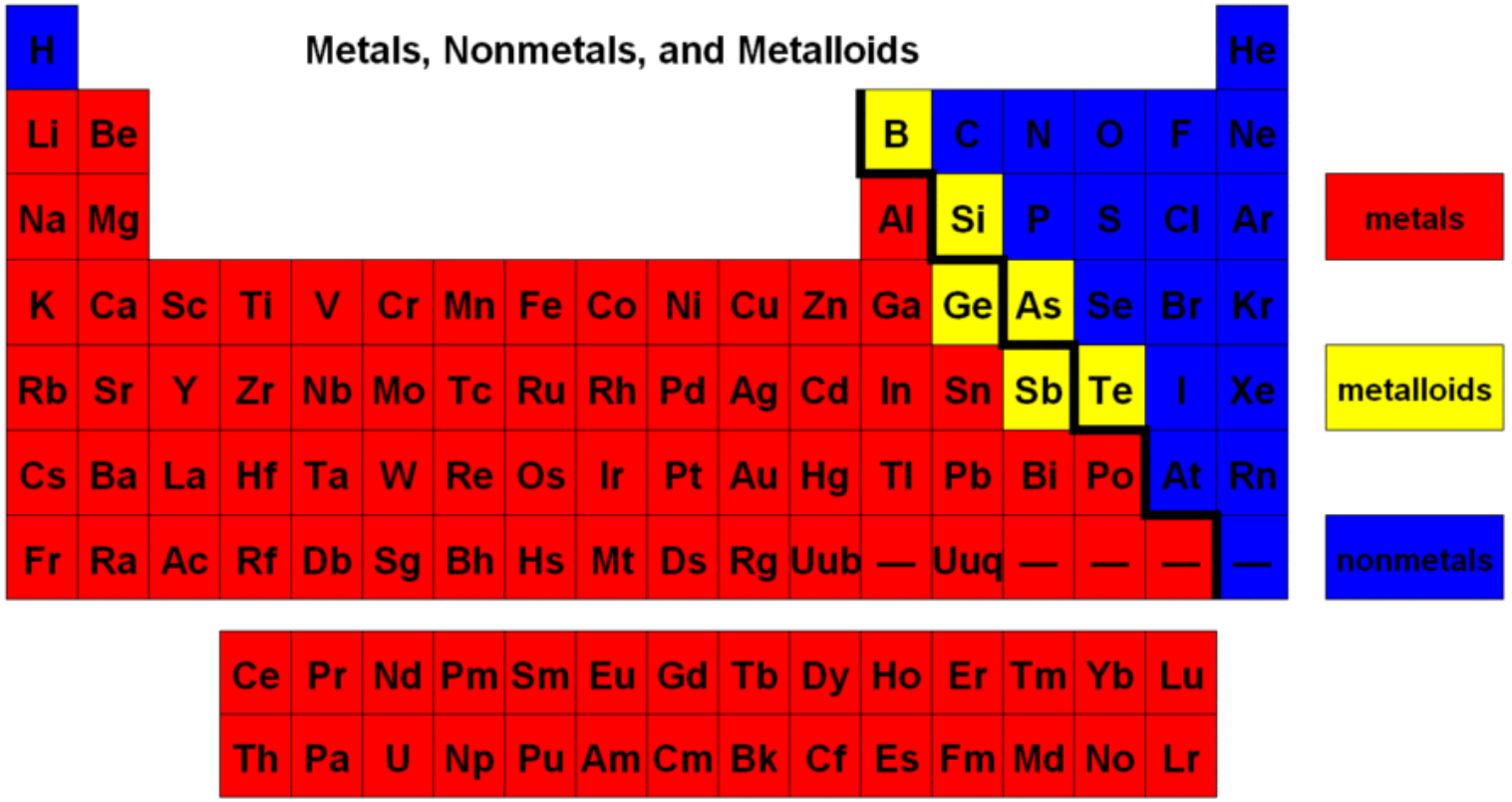
Rapport: Havbunnsmineraler - Testinfrastruktur

Vedlegg E

Mer om Havbunnsmineraler

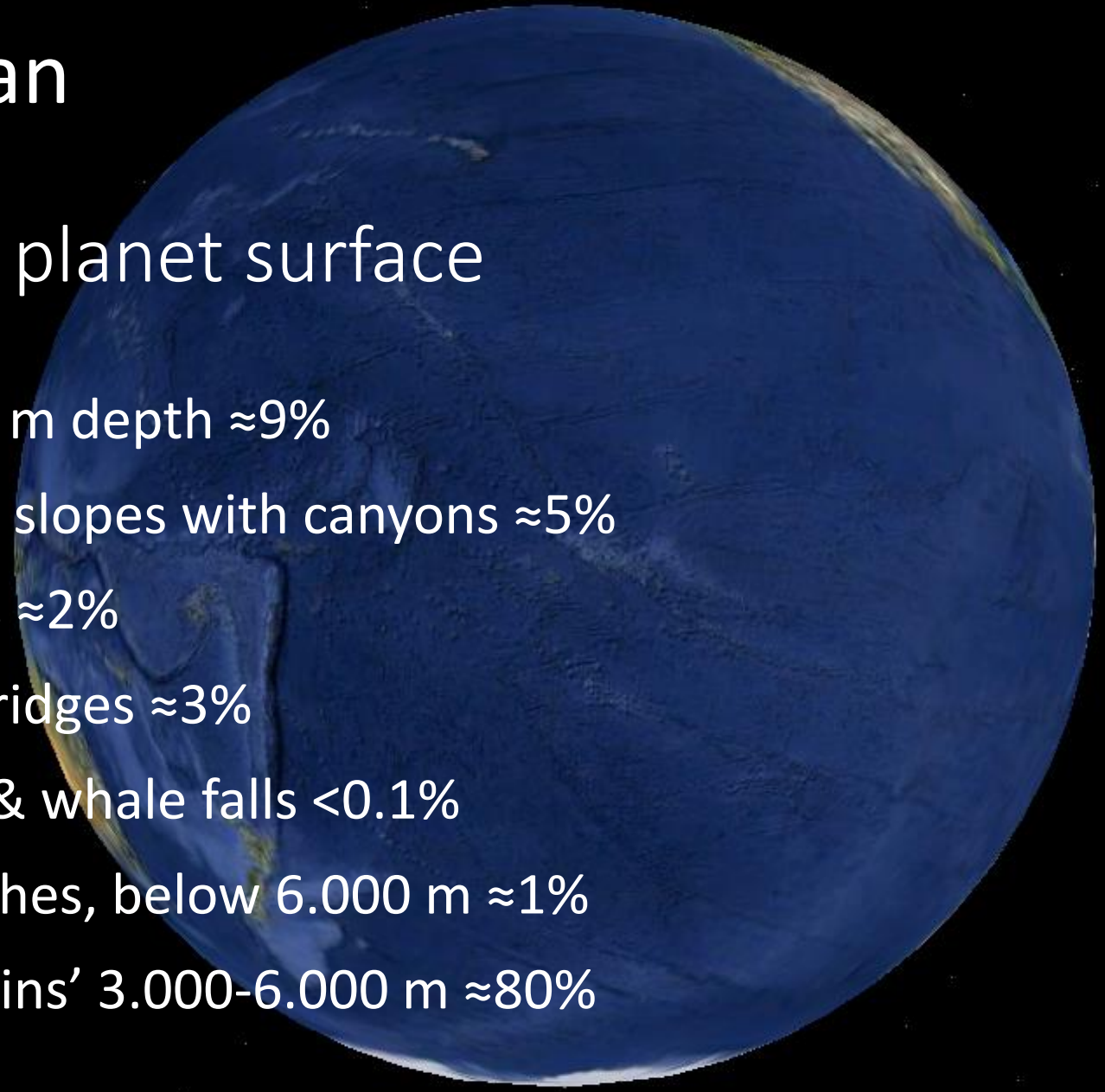
Terms: Minerals, Metals and Alloy



Minerals are solid, naturally occurring inorganic substances **found in nature** made up of one or more elements.

An **alloy is two of more metallic elements** mixed to form a new unique substance.
More than 90% of the metals in use today are part of an alloy.

The Ocean



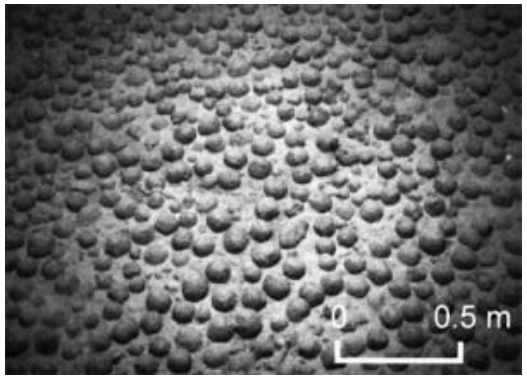
70% of the planet surface

- Shelfs >200 m depth ≈9%
- Continental slopes with canyons ≈5%
- Sea mounts ≈2%
- Mid ocean ridges ≈3%
- Vent, seep & whale falls <0.1%
- Hadal trenches, below 6.000 m ≈1%
- Abyssal ’plains’ 3.000-6.000 m ≈80%

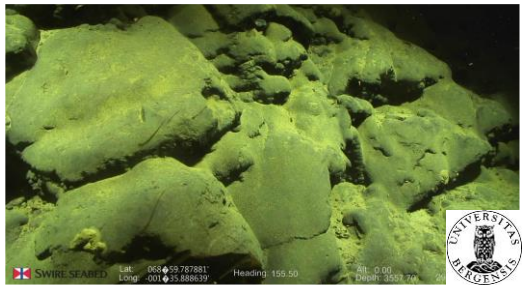
Source: Thomas Dahlgren, UTC Marine Minerals 14 June 2022

Different type of deep-sea mineral deposits

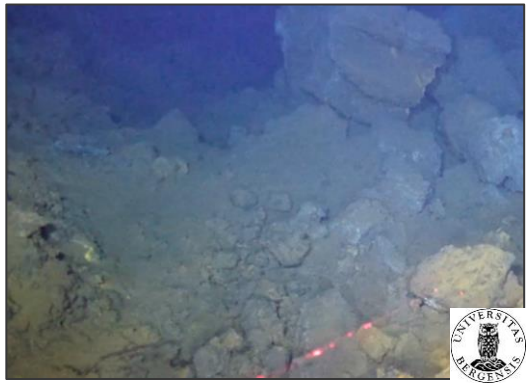
- Polymetalic Nodules
  - Metals: Ni, Co, Cu, Mn, Mo, Fe
  - Located: ~4000 – 6000m, abyssal plains in distal parts of the ocean
  - **2D** deposits in soft seabed (5-25 kg/m^2)
  - Mine size **> 70km^2** per million tons of mined ore



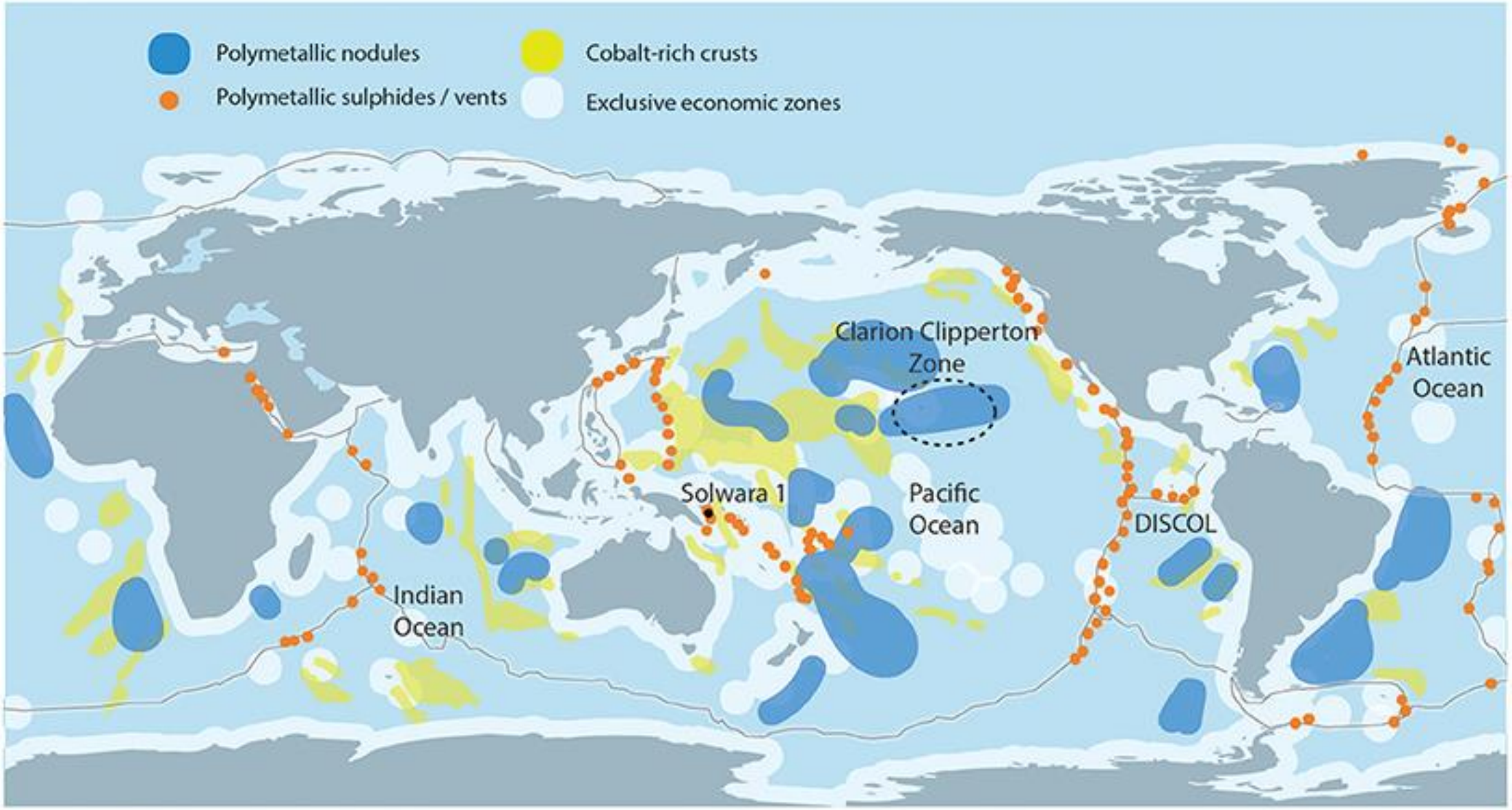
- Cobalt-rich Crusts
  - Metals: Co, Ni, Cu, Mo, Mn, Pt, Te, Ti, Ce, Sc, RRE
  - Located: ~1500-2500m, on seamounts and other seafloor highs
  - **2D** deposits on surfaces on bare rocks up to ~30cm thick
  - Mine size **~20-40km^2** per million tons of mined ore



- Seafloor Massive Sulfides (SMS)
  - Metals: Cu, Zn, Co, Au, Ag
  - Located: ~2000 – 3000m, formed by hydrothermal vents along the ocean spreading ridges
  - **3D** deposits – **highly inhomogeneous deposits**
  - Mine size **< 1km^2**

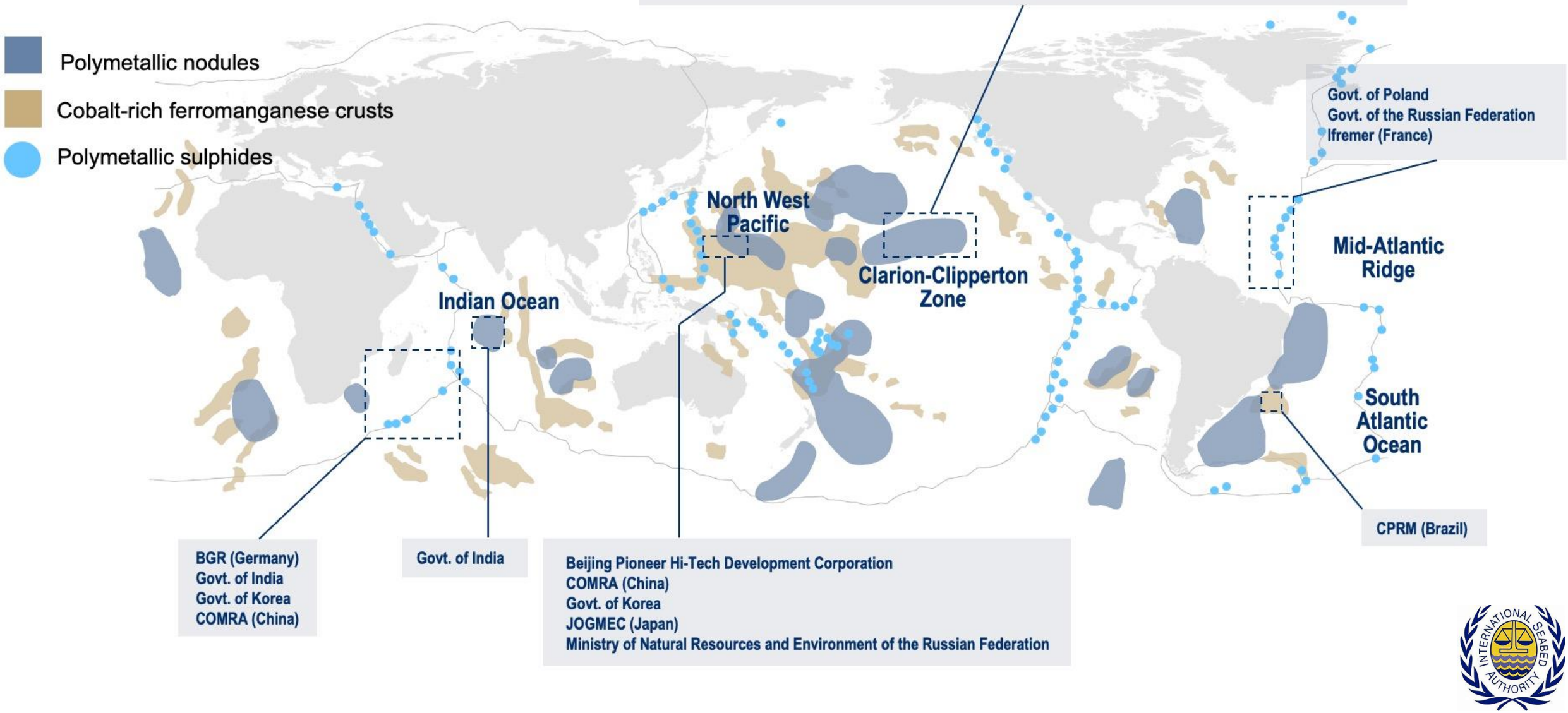


Location of different deep-sea mineral deposits



USGS

Exploration for minerals in the Area



Nodule abundance

Average abundance of nodules

Kilograms per square metre

Source: James R. Hein, US Geological Survey

Manganese	29%
Iron	6%
Silicon	5%
Aluminum	3%
Nickel*	1.4%
Copper*	1.3%
Cobalt*	0.25%
Oxygen	1.5%
Hydrogen	1.5%
Sodium	1.5%
Calcium	1.5%
Magnesium	0.5%
Potassium	0.5%
Titanium	0.2%
Barium	0.2%

Technology for exploration of deep sea minerals

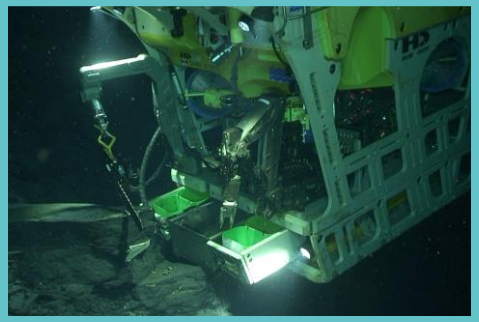
- Geophysical data (including bathymetry)
  - Use of signal sources and sensors - hull mounted, towed, mounted on AUV/ROV
- Geological data
  - Rock and sediment sampling from seabed and subsurface
  - Videos/photographs by cameras – towed, mounted on sampling equipment and AUV/ROV
- Environmental data
  - Biological
  - Oceanographic

Read more about deep-sea data and analysis: https://www.npd.no/fakta/havbunnsmineraler/datainnsamling-og-analyser/

Source: Norwegian Petroleum Directorate

Autonomous underwater vehicle (AUV) used for high resolution seabed mapping

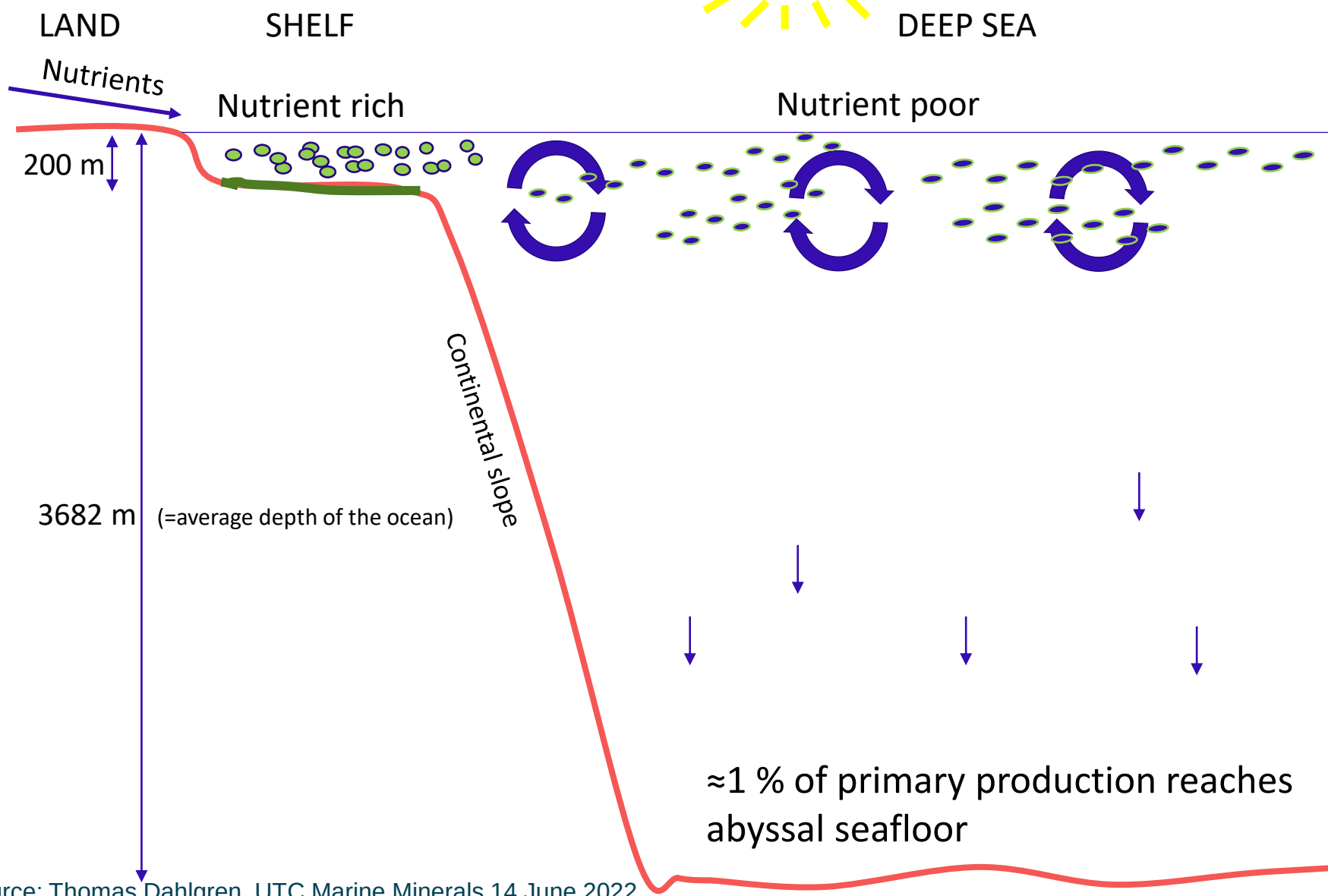
Remote operated vehicle (ROV) used for sampling and more detail mapping of the seabed



Coil-tubing operation of sulfide deposits conducted by NPD 2020

Photos: Courtesy of UiB and NPD

The deep sea is very different from shelf areas



Shelf areas
- Nutrient run off from land makes shelfs nutrient rich
- Most of the green algae production reaches shelf seafloor

Deep Sea
- The open ocean is nutrient poor and production is limited
- 99% of the limited green algae production is eaten and recirculated before reaching seafloor
- Very little food reach the sea floor
- Most species have low abundances
- Most species are small
- Most species are rare
- But this fauna is species rich compared to shelf fauna

Source: Thomas Dahlgren, UTC Marine Minerals 14 June 2022

Environmental studies

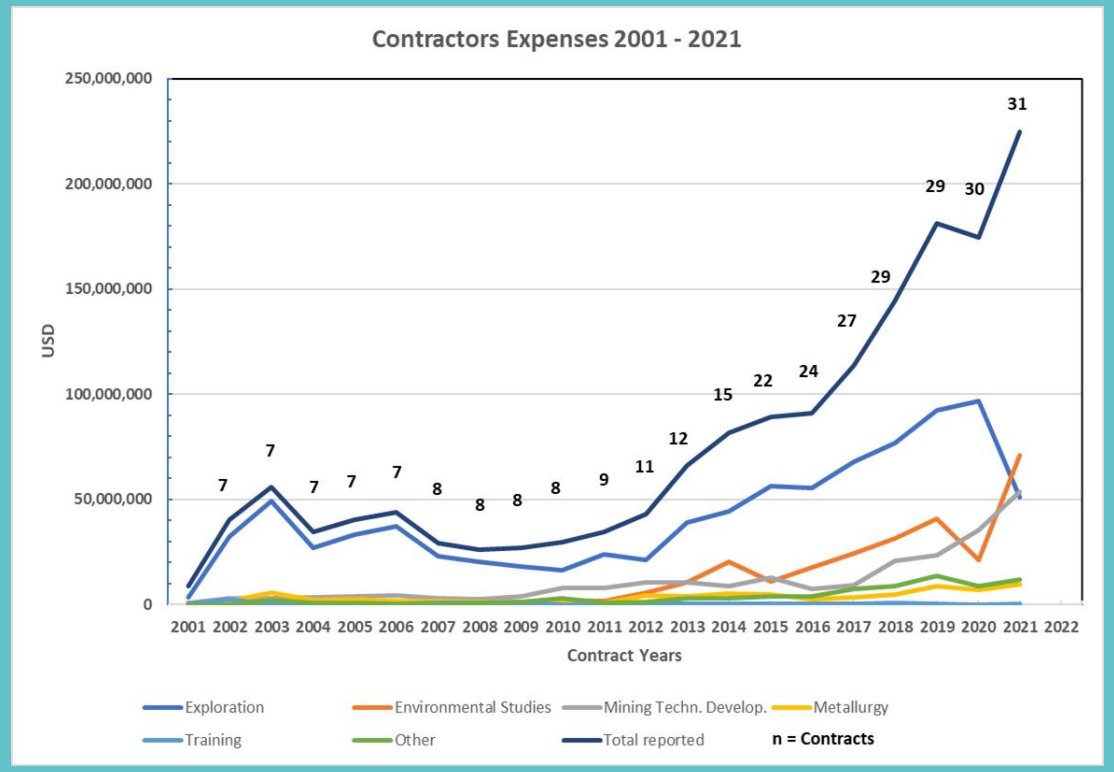
- Total spending on deep-sea exploration in International Waters (“The Area”): USD 1.6 billion

- Environmental studies expected to count for ~50% of the contractor exploration spending.
- Rapid increase in environmental studies over the last years.

- Contractors are using independent researcher to conduct environmental baseline studies.

Project Examples:

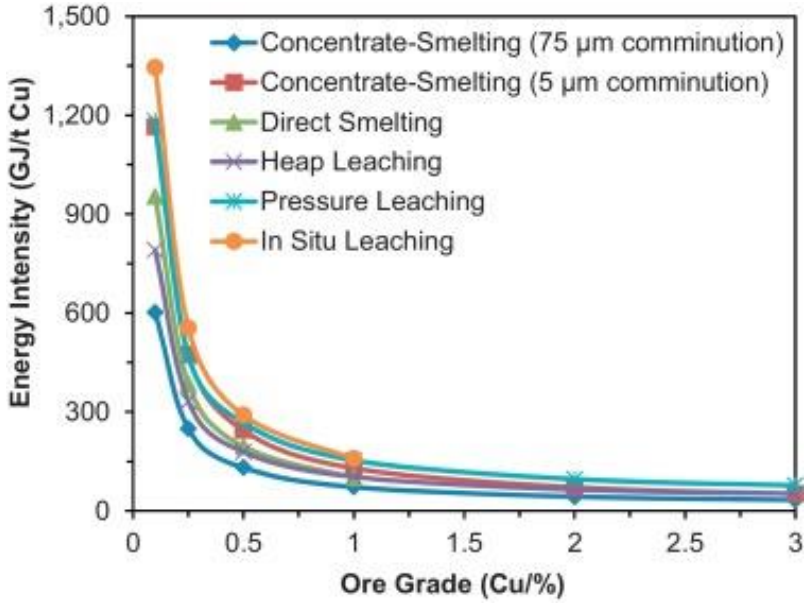
- JPI Oceans have supporter several joint studies, such as:
  - https://www.jpi-oceans.eu/en/miningimpact
  - https://www.jpi-oceans.eu/en/miningimpact-2
  - https://jpi-oceans.eu/en/ecological-aspects-deep-sea-mining
- MIDAS: www.eu-midas.net/
- SponGES: deepseasponges.org



Seabed minerals: Expected ~5-10X ore grade vs. land

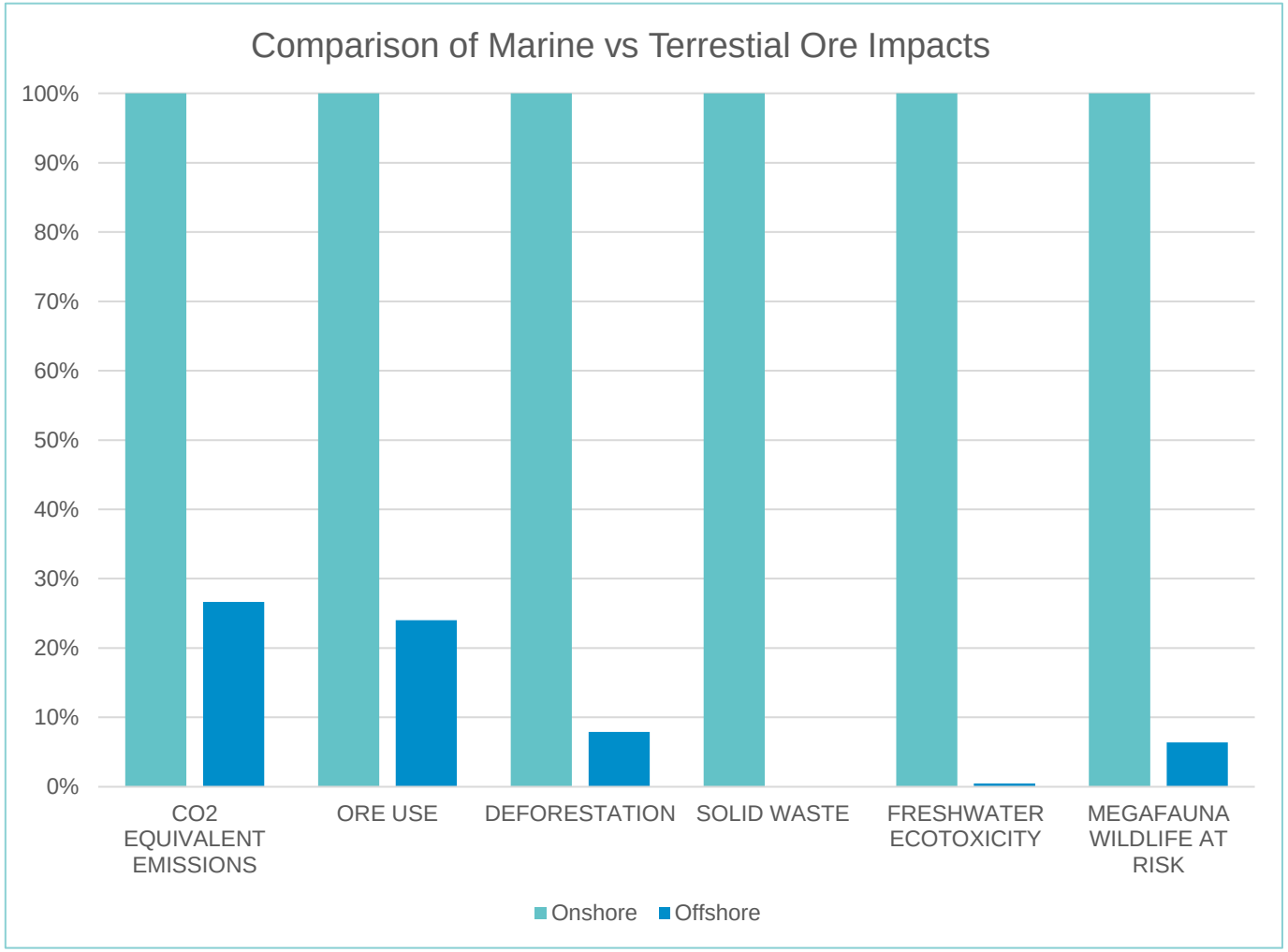
→ Potential for less footprint, energy and waste

Dillon Marsh artwork from Palabora mine



S. Northey et.al. (2014)

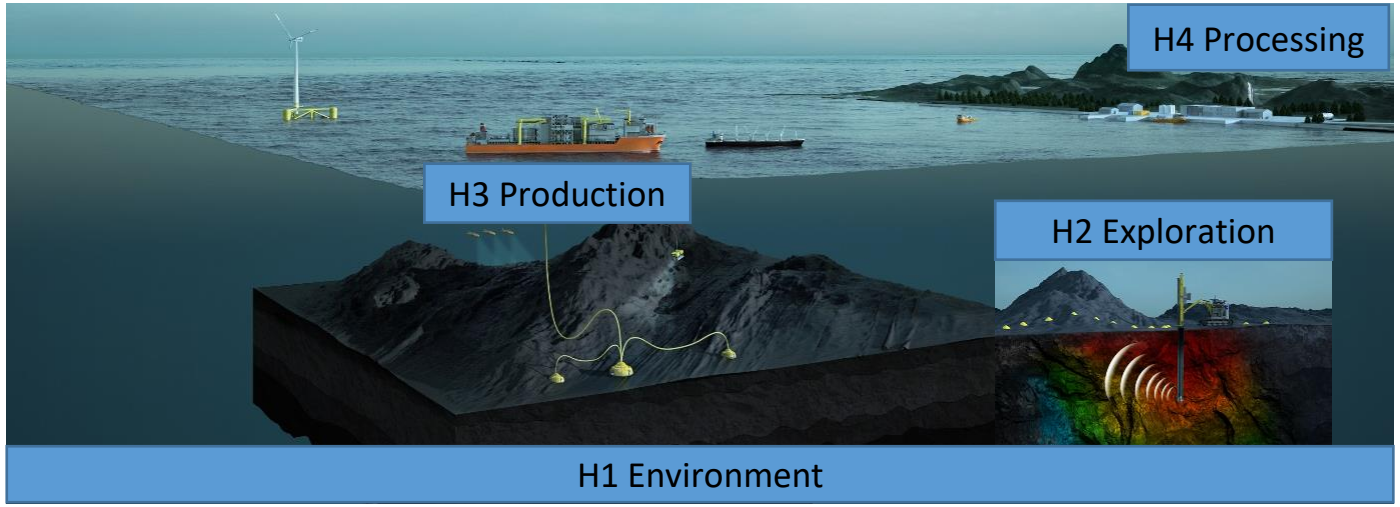
Potential for less negative environmental impact



Paulikas et al, 2020 (for nodules)

Project Examples

EMINENT – Energy MINerals for the NEtzero Transition



The main goal with the project is to establish the basis for a complete value chain for seabed minerals with the goal of **significant less environmental footprint** compared to current land-based mining.

Green Platform
Granted: 70,8 MNOK
Total budget: 139 MNOK

EcoSafe Ridge Mining

- Address knowledge gaps regarding benthic ecosystems associated with mineral deposits
- Investigate potential environmental risk and impacts from deep-sea mining
- Assess the possibility of environmentally responsible deep-sea mining in Norway
- Total budget of approximately 18 million NOK, where more that 13 granted by RCN

The Research Council of Norway

Picture: Courtesy of UiB

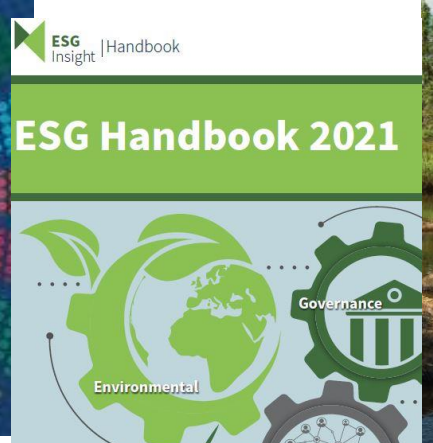
Universitas Bergensis · Universitetet i Stavanger · NORCE · NIOZ · GCE Ocean Technology · Offshore Norge · Aanderaa a xylem brand · equinor · LOKE Marine Minerals · Adepth minerals

ESG handbook

- Purpose: Enable evidence-based assessments of the ESG performance of marine minerals projects in the context of global standards.

- E – Environmental
- S – Social
- G – Governance

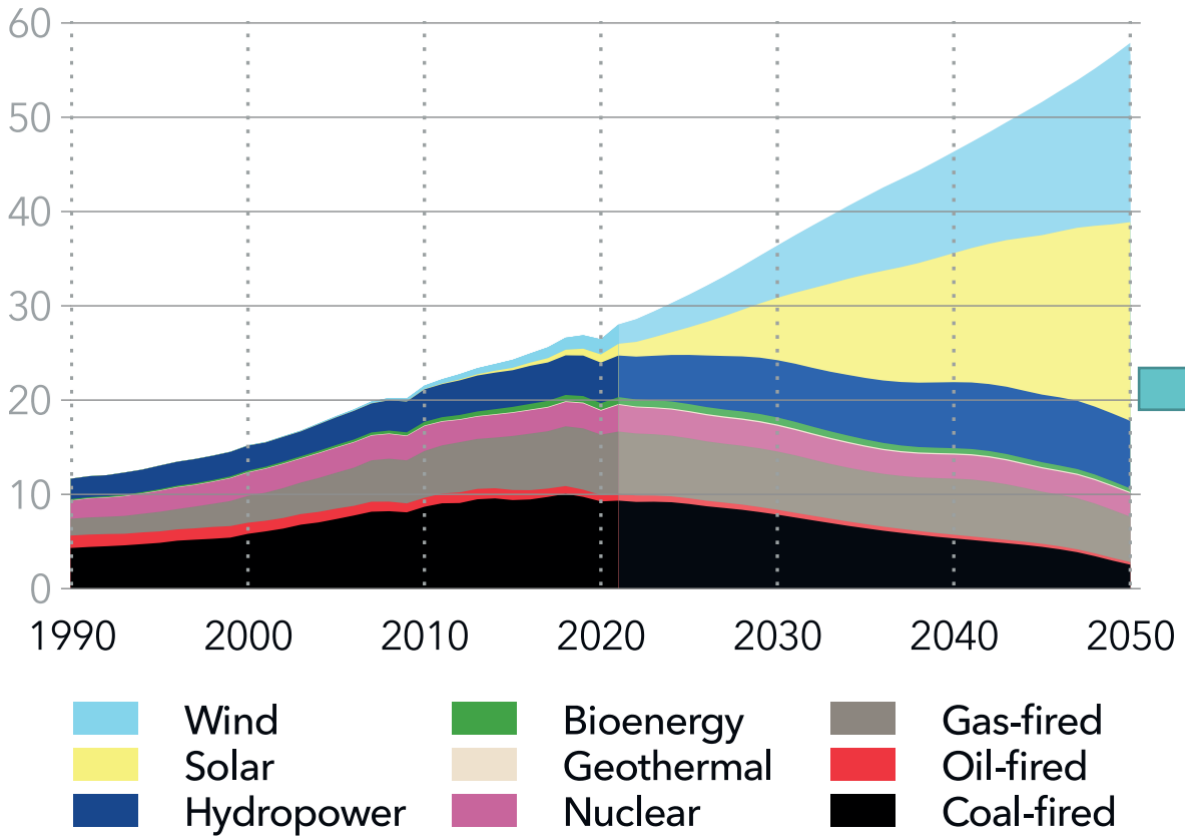
- Main project (2022-2023)



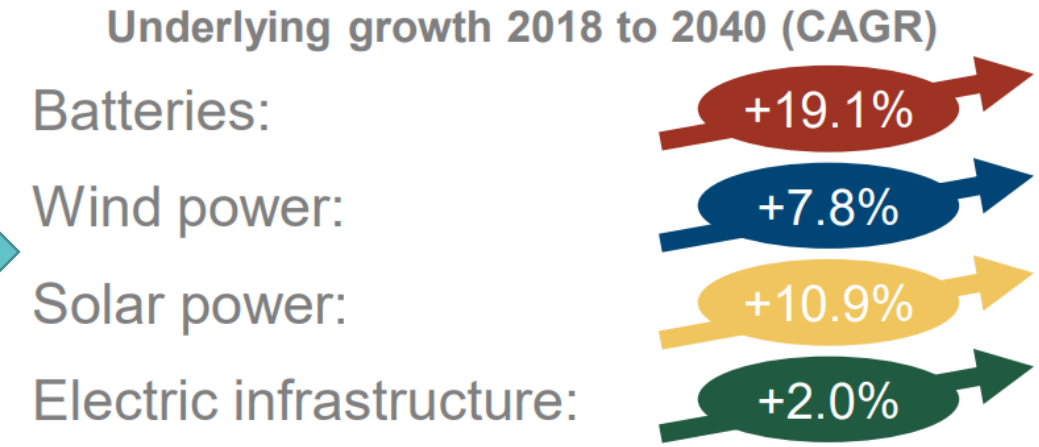
Collaborating institutions per 24 February 2023

Drivers, importance, perception and possibilities

The Energy Transition

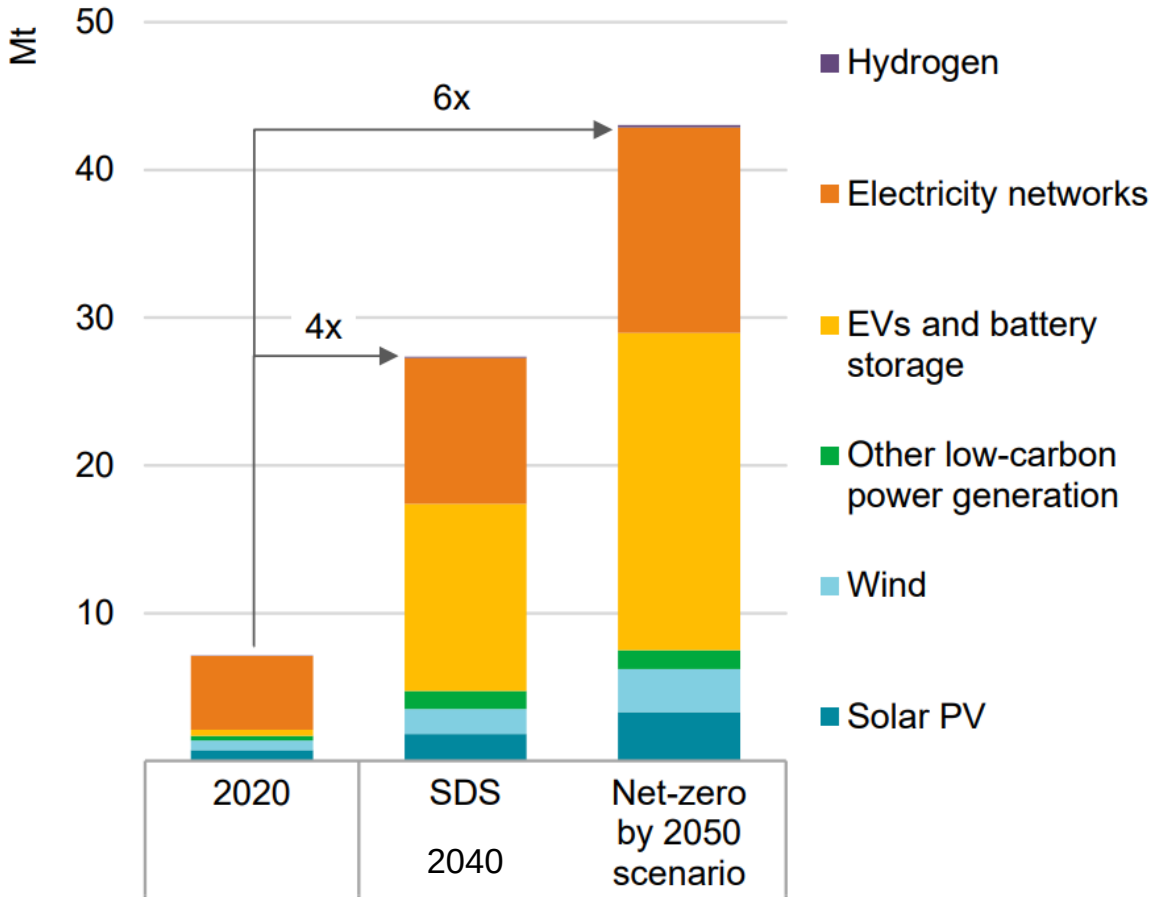


World grid-connected electricity generation [PWh/yr]
DNV Energy Transition Outlook 2021



Rystad Energy 2020

Minerals - Key for the Energy Transition

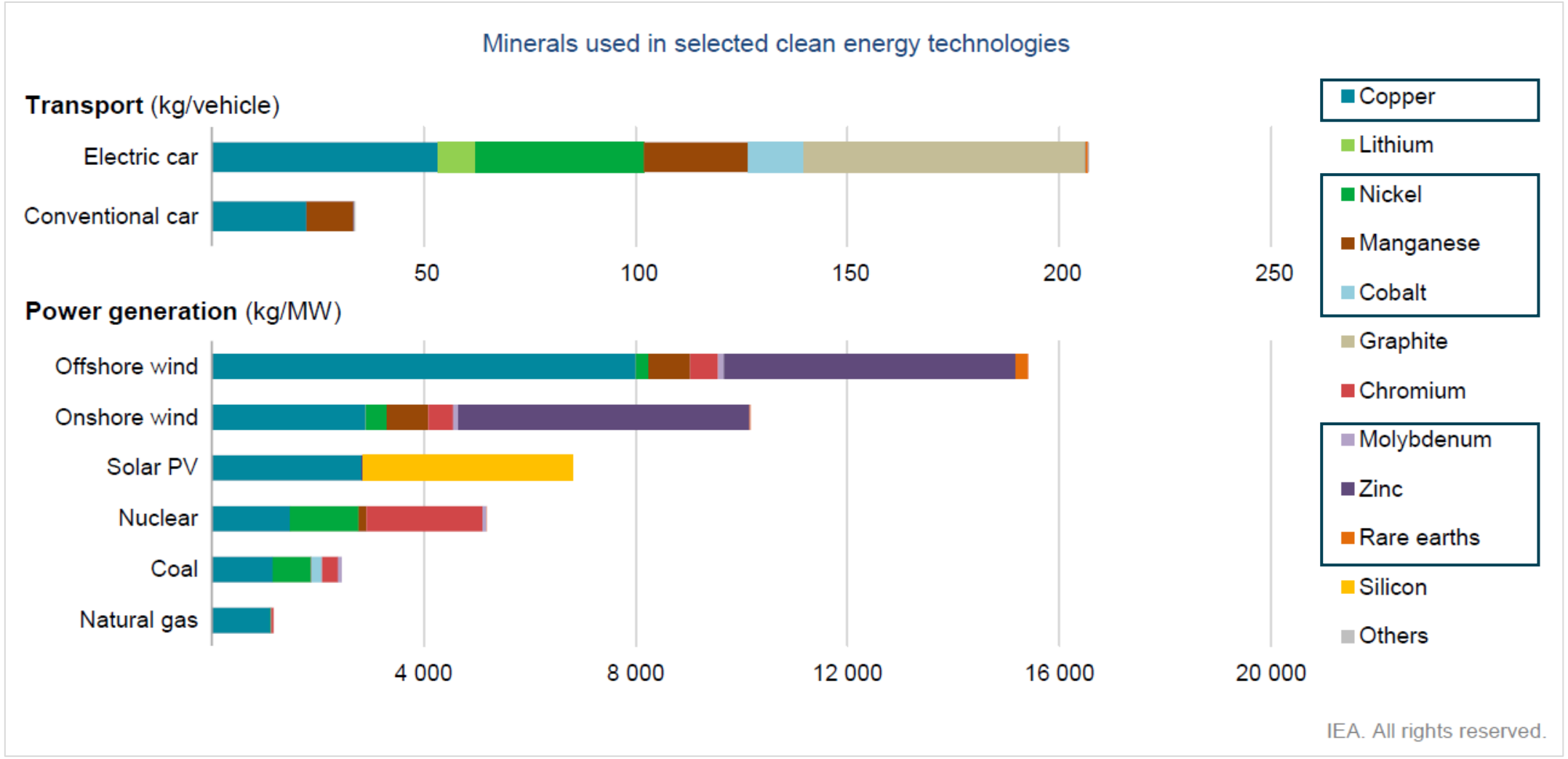


The higher climate ambision – the higher need for minerals

The data shows a looming mismatch between the world's strengthened climate ambitions and the availability of critical minerals that are essential to realising those ambitions" – Dr. Fatih Birol, IEA Executive Director

IEA 2021: The Role of Critical Minerals in Clean Energy Transition

Seabed minerals: Key metals for the energy transition

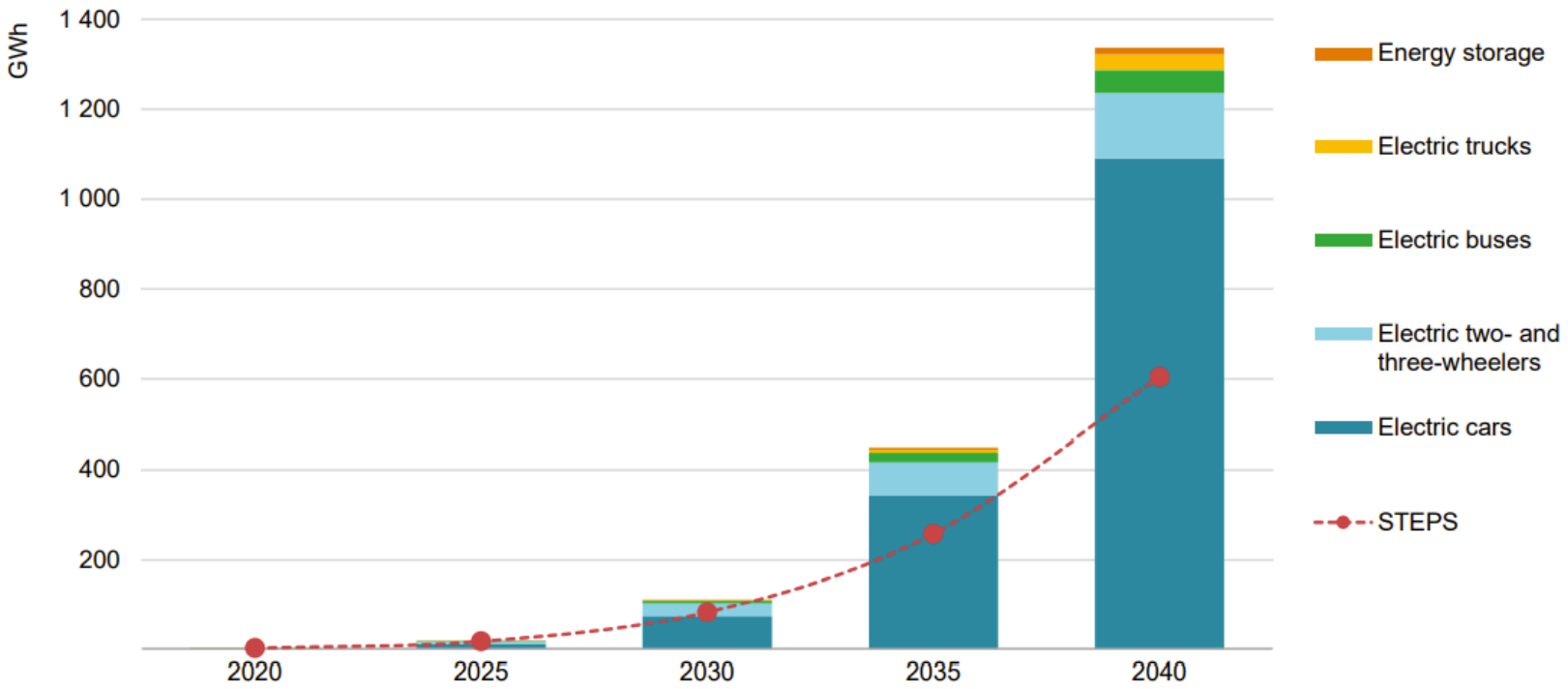


Note: Steel and aluminium not included

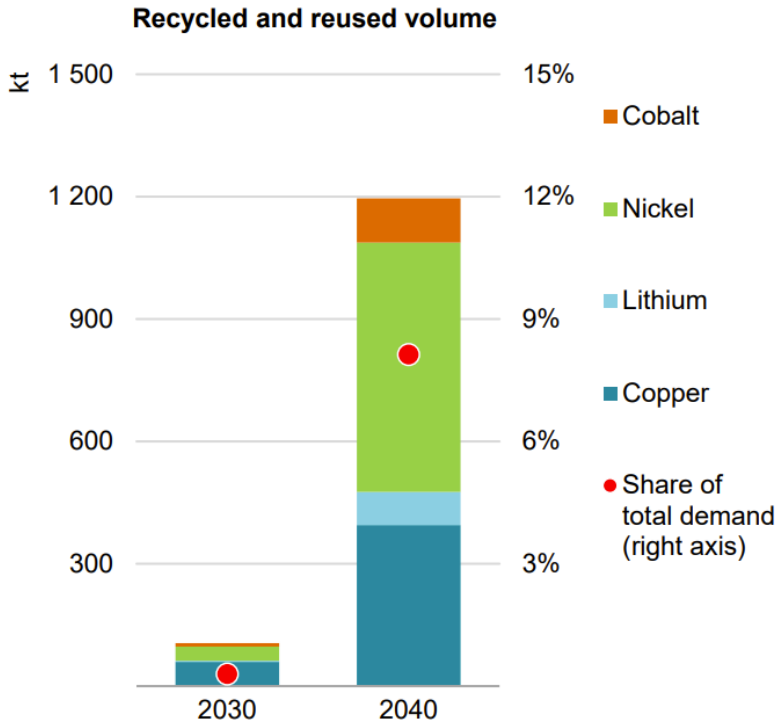
IEA 2021

Seabed minerals of highest economical interest

Contribution of battery recycling and reuse



EV and storage batteries reaching the end of their first life



Contribution of recycling and reuse

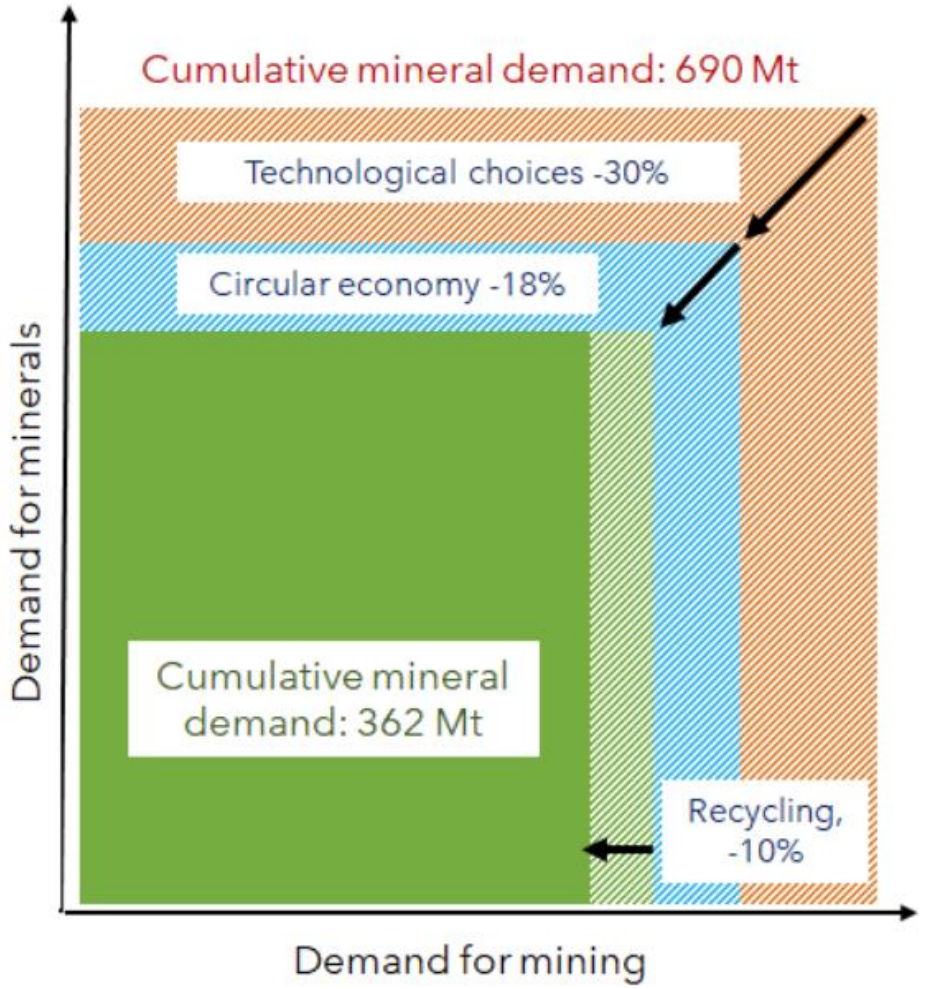
Recycling and circular economy is far from sufficient

Even the most optimistic scenarios requires significant amount of mining

“Responsible mining is needed for the green transition”

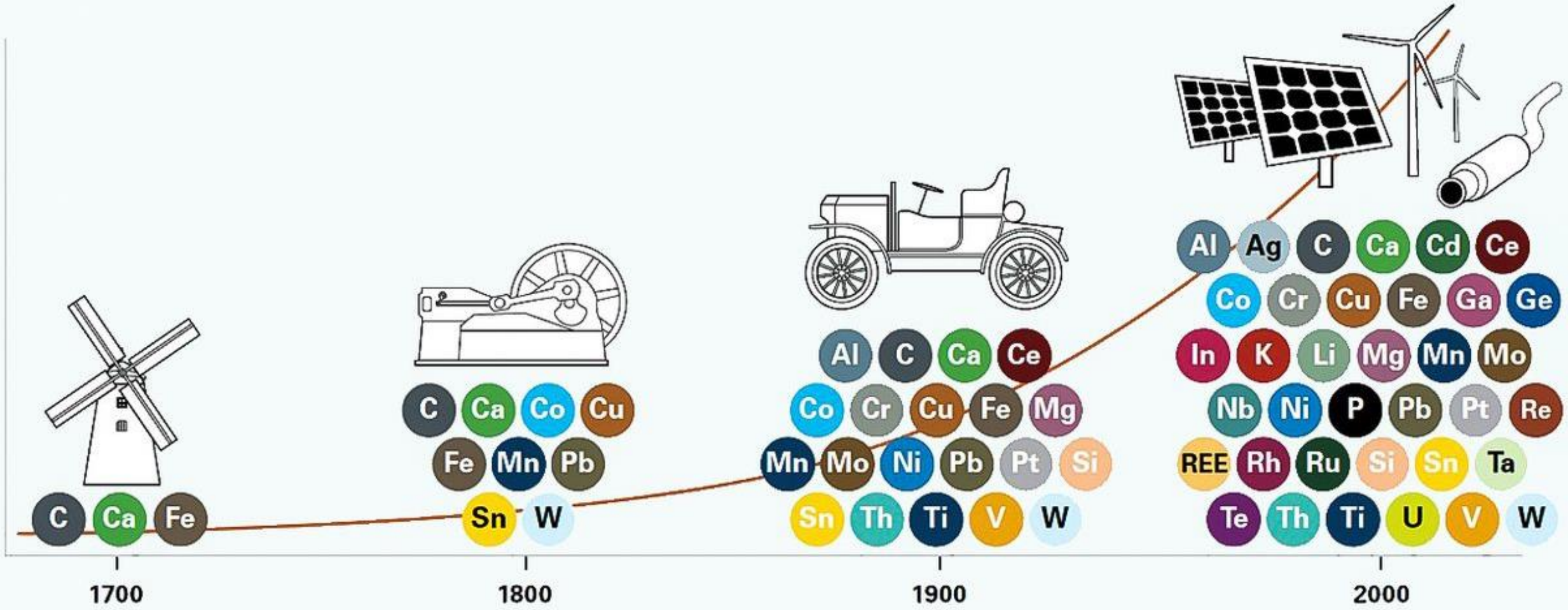
“The coming decades will rely on the primary extraction of minerals for the transition to a net-zero energy system”

58% reduced demand vs. “Business-as-usual”



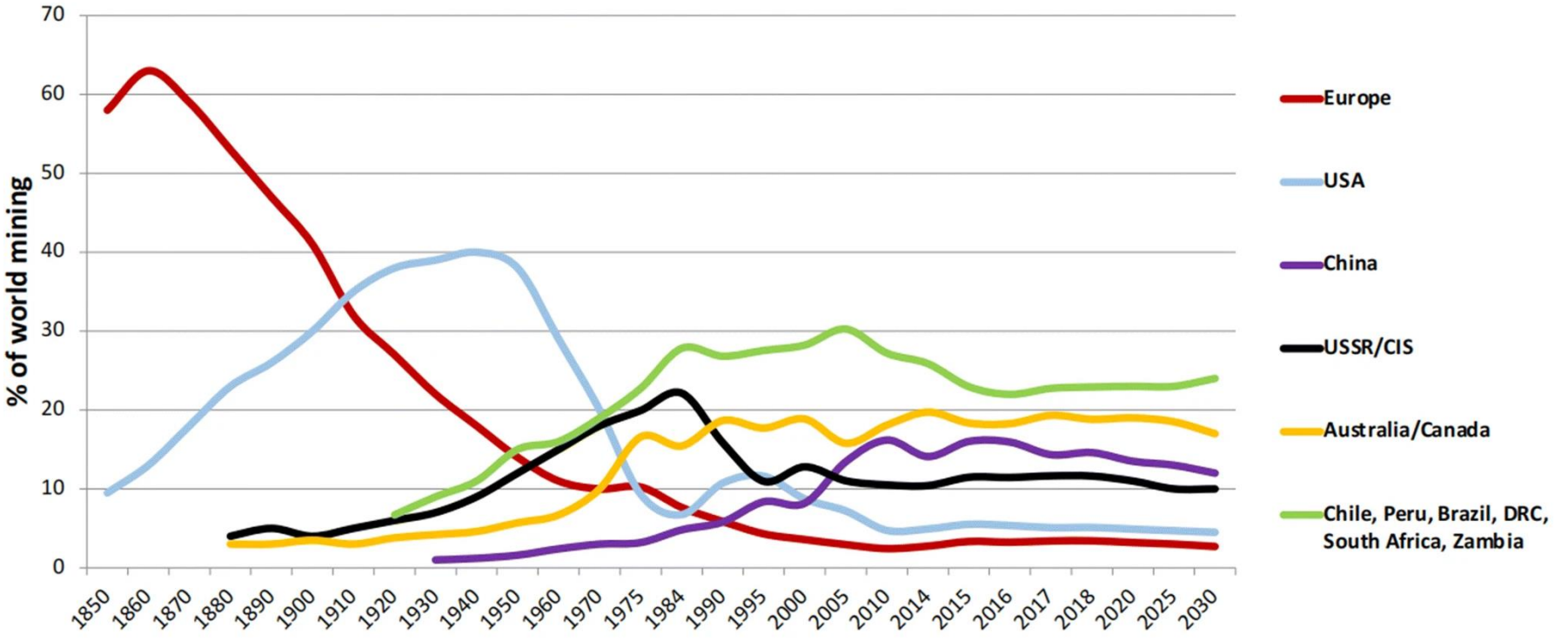
Source: The Future is Circular, SINTEF report for WWF, 2022

Increasingly complex systems



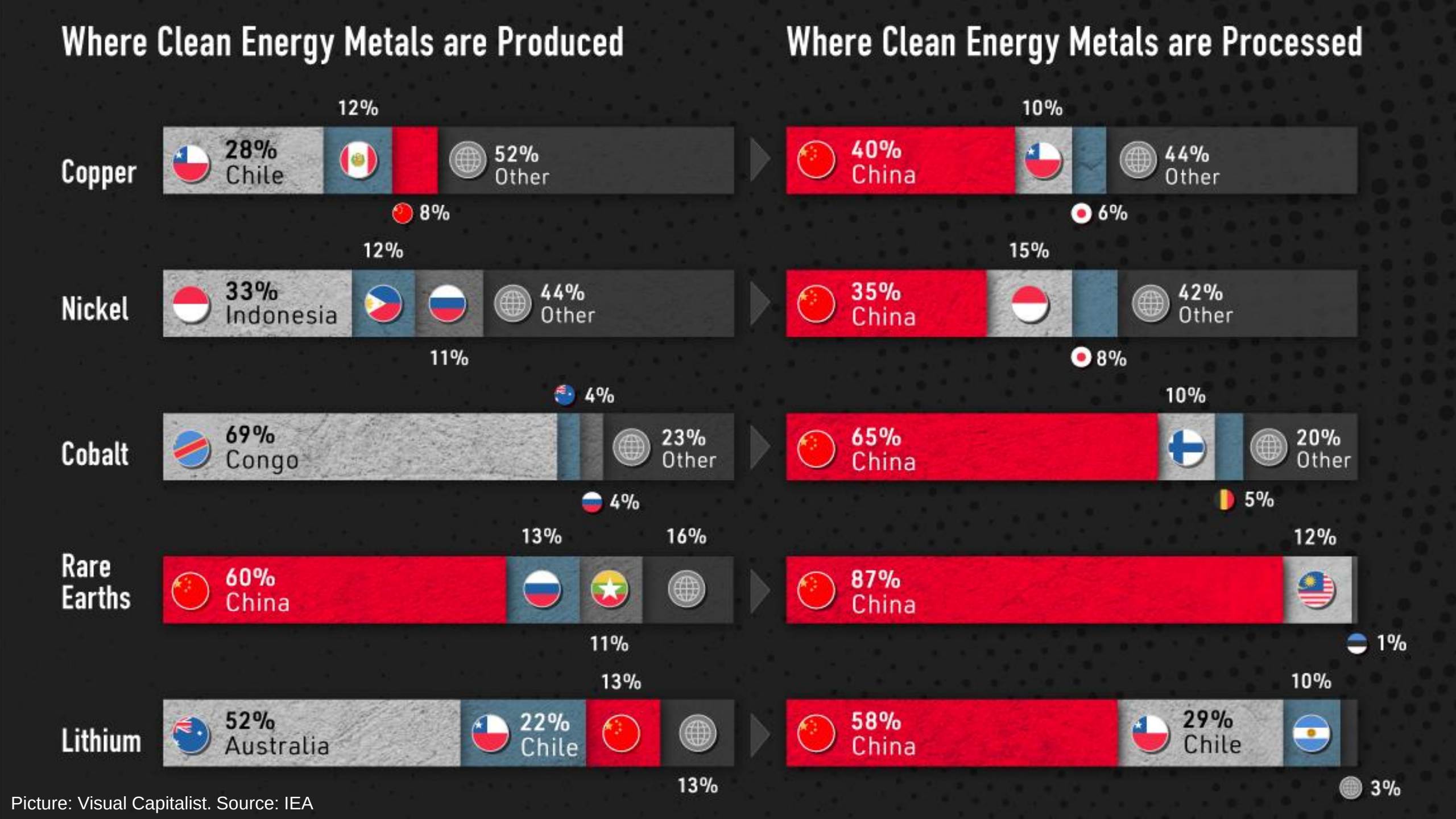
Achzet et al (2009)

Europe has outsourced mining
- but becoming increasingly aware of supply risk



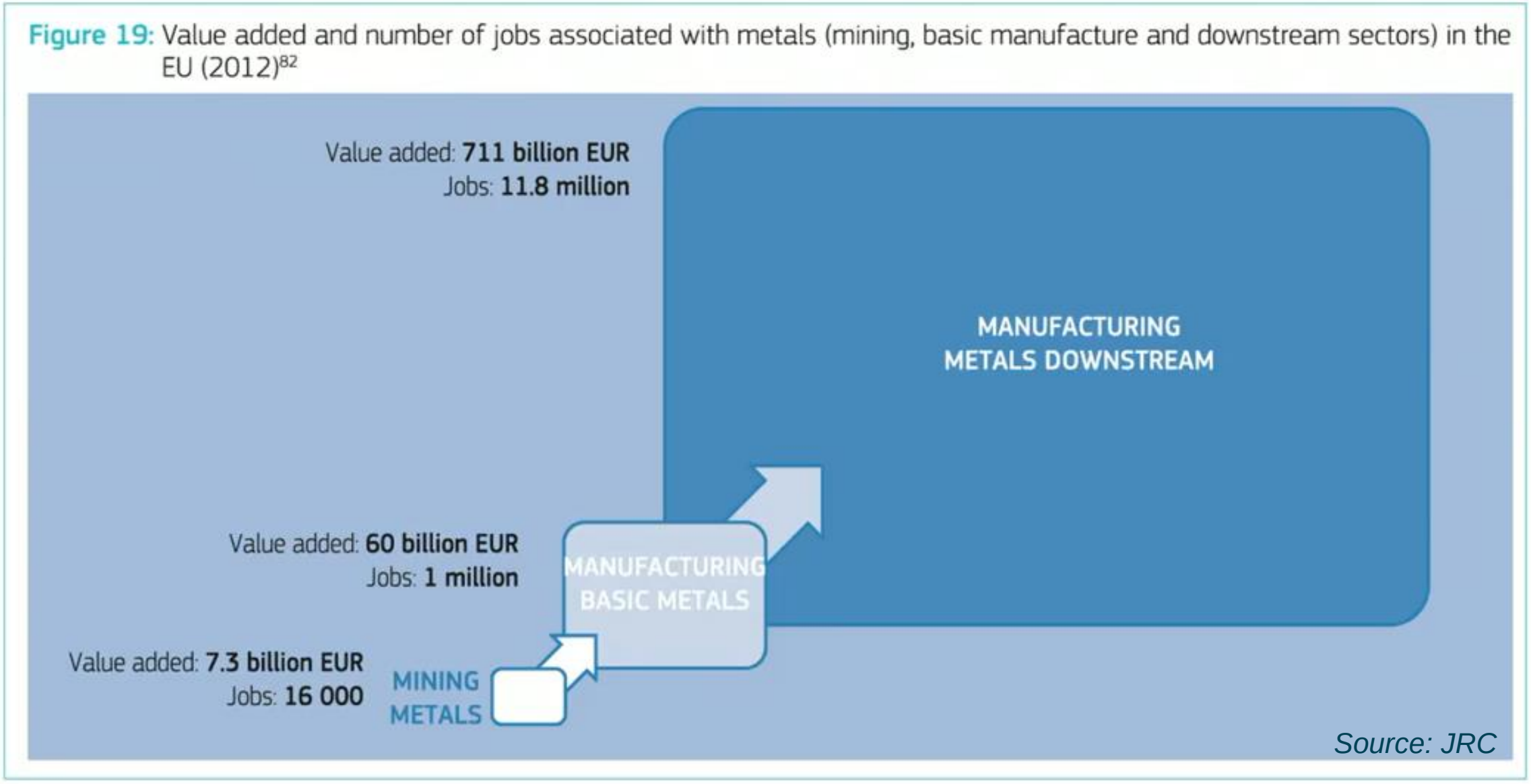
% of value of total production excludig coal

Source: RMG Consulting 2021



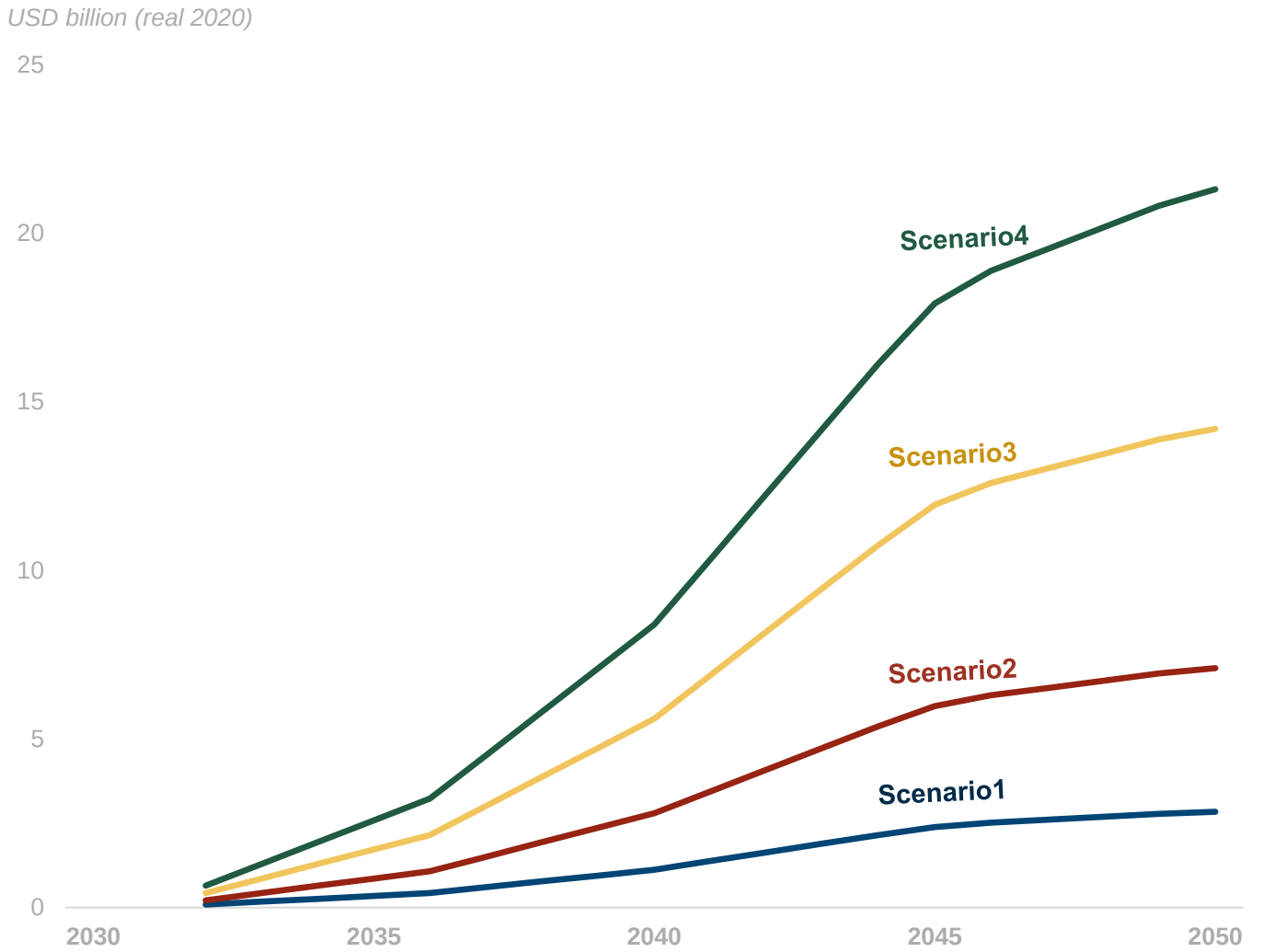
Picture: Visual Capitalist. Source: IEA

Metals are key for Europe's value creation



Marine minerals with annual revenue potential up to USD 20 billion

Annual Norwegian marine minerals revenue split by scenario



Source: Rystad Energy research and analysis

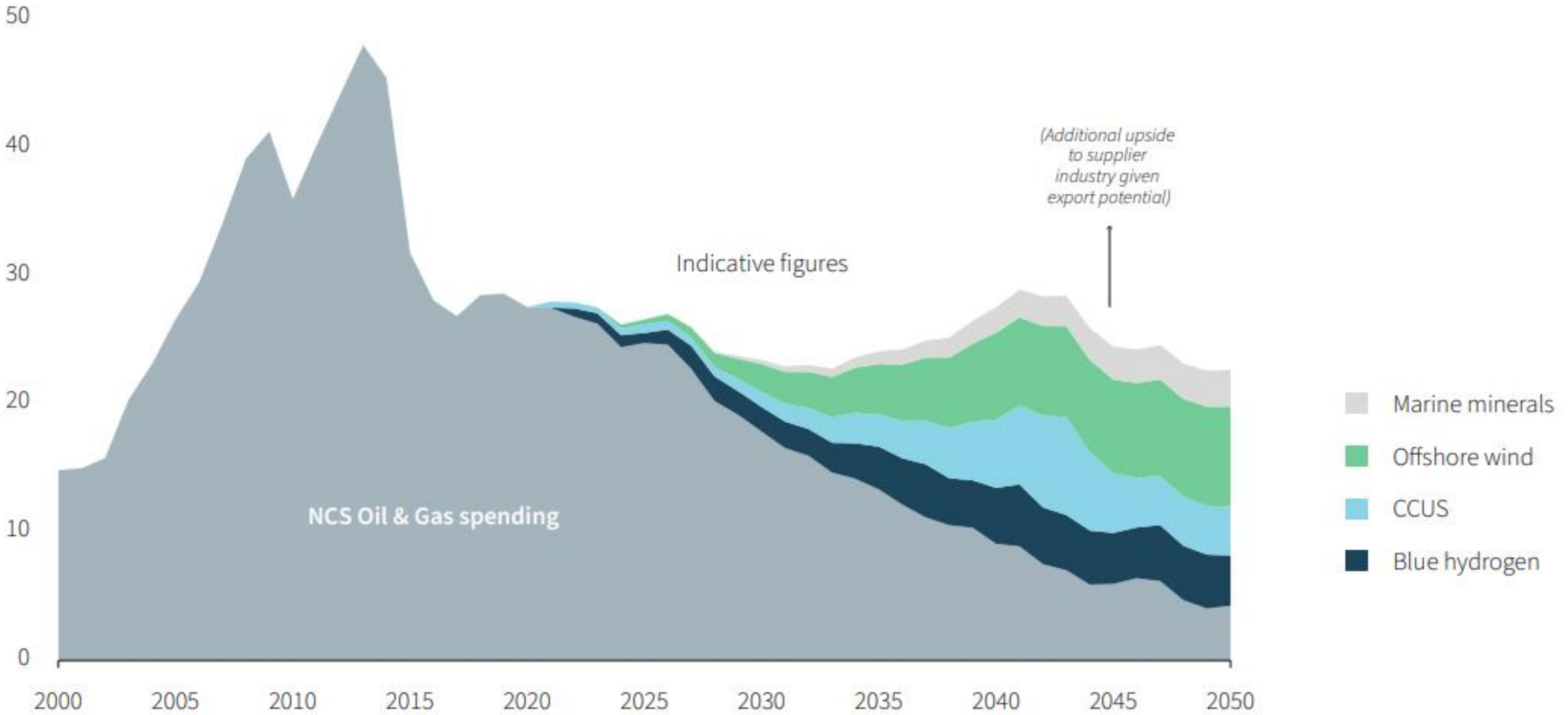
- Marine minerals are «in the money»
- 3-21 000 employees depending on senario
- Export, processing and value of minerals not included

6 reflections since the launch of the report in November 2020

Marine minerals industry will make use of all existing Norwegian oil and gas competence

NORWEGIAN COMPETENCE				COMMODITY INDUSTRY RELEVANCE				COMMENT
Norwegian geographical cluster	Field of industry competence	2019 Norwegian employment *[# employees]*	Examples of relevant players*	Oil and gas	Bottom fixed wind	Offshore floating wind	Marine minerals	Competence relevance in a potential marine minerals industry
Eastern Norway	Seismic	2,500	TGS, emgs, roxar, allton, PGS, magseis, fairfield	●●●	○○○	○○○	●●●	High frequency seismic surveys used for detecting minerals in seabed formations. E.g. by use of seismic vessels, AUVs and electromagnetic (EM) methods
	Geology			●●●	●○○	●○○	●●●	Initial and life cycle geological studies and analysis of formations. Studying mineral resource potential and mapping of field characteristics
	Engineering	9,500	OLAV OLSEN, mossmaritime, GLOBAL MARITIME	●●●	●○○	●●○	●●○	Design and engineering of marine minerals extraction concept, incl. the mining production vessel and e.g. the solution for potential low carbon energy sourcing
	Subsea	16,500	AkerSolutions, TechnipFMC, subsea 7	●●●	●○○	●○○	●●○	Delivering the vertical transportation system (risers), subsea pump and mining tool for ore cutting collection
West coast	Marine operations	9,000	DEEPOCEAN, DOF, Østensjø Rederi, SOLSTAD OFFSHORE	●●●	●●○	●●●	●●●	Transportation of de-watered mineral masses on wet bulk shuttle tankers. Also in need of various support vessels and potentially personnel transfer
	EPC- and shipyards	15,000	aibel, VARD, KVÆRNER, KLEVEN, ULSTEIN	●●●	●○○	●●○	●●●	Construction, hook-up and commissioning of mining production vessel (e.g. topside modules) and subsea components. Various scope on wet bulk tankers
	Drilling	10,000	Transocean, Seadrill	●●●	○○○	○○○	●○○	Deep water (1000-3000 m depths) shallow drilling down to ca. 100 meters below seabed. Coiled tubing methods already used for marine mineral purposes
South coast	Drilling rig- and topside equipment	22,000	Schlumberger, ABB, mhwirth, NOV, WÄRTSILÄ	●●●	●○○	●○○	●●○	Engineering and fitting of drilling rigs and the mining production vessel. Pumps, water treatment, loading/discharge systems etc.
Country wide	Automation and digital technologies	26,000	Sekal, Cognite, Eelume, KONGSBERG	●●●	●○○	●○○	●●●	Automation needed for remote operations and subsea ROVs. Digital technologies through the value chain, e.g. for exploration, operations monitoring, logistics
	Other, incl. maintenance services		DNV·GL, AXESS, JOTUN	●●●	●●●	●●●	●●●	Various operational services and maintenance activities. For example classification, IMR operations and manning

Figure 60. Estimates on potential investments (billion USD) in new industries as compared to the expected investment level* on the NCS (Rystad Energy, 2021)



*Includes both capital and operational expenditures, in addition to historical exploration costs and assumed future exploration costs
Source: Rystad Energy research and analysis; Rystad Energy UCube

OG21 – Rystad Energy 2021

Public perception tend to be

Mining = Bad

Batteries = Good

Maritime batterier: Corvus dobler salget – må bygge ny batterifabrikk i Norge og USA

Den norske batteriprodusenten Corvus Energy vokser ut av fabrikken som ble åpnet for to år siden. Samtidig etablerer selskapet en mindre fabrikk i USA for å følge opp Joe Bidens grønne satsing.

Freyr vil bygge batterifabrikk til 40 milliarder i Mo i Rana

Freyrs industrieventyr kan bety 2.500 nye arbeidsplasser i regionen, men avhenger av vindkraft. Naturvernere og samer er skeptiske.

Norway rank top on ESG

- Norway are in a good position to establish battery value chain
- Seabed minerals can strengthen our current relatively week position related to raw materials

Figure 1: BNEF 2022 global lithium-ion battery supply chain ranking

Country	Raw Materials	Battery manufacturing	ESG	Industry, innovation and infrastructure	Downstream demand	Overall ranking
China	1	1	17	9	1	1
Canada	3	8	6	4	10	2
US	6	4	16	5	2	3
Finland	9	15	2	1	11	4
Norway	18	10	1	3	7	5
Germany	21	6	4	7	2	6
South Korea	17	2	10	6	5	6
Sweden	21	9	3	2	8	8
Japan	13	3	8	12	8	9
Australia	2	15	9	13	11	10
France	24	10	5	10	5	11
UK	26	15	7	8	4	12
Czechia	23	10	11	11	18	13
Poland	24	5	15	16	15	14
Hungary	26	6	13	14	20	15
Chile	7	18	14	23	19	16
Turkey	15	18	21	15	13	17
India	13	10	26	21	13	18
Vietnam	20	10	20	18	17	19
South Africa	8	18	19	17	26	20
Brazil	4	18	23	22	20	21
Indonesia	5	18	22	27	25	22
Argentina	11	18	12	19	26	23
Slovakia	26	18	18	25	24	24
Thailand	26	18	24	20	16	25
Philippines	10	18	29	28	22	26
Mexico	16	18	27	26	23	27
Morocco	19	18	25	24	28	28
DRC	11	18	30	29	30	29
Bolivia	26	18	28	30	28	30

Source: BloombergNEF. Note: "III" stands for infrastructure, innovation, and industry.

Minerals key part of the Norwegian policy

«Norge har store mineralforekomster som vil være viktige i det grønne skiftet»

«Vi har muligheten til å utvikle verdens mest bærekraftige mineralnæring»

«Gitt betydningen av mineraler for grønn omstilling er det naturlig å se arbeidet med det grønne industriløftet og mineralstrategien i sammenheng»

«Forutsatt at utvinning kan skje på en lønnsom måte og med akseptabel grad av miljøpåvirkning, kan dette bli en spennende ny næring»
Olje- og energiminister Terje Aasland.

World Class Ocean Technology
from Norway

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