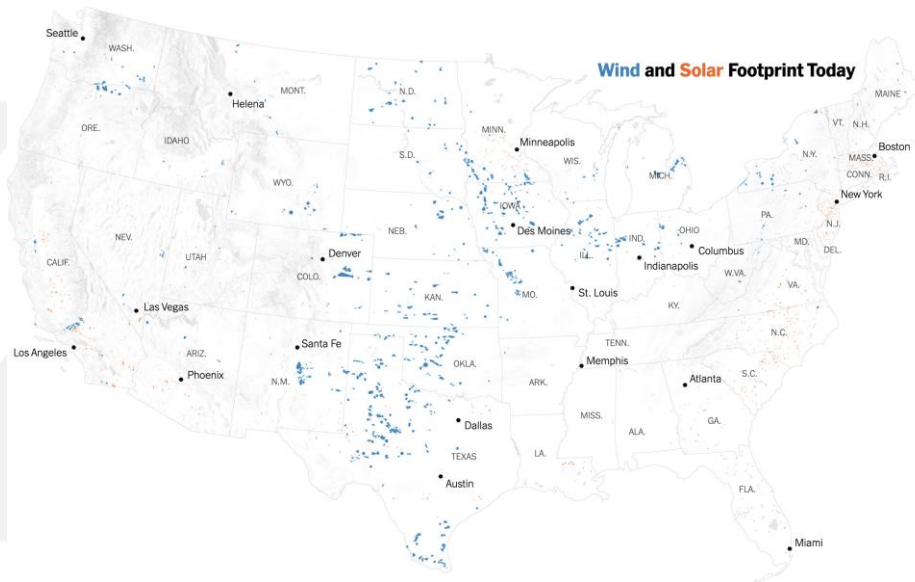
Electrify everything to achieve net-zero emissions



The U.S. is 4% of global population but consumes 17% of global energy



The U.S. is 4% of global population but consumes 17% of global energy



Magnet generation

26	60	5	66
Fe	Nd	B	Dy
Iron	Neodymium	Boron	Dysprosium

Steel used to build turbines

26	6
Fe	C
Iron	Carbon

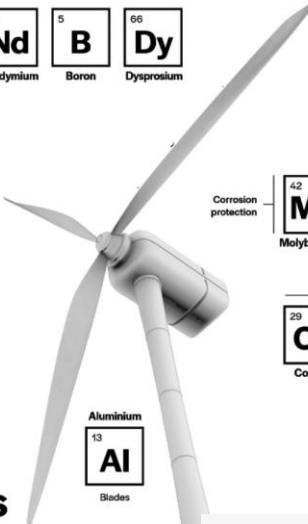
Battery energy storage

3	28	25
Li	Ni	Mg
Lithium	Nickel	Manganese

27	6	23
Co	C	V
Cobalt	Carbon	Vanadium

Aluminium

13
Al
Blades



More than 220 tonnes of coal is required to build a wind turbine.

Windfarms

Corrosion protection

42	30
Mo	Zn
Molybdenum	Zinc

Controls

29	14
Cu	Si
Copper	Silicon

Solar panels

48	52	42	4	32	31
Cd	Te	Mo	Be	Ge	Ga
Cadmium	Tellurium	Molybdenum	Beryllium	Germanium	Gallium

49	47	14
In	Ag	Si
Indium	Silver	Silicon

Semi-conductor

5	15
B	P
Boron	Phosphorous


Copper Wiring

29
Cu
Copper

Frame

13	22
Al	Ti
Aluminium	Titanium

30	12
Zn	Mg
Zinc	Magnesium



ELECTRIC VEHICLE

Safe and efficient transportation

ICMM
International Council
on Mining & Metals

Al Aluminium
Mg Magnesium

A 10% reduction in the weight of a car can result in a 6%-8% fuel economy improvement. Replacing cast iron and traditional steel components with lightweight materials such as magnesium or aluminium alloys can reduce the weight of a vehicle's chassis by up to 50%.

Cu Copper

The average car contains at least 15kg of copper. It's an essential component in the functioning of the motor, wiring, radiator, connectors, brakes and bearings.

Li Lithium
Co Cobalt
Ni Nickel

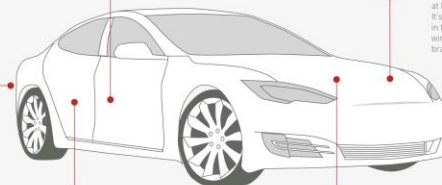
Lithium, cobalt and nickel rich metal-oxide batteries emit no tailpipe pollutants when running, making a significant reduction in local air pollution.

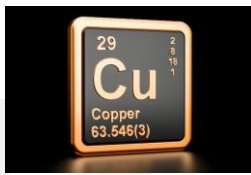
Fe **Mn** **Mo** **V**

Steel (an alloy of iron and carbon) - strengthened using small additions of manganese, molybdenum and vanadium provides a strong yet lightweight frame for cars. There is increasing competition between steels and aluminium to provide the greatest efficiency.

Dy Dysprosium
Nd Neodymium

Electric cars are three to four times more efficient than combustion engines. Rare-earth metals are used in the motors and generators of many electric cars.





Copper demand



5 tonnes per MW



10 tonnes/MW



5 tonnes/MW

Can we mine copper fast enough to meet projected demand for electrification?



Copper demand



IEF

Copper Mining and Vehicle Electrification

A Report by the **International Energy Forum**
May 2024

IEF INTERNATIONAL
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FORUM

Copper Mining and Vehicle Electrification

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SimeXmin
XI SIMPÓSIO BRASILEIRO
DE EXPLORAÇÃO MINERAL XI BRAZILIAN SYMPOSIUM
ON MINERAL EXPLORATION

The night sky over Africa in the IEA **Energy for All** case

2016

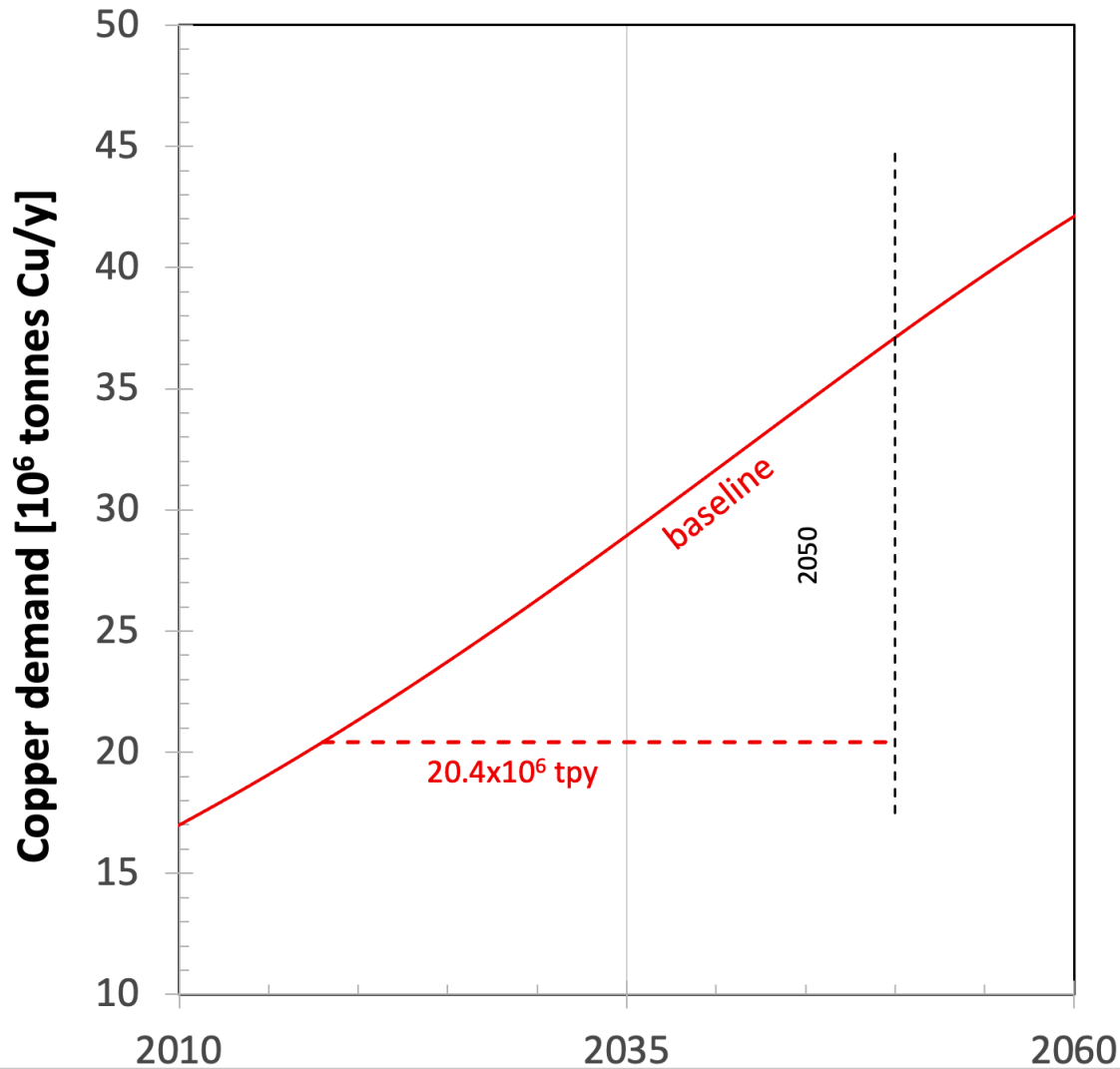


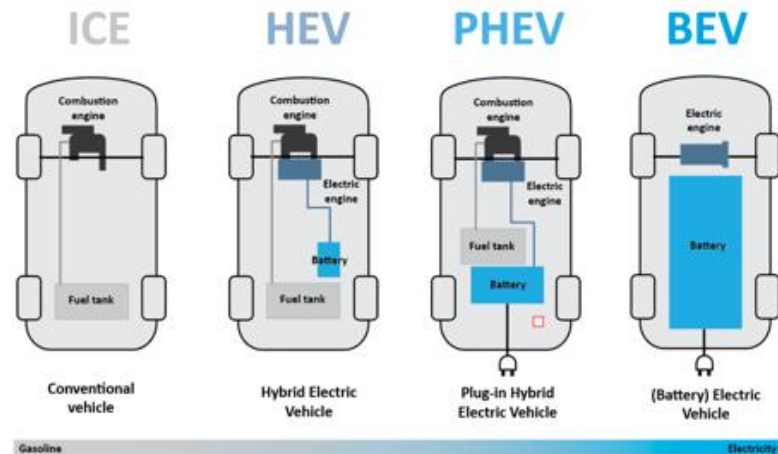
2030

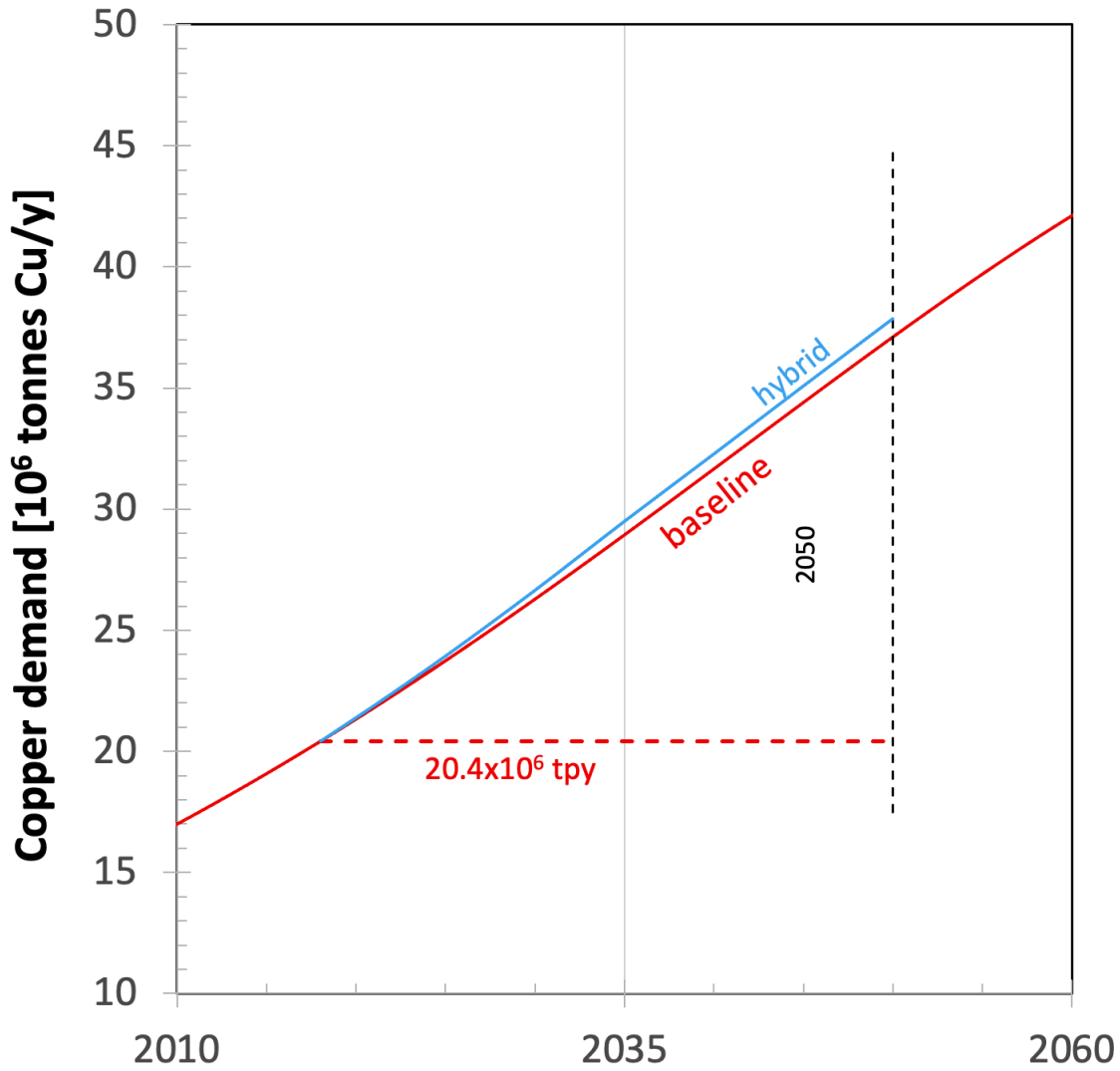


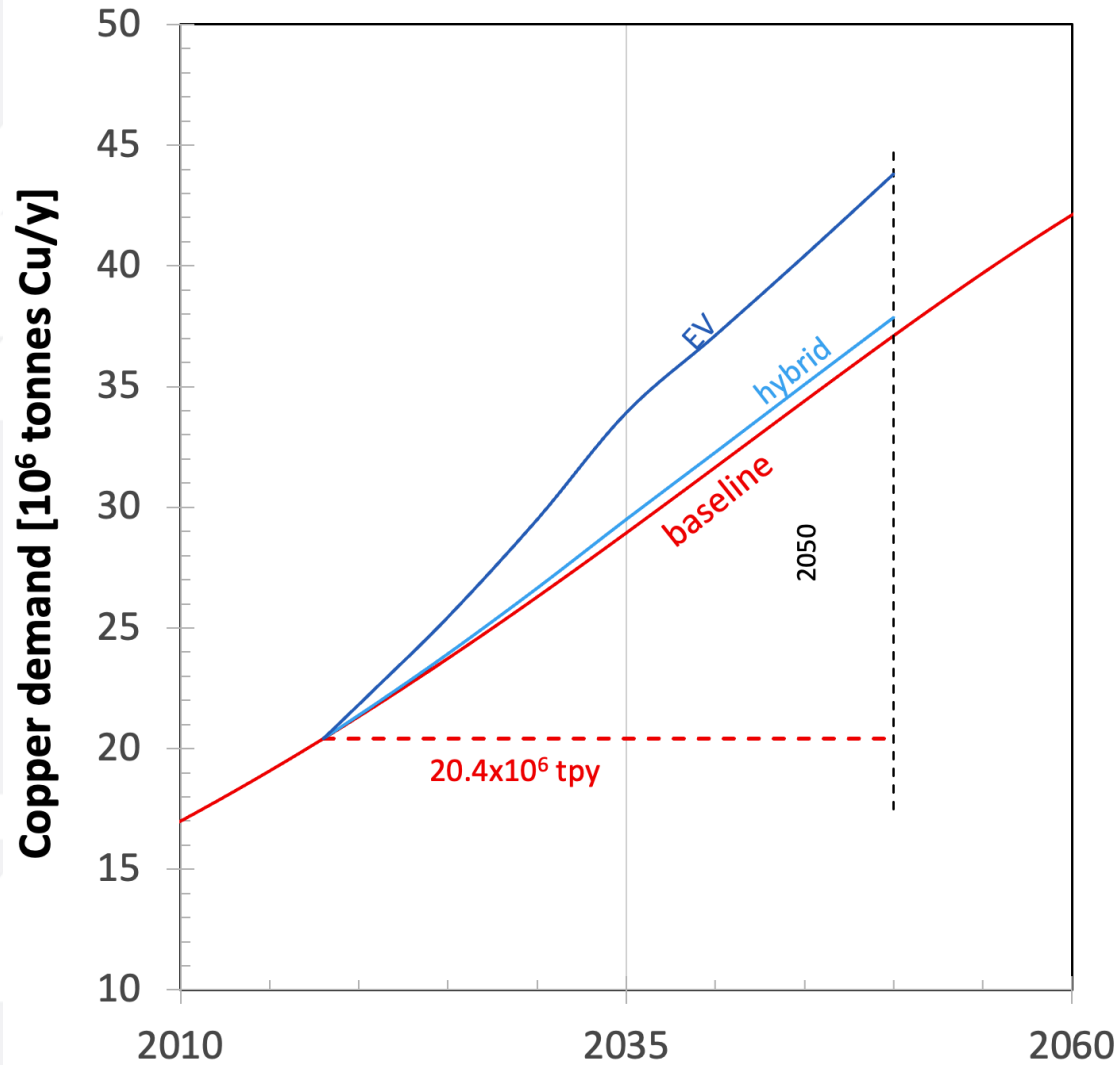
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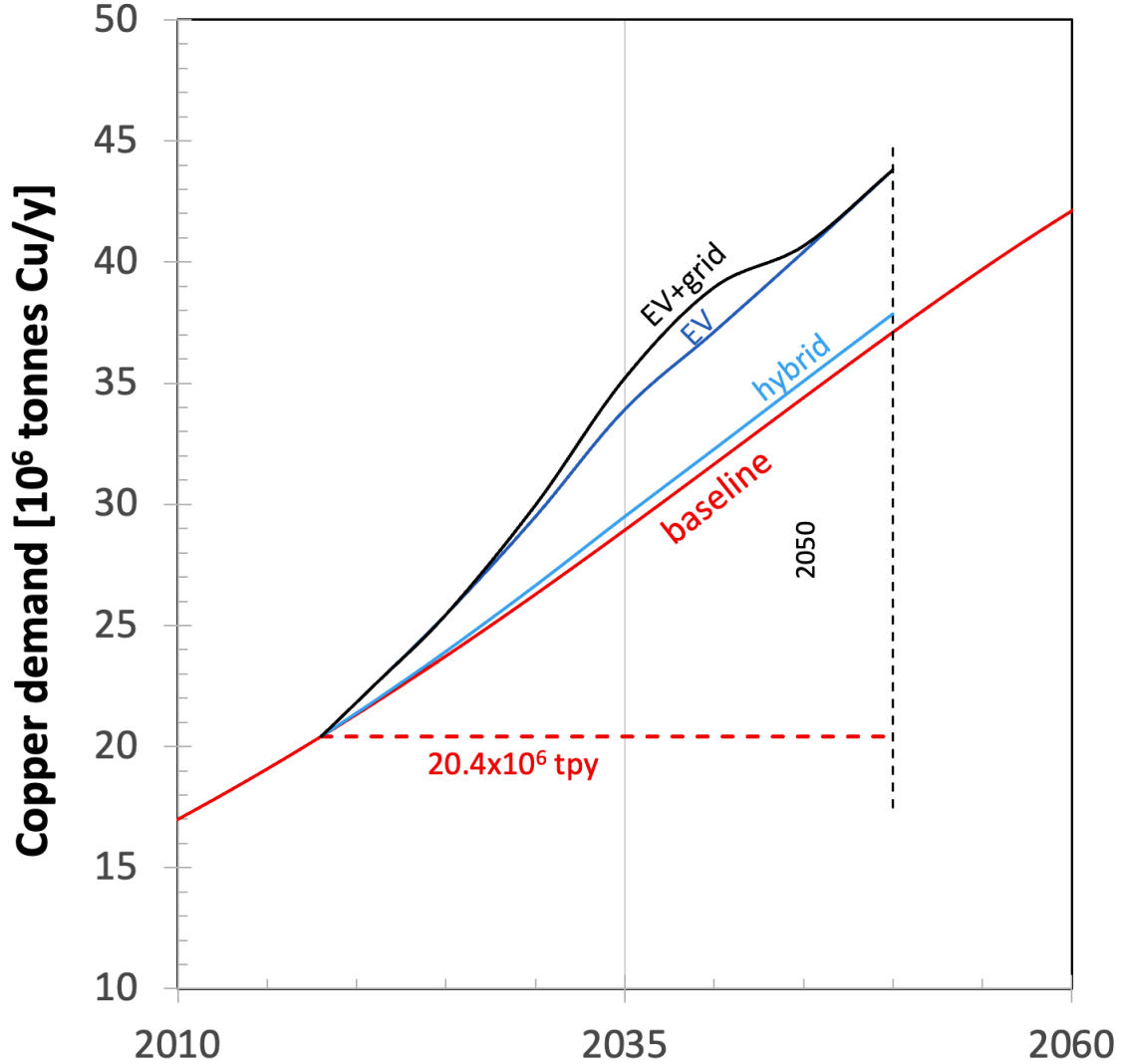


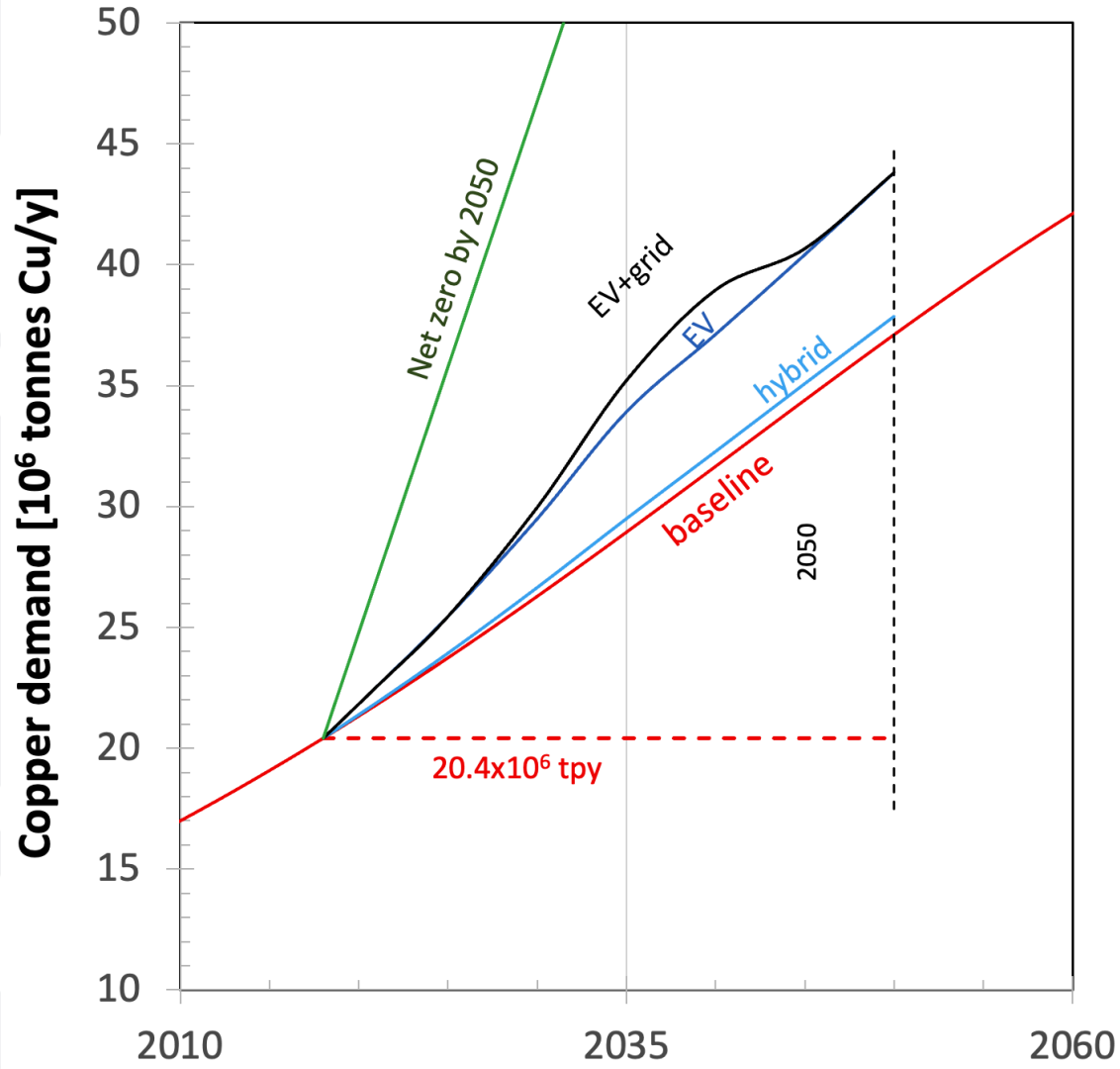




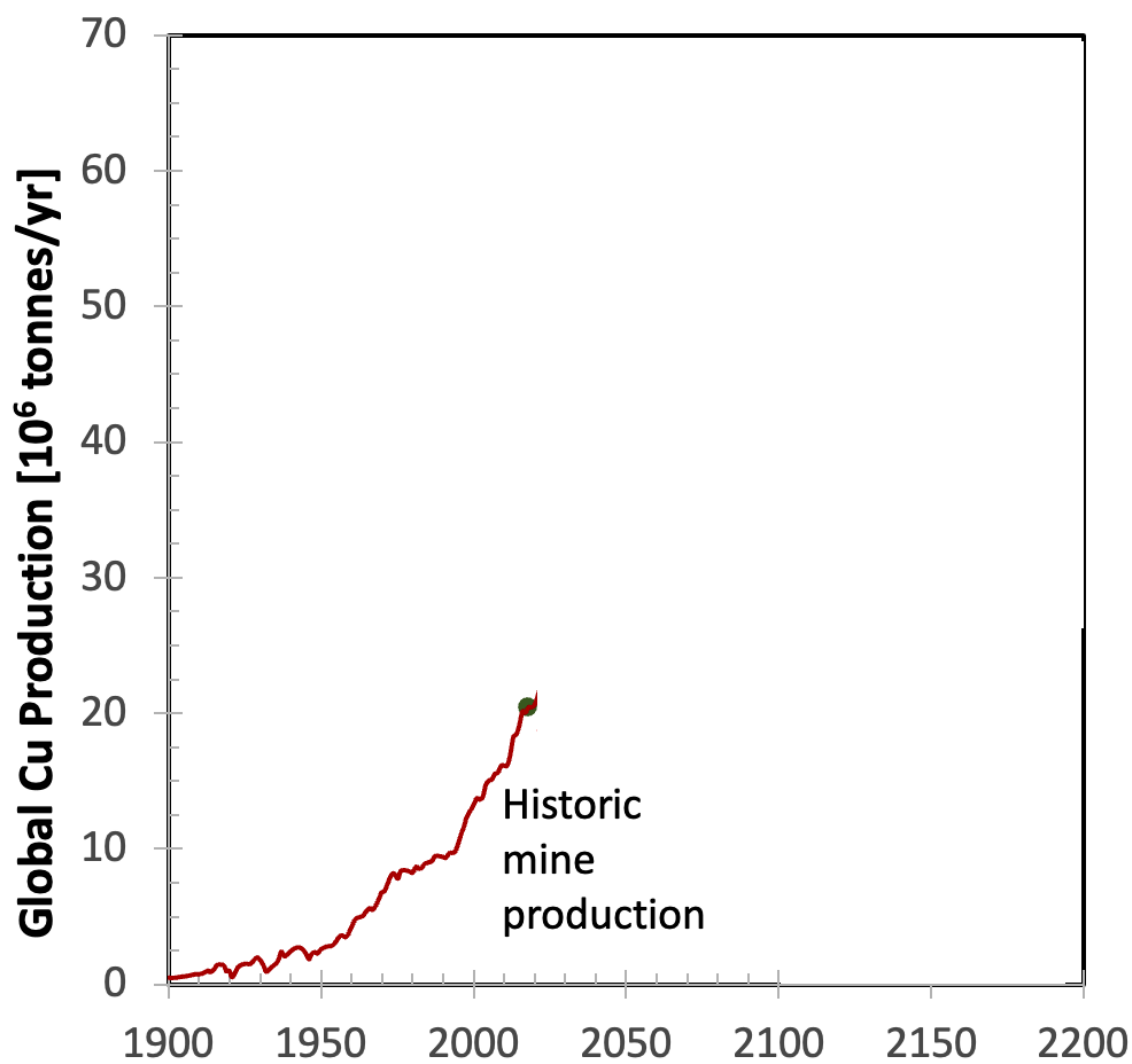


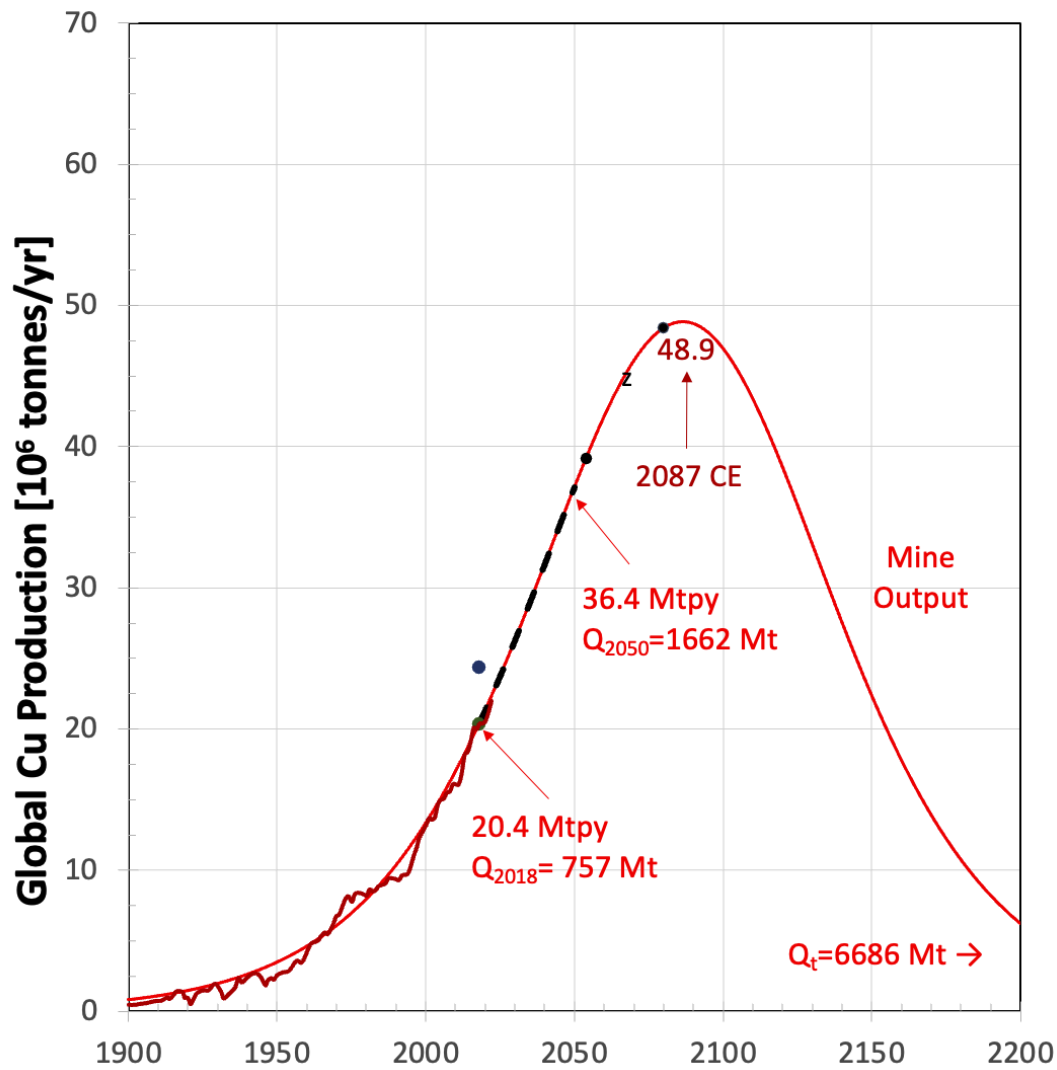


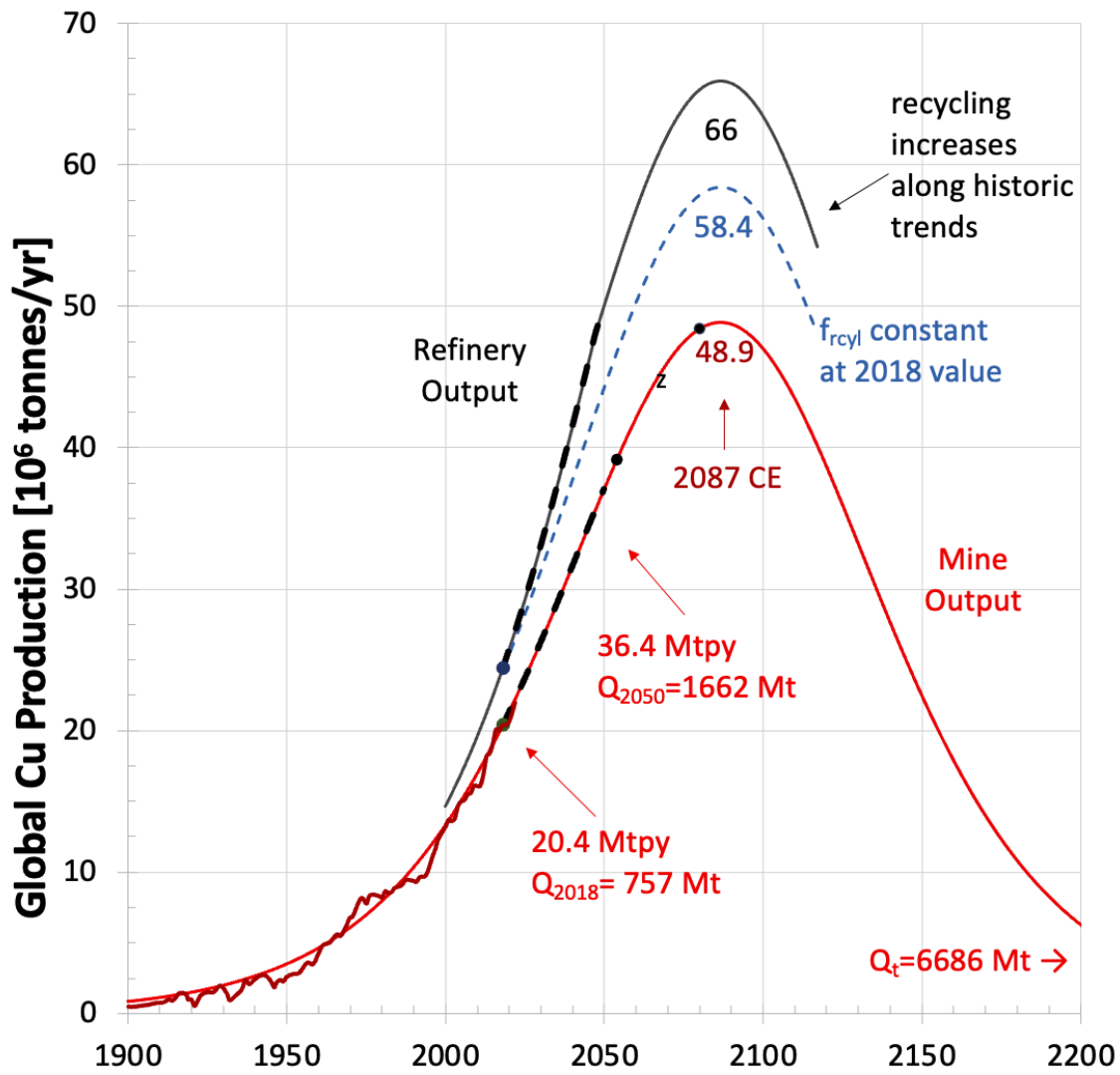




Copper supply







Miners' labor supply problem goes from 'challenging' to 'diabolical'

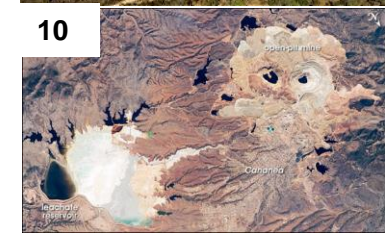
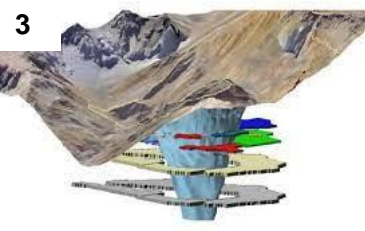
Global
Market Intelligence

Globally, at least 400 new mines will need to be built to meet demand for renewable energy, according to Benchmark Mineral Intelligence.

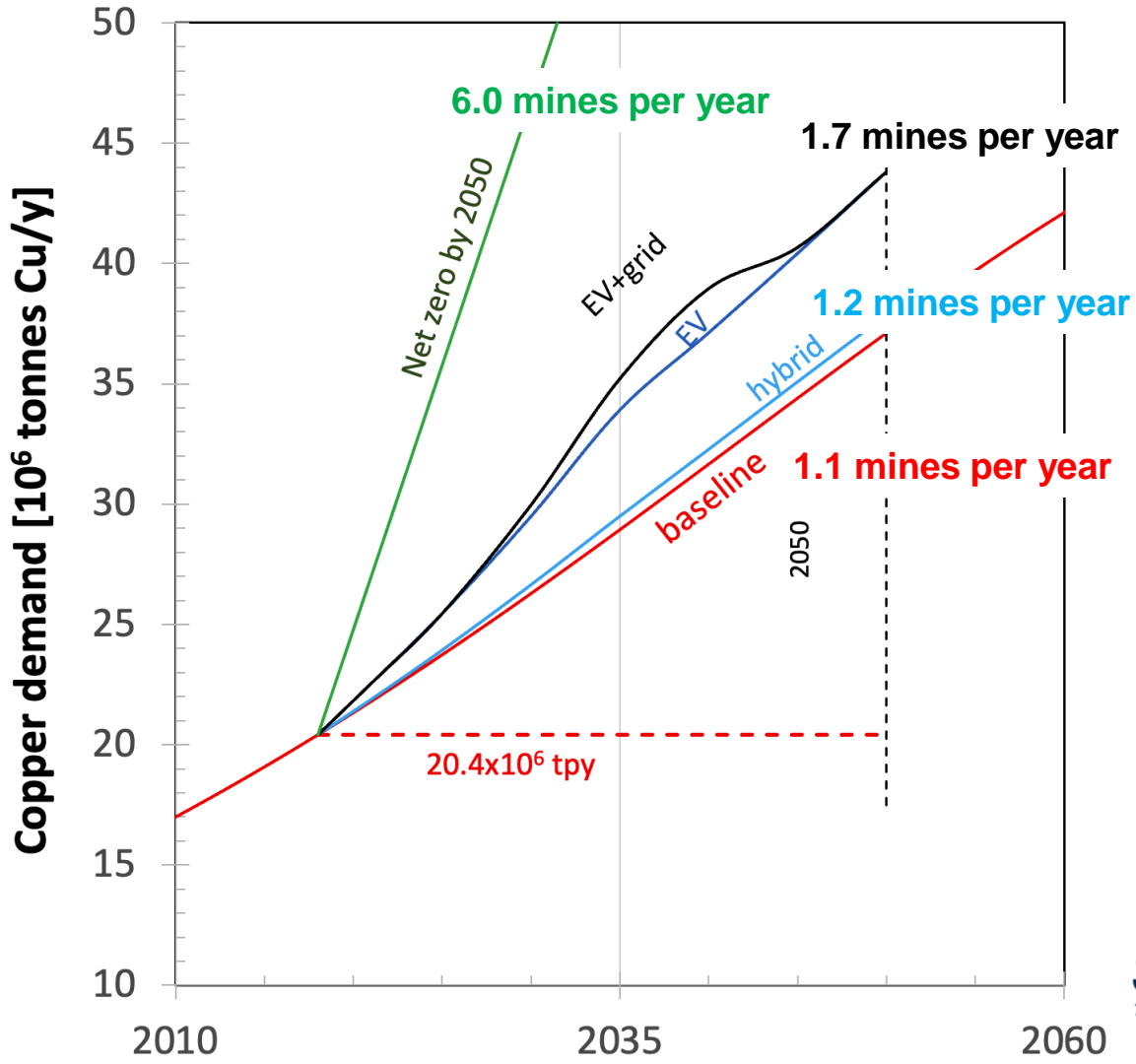
Top 10 copper mines, Mt/yr

	2022
Escondida (Chile)	1.060
Collahuasi (Chile)	0.589
El Teniente (Chile)	0.456
Cerro Verde (Peru)	0.434
Morenci (USA)	0.401
Grasberg Block Cave (Indonesia)	0.396
Chuquicamata (Chile)	0.373
Cobre Panama (Panama)	0.345
Kamoa-Kakula (DRC)	0.334
Buenavista del Cobre (Mexico)	0.332
TOTAL	4.719

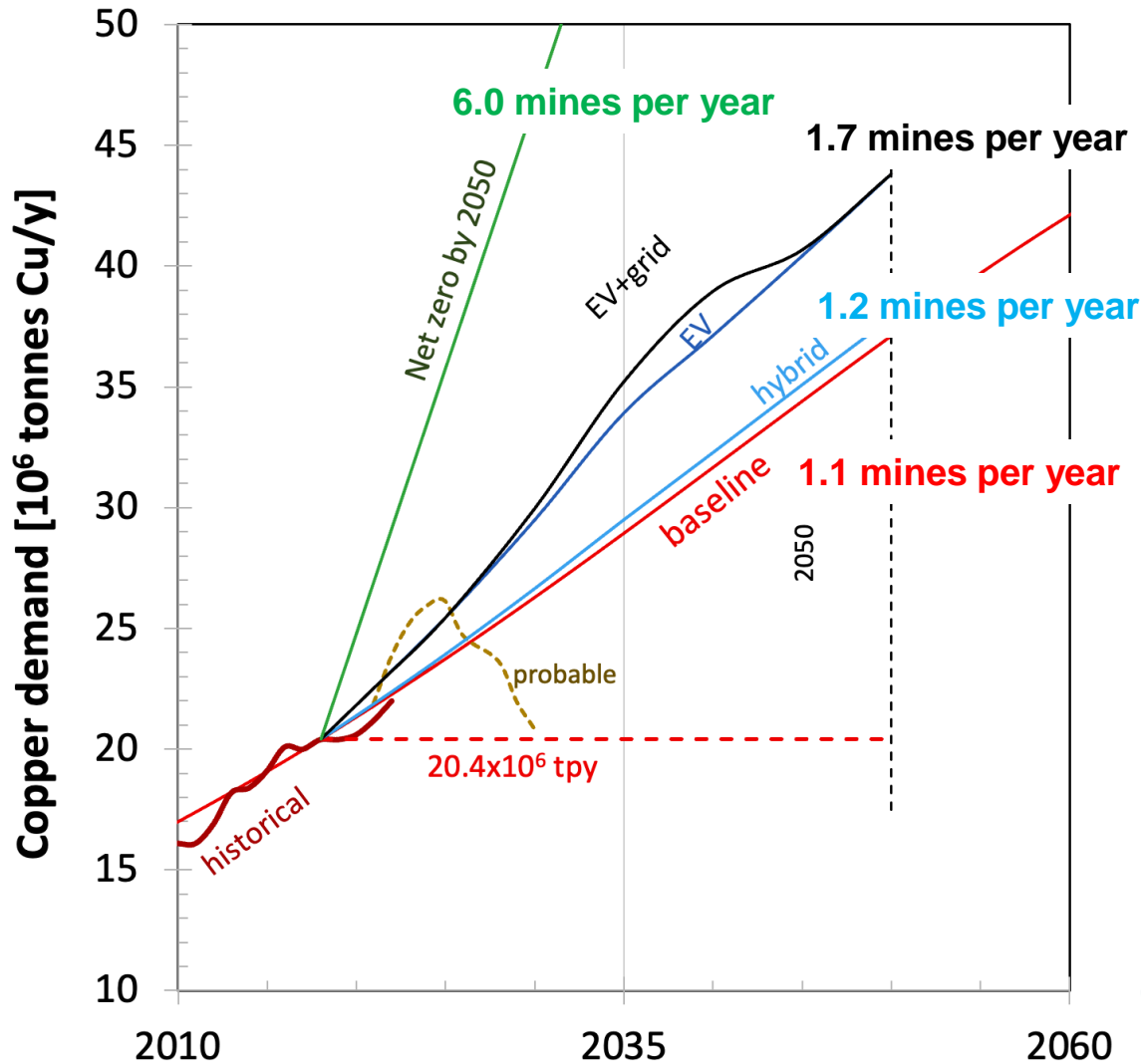
The average mine in this list produces ~0.5 million tonnes of copper per year.



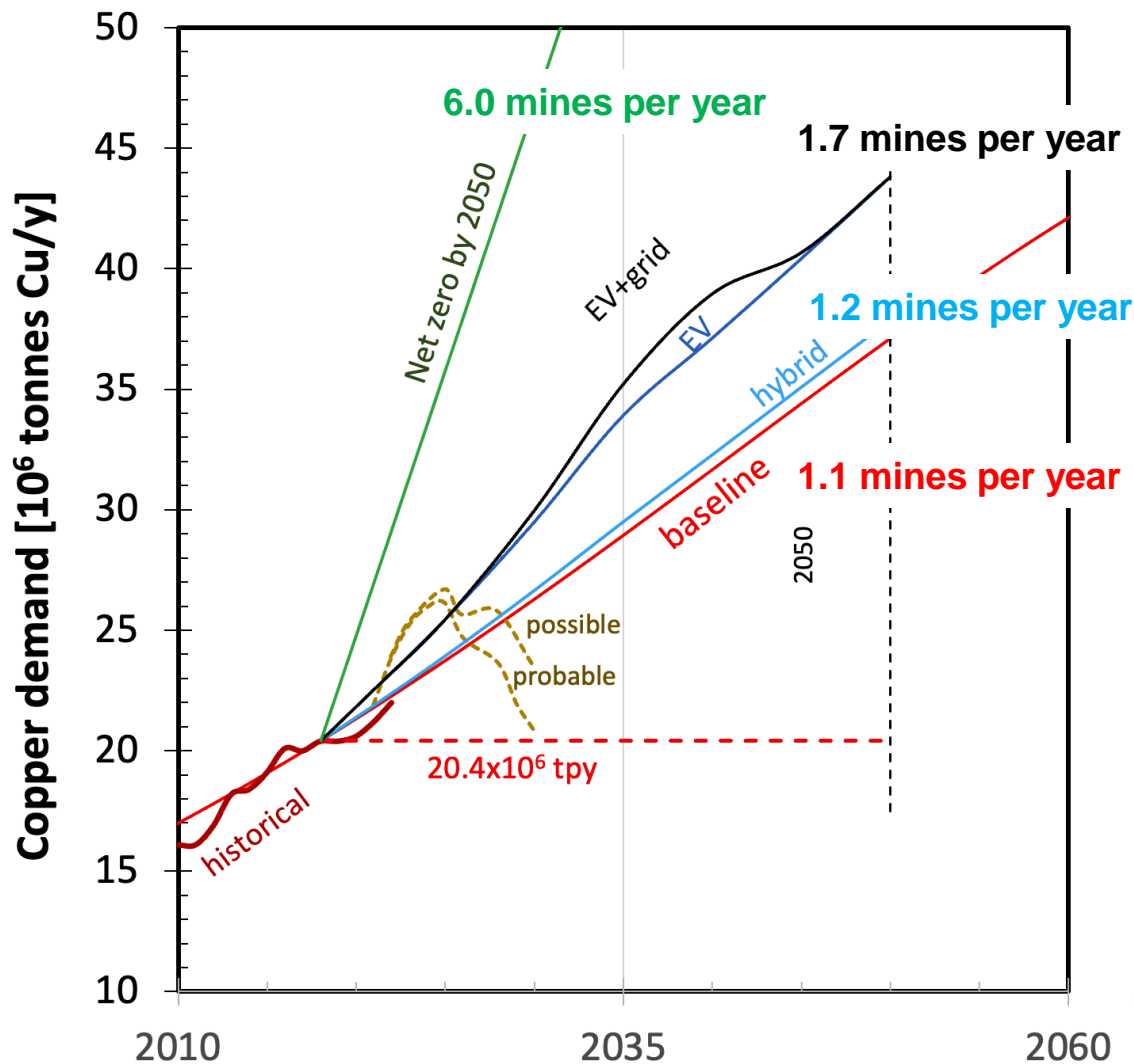
New mines needed to meet demand



Expected future mine production



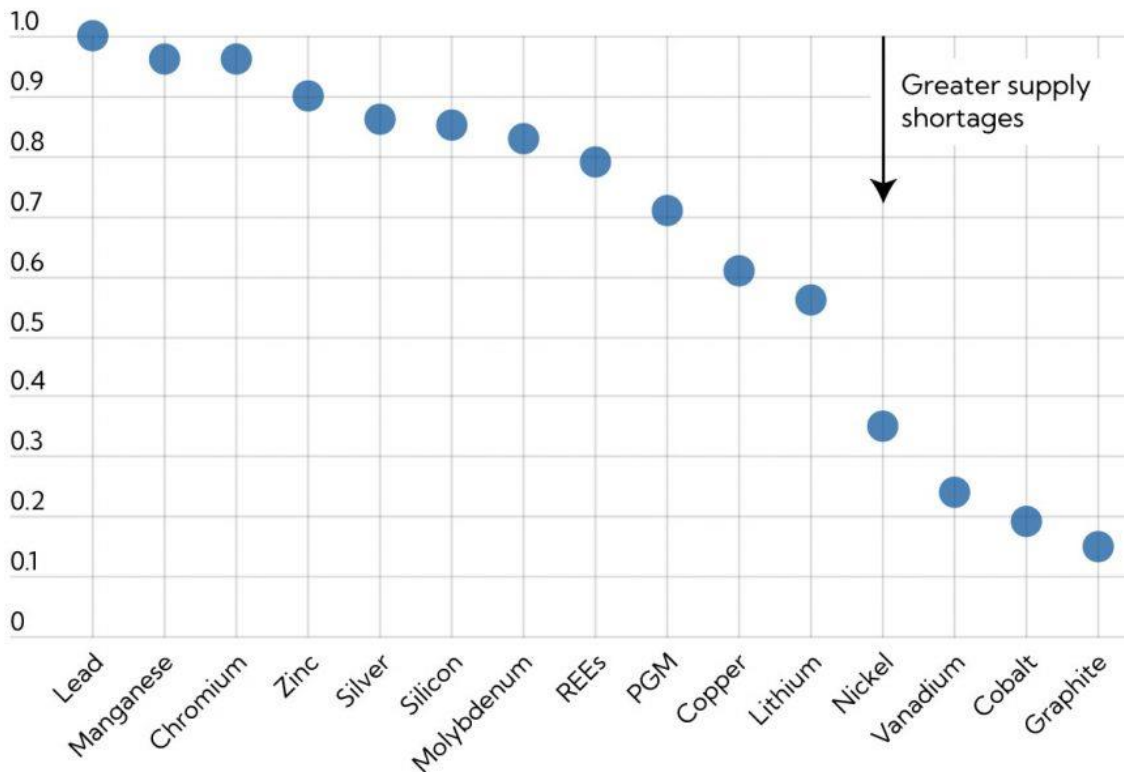
Expected future mine production



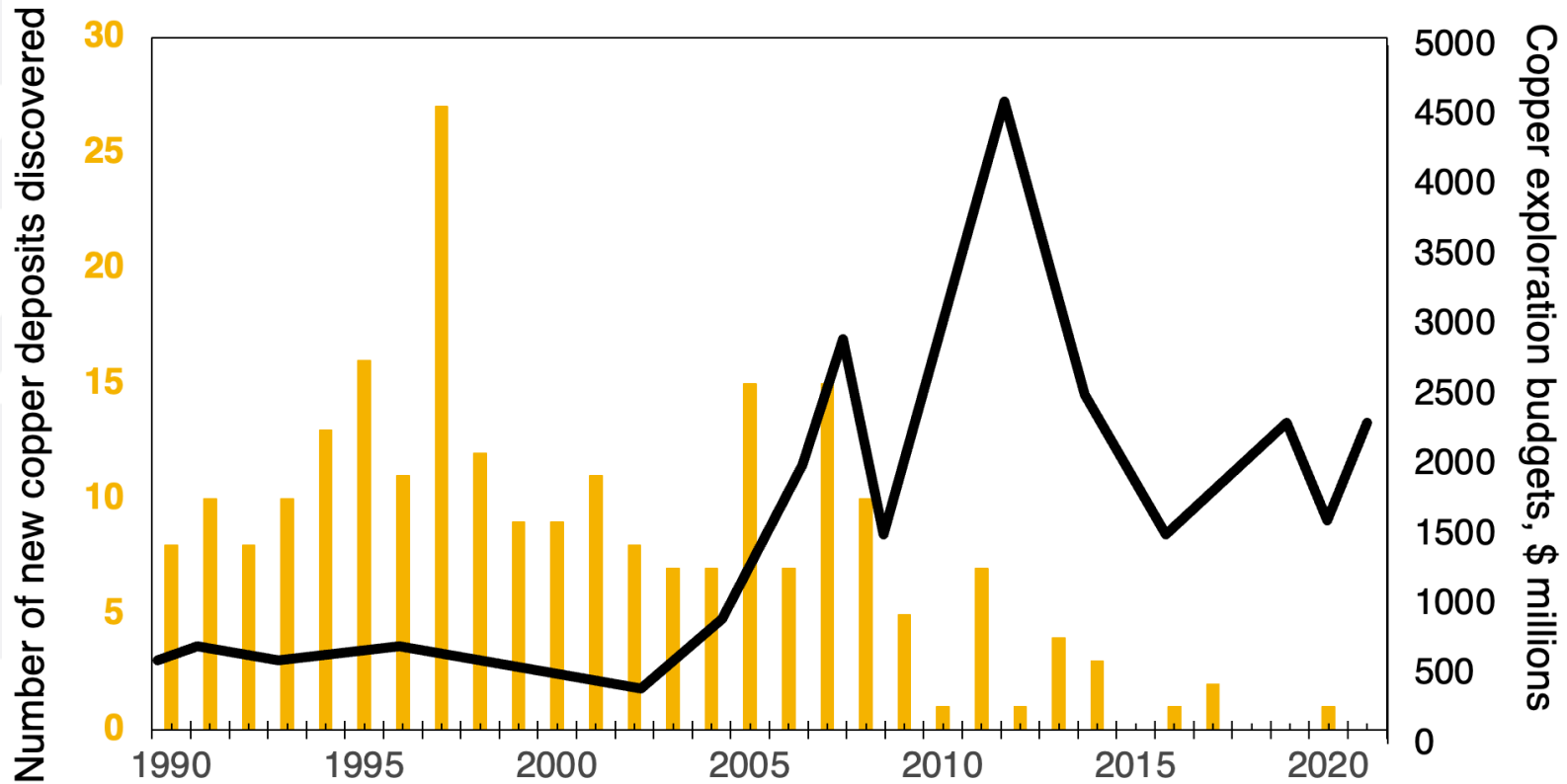
Metals in a net-zero scenario

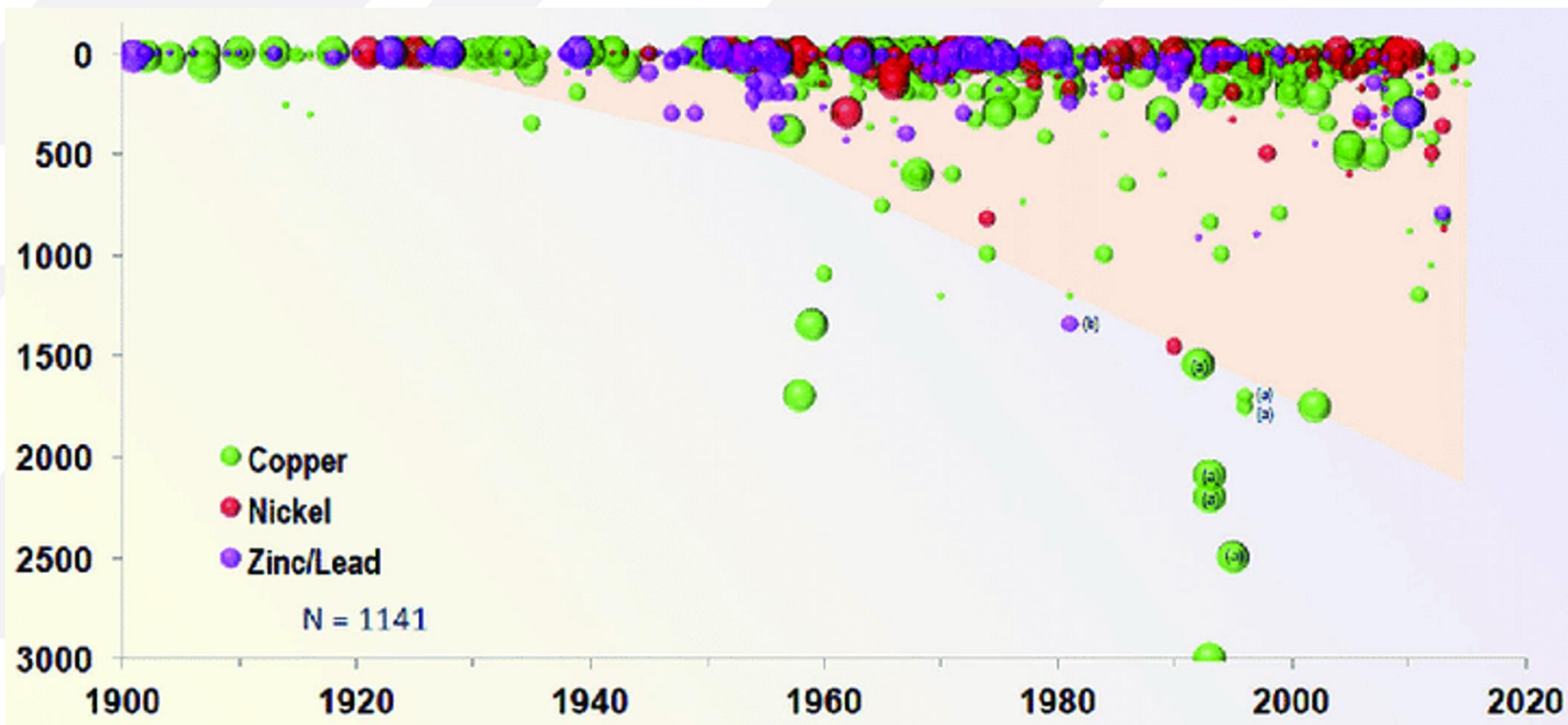
Current production rates of some important metals, including copper, are likely to be inadequate to satisfy future demand.

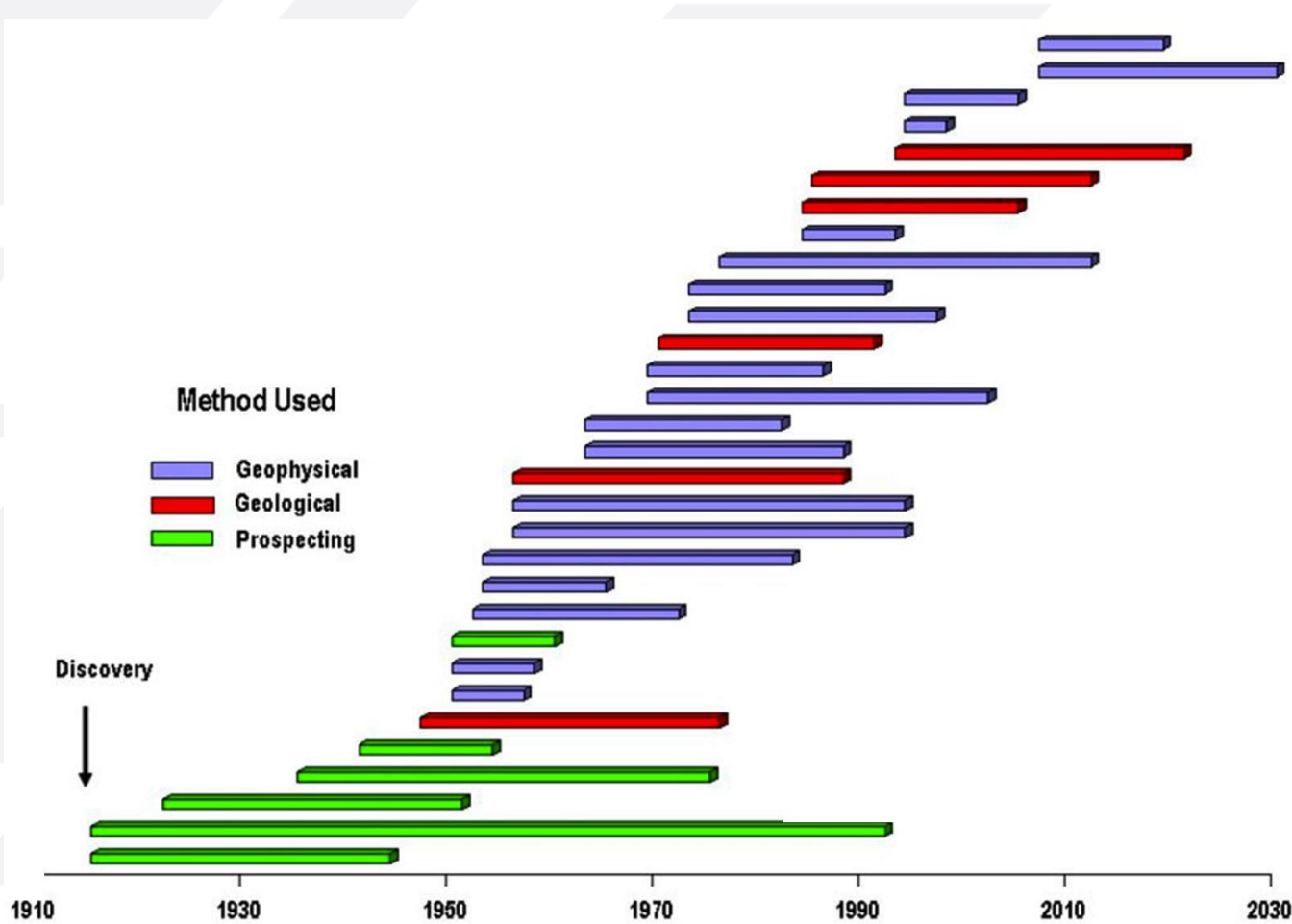
(supply/demand ratio, energy and non-energy demand coverage)



The growing copper supply gap

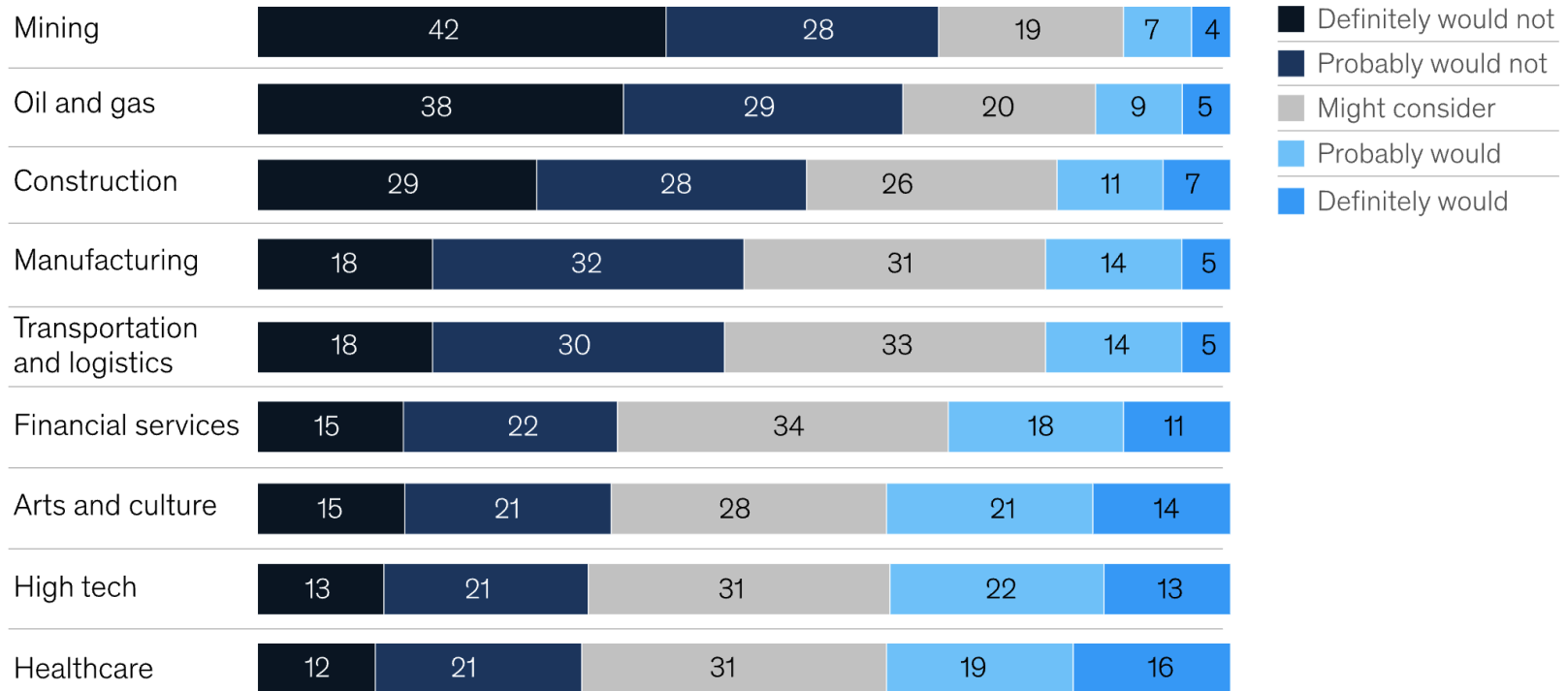






Mining is not attractive to young talent.

Share of respondents, ages 15 to 30, who would consider working in the following sectors, %





Obrigado!

Adam Simon

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