GCE Ocean Technology

Cluster Management Excellence
GOLD
PROVEN FOR CLUSTER EXCELLENCE

Seabed Minerals

- Bergen Energy Lab 24 January 2023

Jon Oddvar Hellevang · · · · · R&D MANAGER, GCE OCEAN TECHNOLOGY

GCE Ocean Technology

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Industry

AkerSolutions · Coast Center Base AS · CGG · DNV · equinor · TechnipFMC · OneSubsea (A Schlumberger Company)

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NORCE · SINTEF

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Higher Education Institutions

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Innovasjon Norge · Forskningsrådet · siva

Cluster Relations

Arena Pro Ocean Hyway Cluster · Blue Maritime Cluster · GCE Node (An industry-driven cluster for ocean technologies) · Kongsberg Innovasjon · maritime cleantech · NCE Media · NCE Seafood Innovation Cluster · energy valley · hub for ocean

National Relations

AKSEL · Bunnsolid · Bergen Næringsråd · connect Norge · FFU · Lumen · maritime Bergen · Norwegian Cognitive Center · Norwegian Energy Partners · NTNU Ocean Club · Ocean Innovation Norwegian Catapult Centre · SPE Bergen Section · SUT Society for Underwater Technology · UTC Underwater Technology Conference · UTF Underwater Technology Foundation · VNR Vest Næringsråd

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AHK Deutsch-Norwegische Handelskammer · BlueTech Cluster Alliance · Canada's Ocean Supercluster · EMEC European Marine Energy Centre Ltd Orkney · FIESP · Heriot Watt University · Martin Trust Center for MIT Entrepreneurship · Ocean Energy Europe · Organização Nacional da Indústria do Petróleo · Scottish Hydrogen & Fuel Cell Association · Governo do Rio de Janeiro Secretaria de Desenvolvimento Econômico, Energia, Indústria e Serviços · Australia · Wind Europe


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© The metals company


Offshore Renewable Energy

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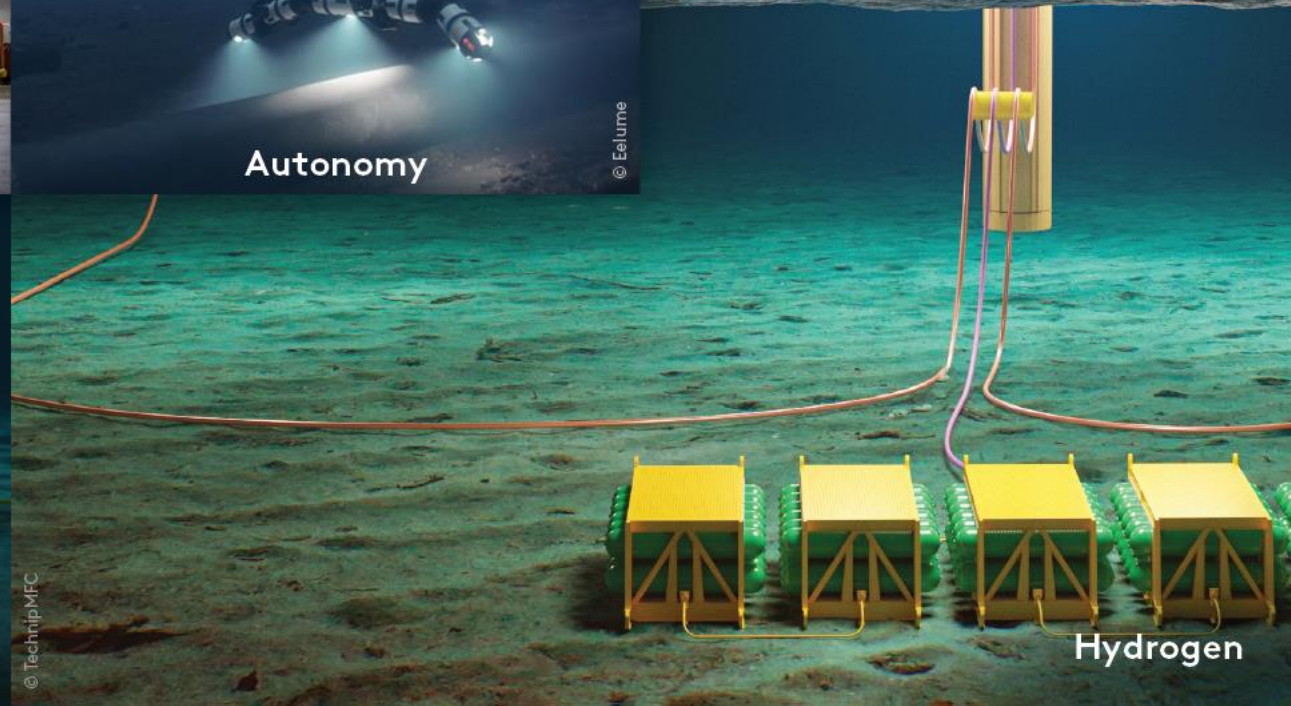
Hydrogen
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GCE Ocean Technology and Marine Minerals

- First seminar in 2014
- Key part of our strategy since 2015
- Topic for Subsea Innovation Day 2016
- Co-host Underwater Mining Conference 2018
- Part of establishing NMM 2018/2019
- Part of NMM-board from the beginning
- Ocean Innovation Catapult, with large high pressure test facilities 2018/2020
- Webinar: Marine Minerals Possibilities 2020
- Rystad Report – Norwegian Potential 2020
- Marine Minerals – One Day Seminar 2021

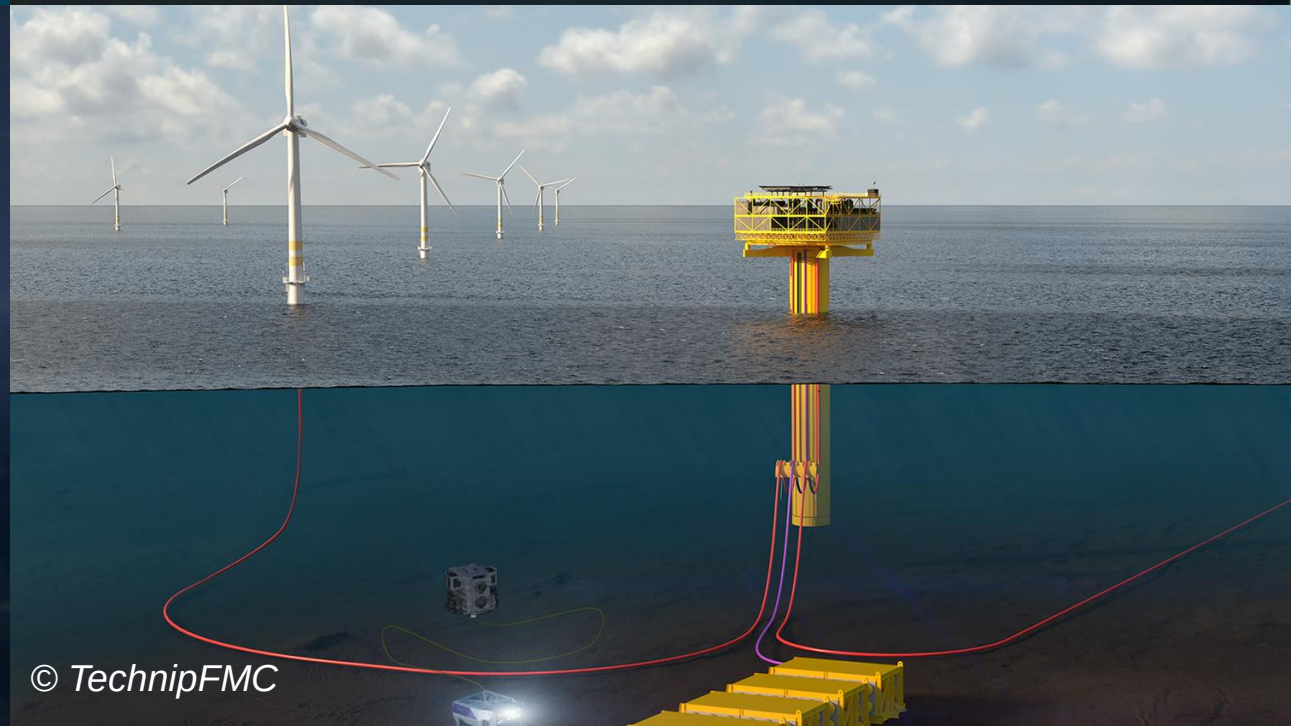
- EcoSafe Ridge Mining project granted 2021
- Marine minerals – Test infrastructure 2022
- ESG Handbook for marine minerals 2022
- Deep Sea Minerals – Accelerating the energy transition, granted 2022

UMC 2018

Tina Bru, Norwegian Minister of petroleum and energy at Marine Minerals – One Day Seminar 2021

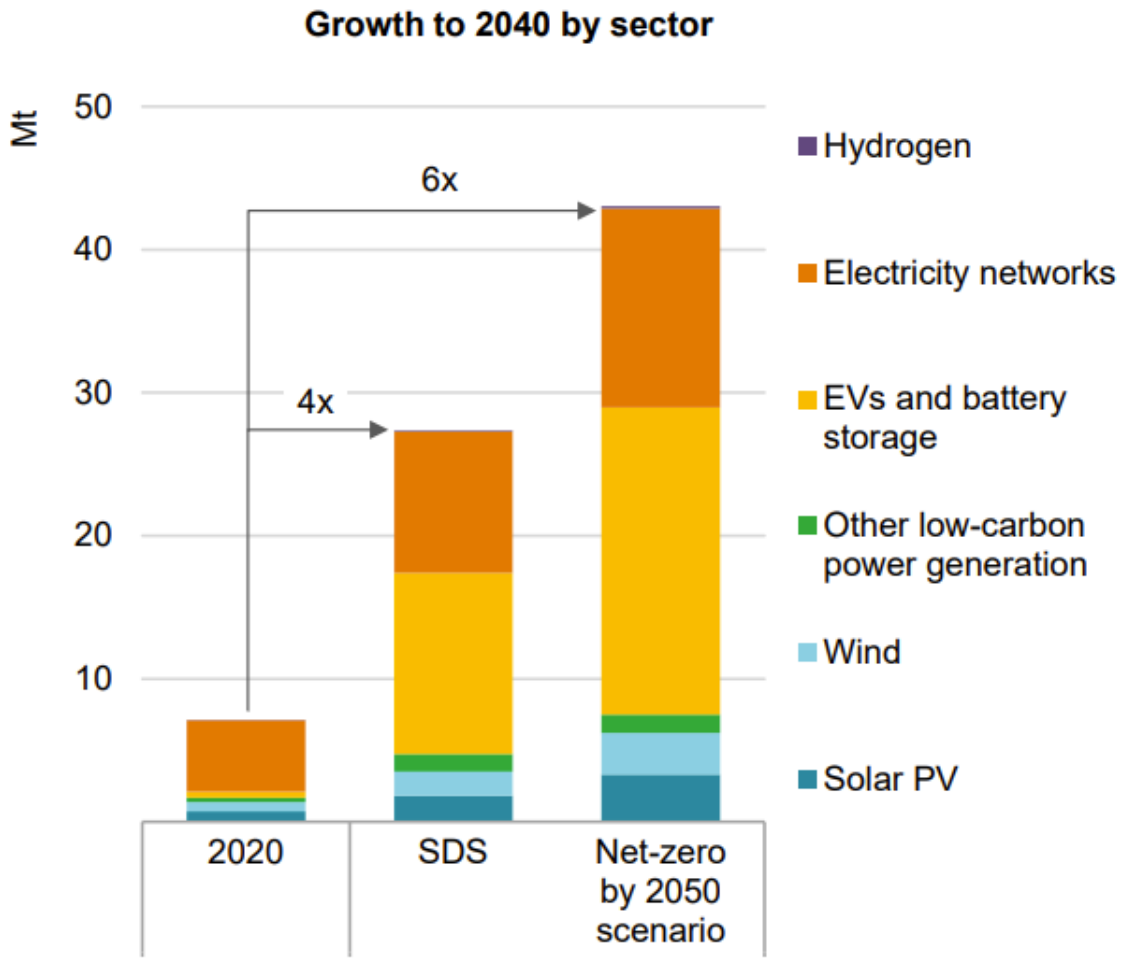
Facilitating Innovation

- Provide financial and professional support to establish externally funded RDI projects.
- Secured more than **2 billion NOK** in external funded RDI projects.



Minerals – Key for the Energy Transition

Mineral demand for clean energy technologies



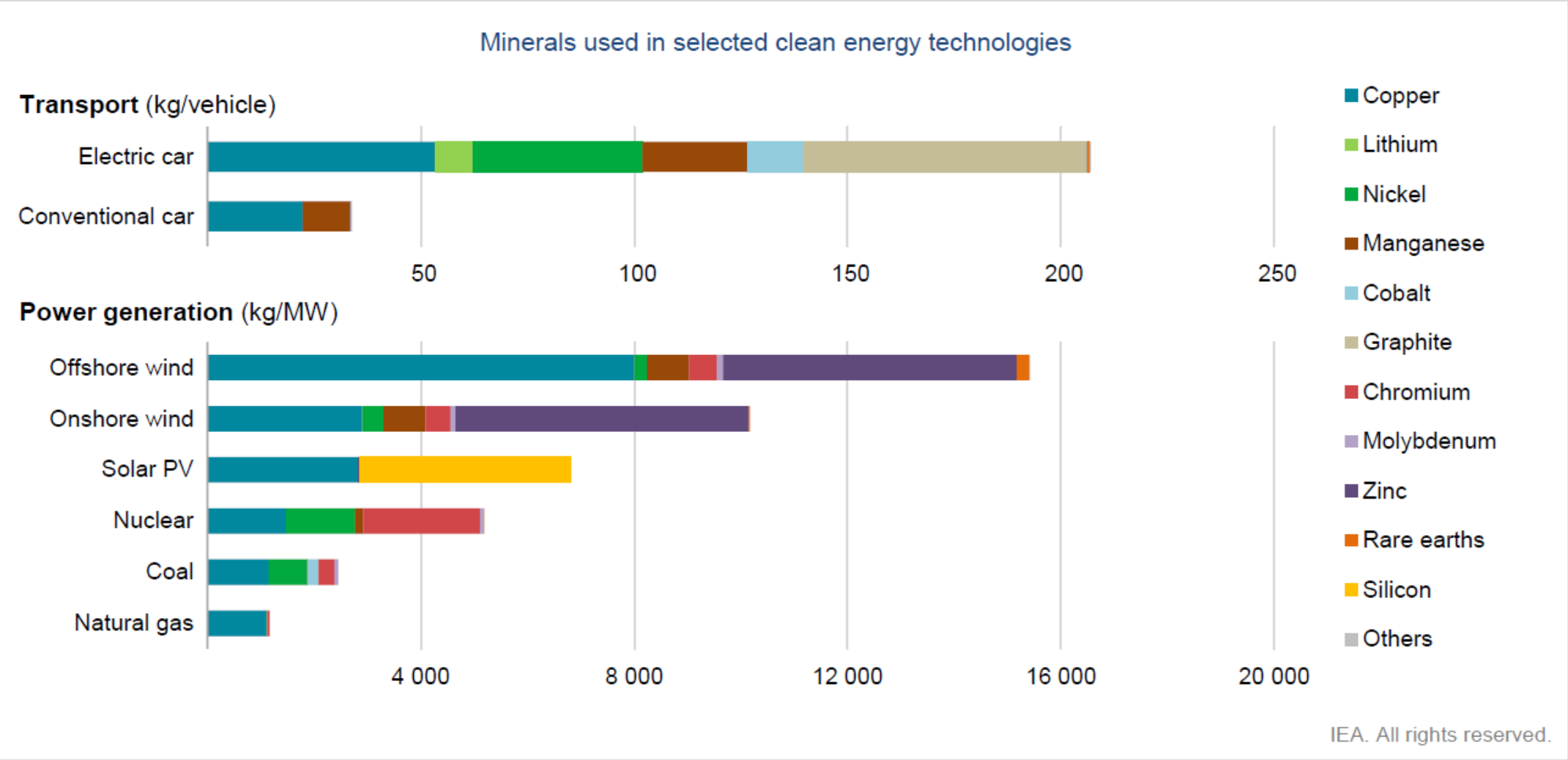
The higher climate ambision – the higher need for minerals

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

Note: Steel and aluminium not included

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

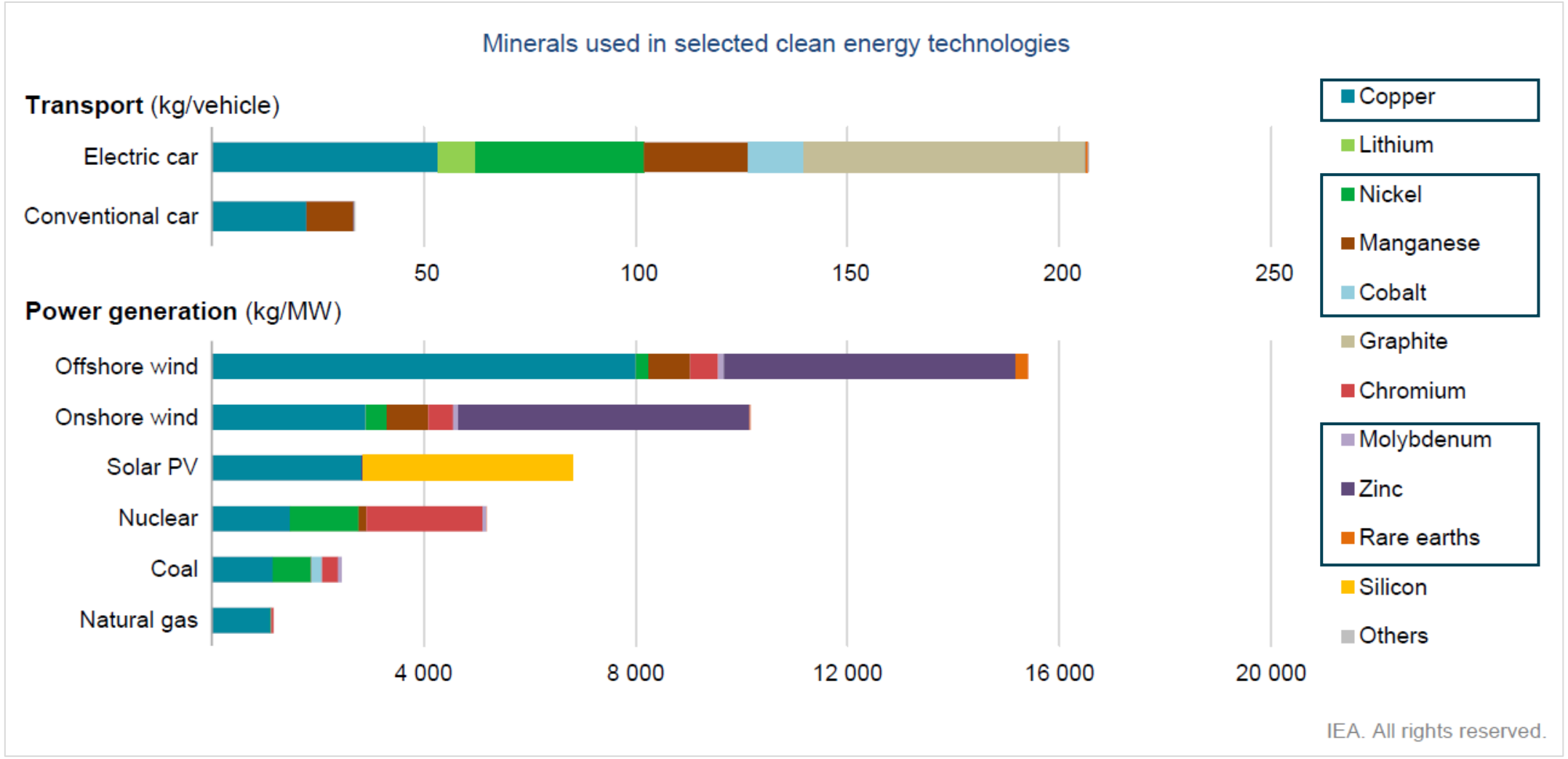
Renewable energy and electric cars requires more minerals



Note: Steel and aluminium not included

IEA 2021

Renewable energy and electric cars requires more minerals

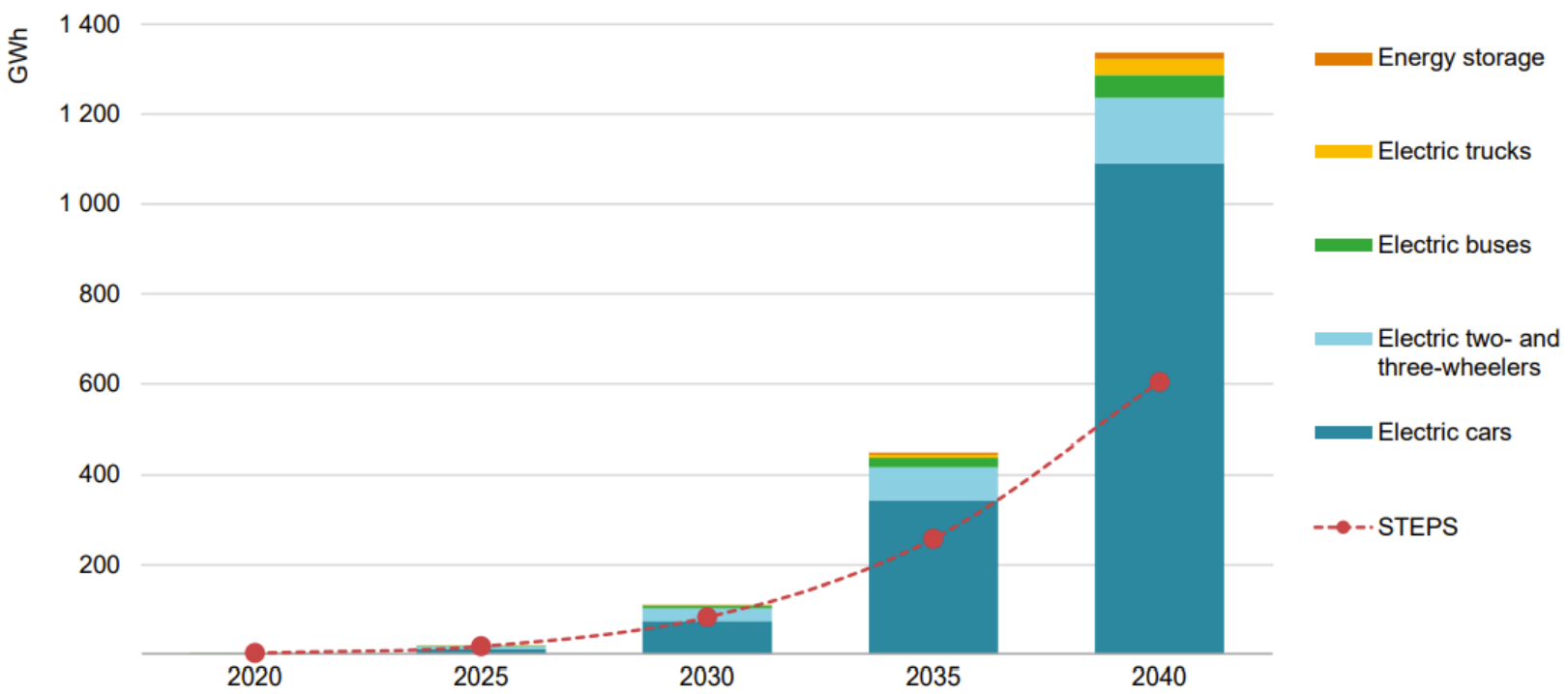


Note: Steel and aluminium not included

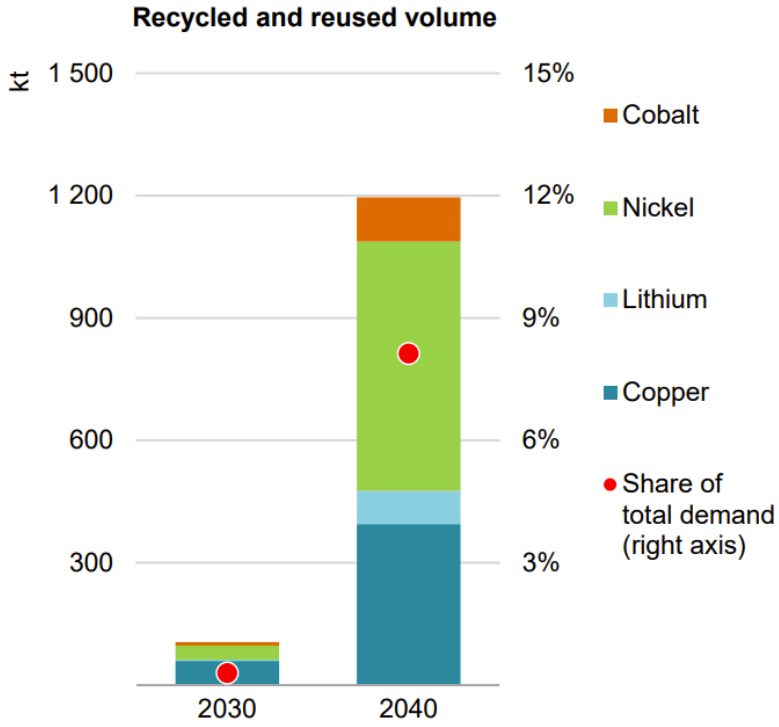
IEA 2021

Seabed minerals of highest economical interest

Contribution of battery recycling and reuse



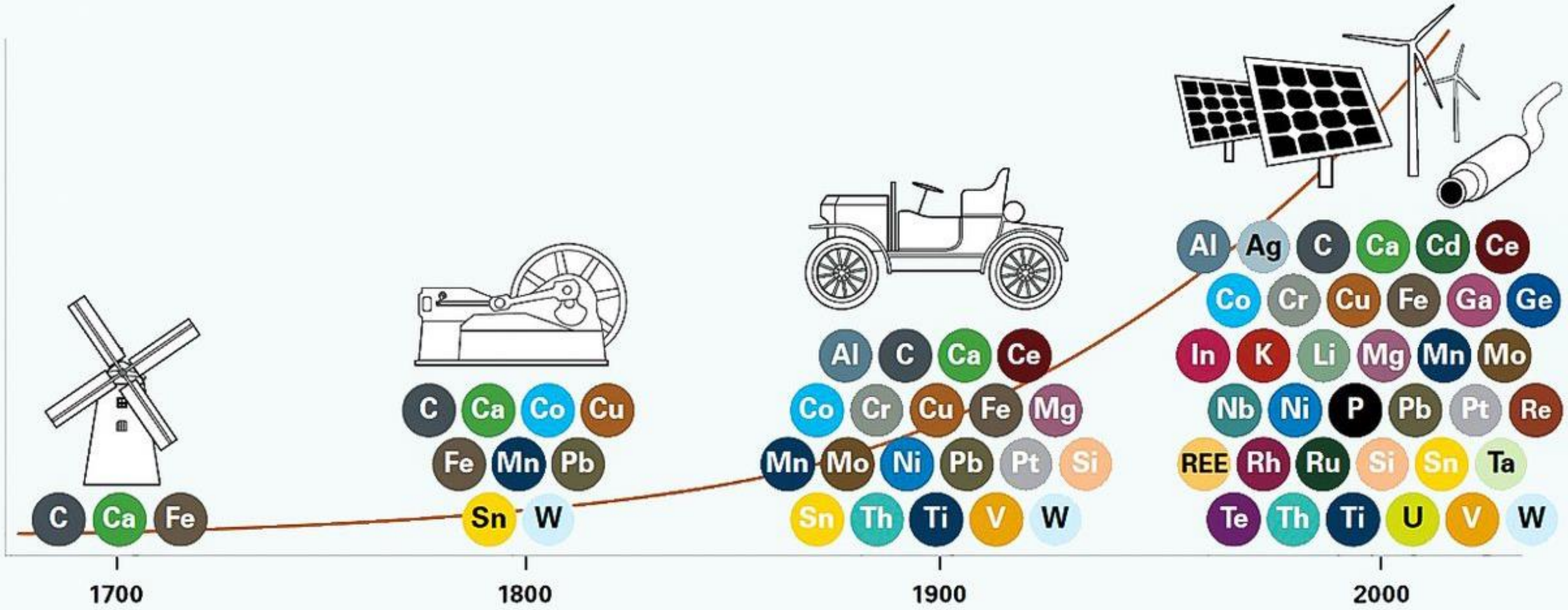
EV and storage batteries reaching the end of their first life



Contribution of recycling and reuse

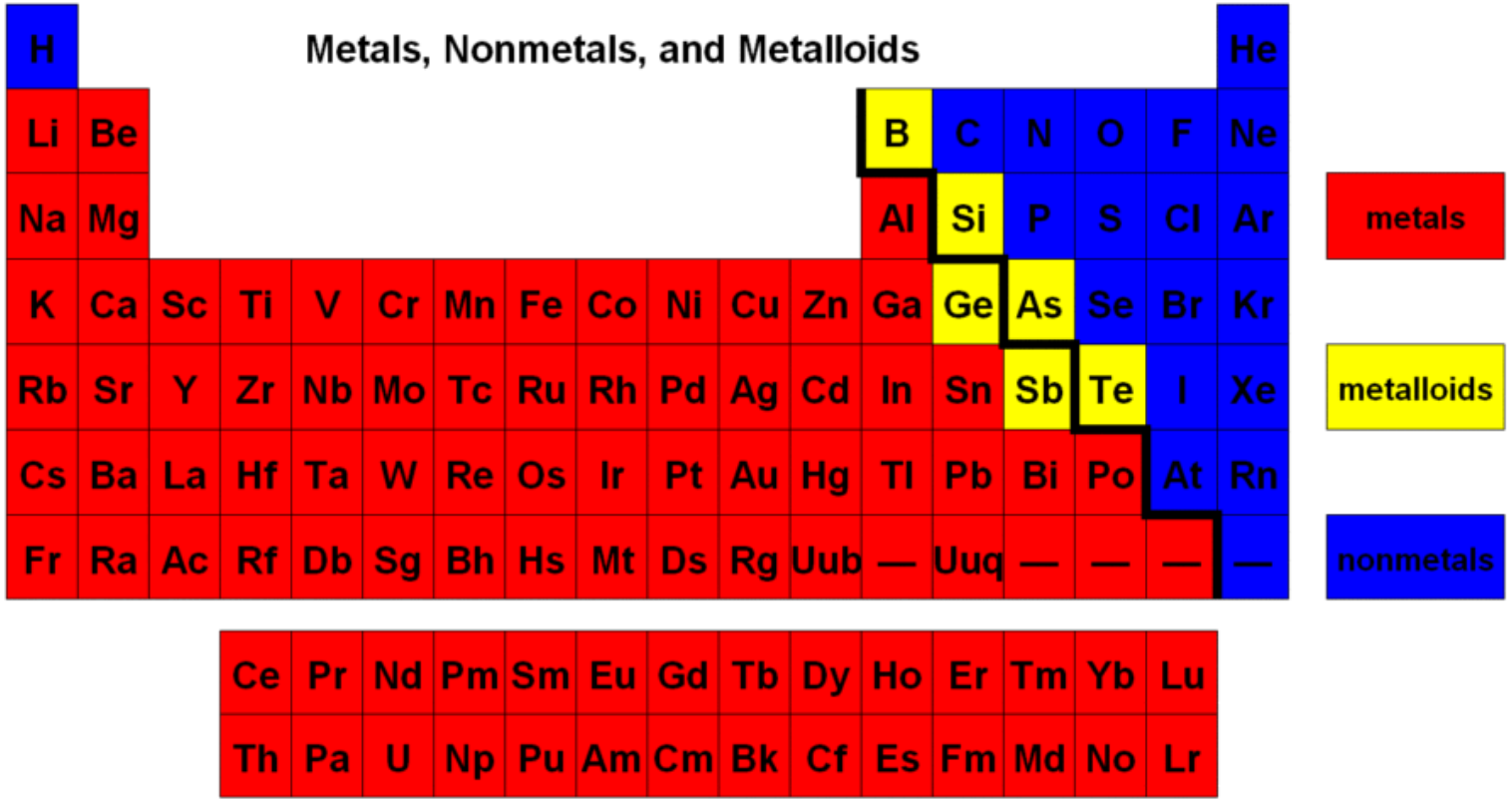
IEA 2021

Increasing complex technology



Achzet et al (2009)

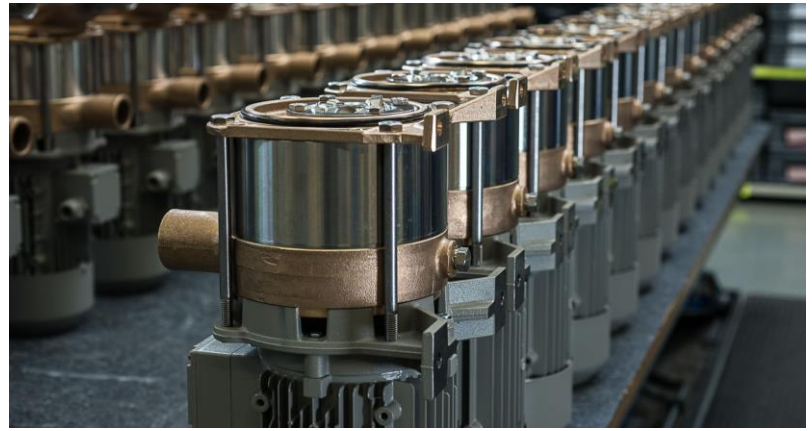
Minerals, Metals and Alloy



Key feature of metals:

- Good conductor of heat and electricity
- Tough and strong
- Malleable and ductile

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 alloys.

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

Iron Ore*
2.6B

LARGEST END-USE

- Steelmaking
- Construction
- Chemicals
- Alloying Agents
- Energy/Batteries
- Magnets
- Electronics
- Other

INDUSTRIAL METALS
181,579,892 tonnes

Aluminum** 68.0M
Chromium 41.0M
Copper 21.0M
Manganese 20.0M
Magnesium** 950K
Zinc 13.0M
Lead 4.3M
Nickel 2.7M
Titanium*** 9.0M
Zircon* 1.2M
Strontium 360K
Uranium 48.3K
Bismuth** 19K
Mercury 2.3K
Beryllium 260

TECHNOLOGY AND PRECIOUS METALS
1,474,889 tonnes

Molybdenum 300K
Lithium 106K
Tungsten 79K
Tin 300K
Rare Earth Oxides 280K
Cobalt 170K
Vanadium 110K
Niobium 75K
Silver 24K
Cadmium 24K
Gold 3K
Tantalum 2.1K
Indium** 920
Gallium 430
Platinum Group Metals 380
Rhenium 59

ELEMENTS

Source: *USGS Mineral Commodity Summaries (2022)*

**Ore production does not reflect actual metal production as metals only make up a certain portion of ores.*

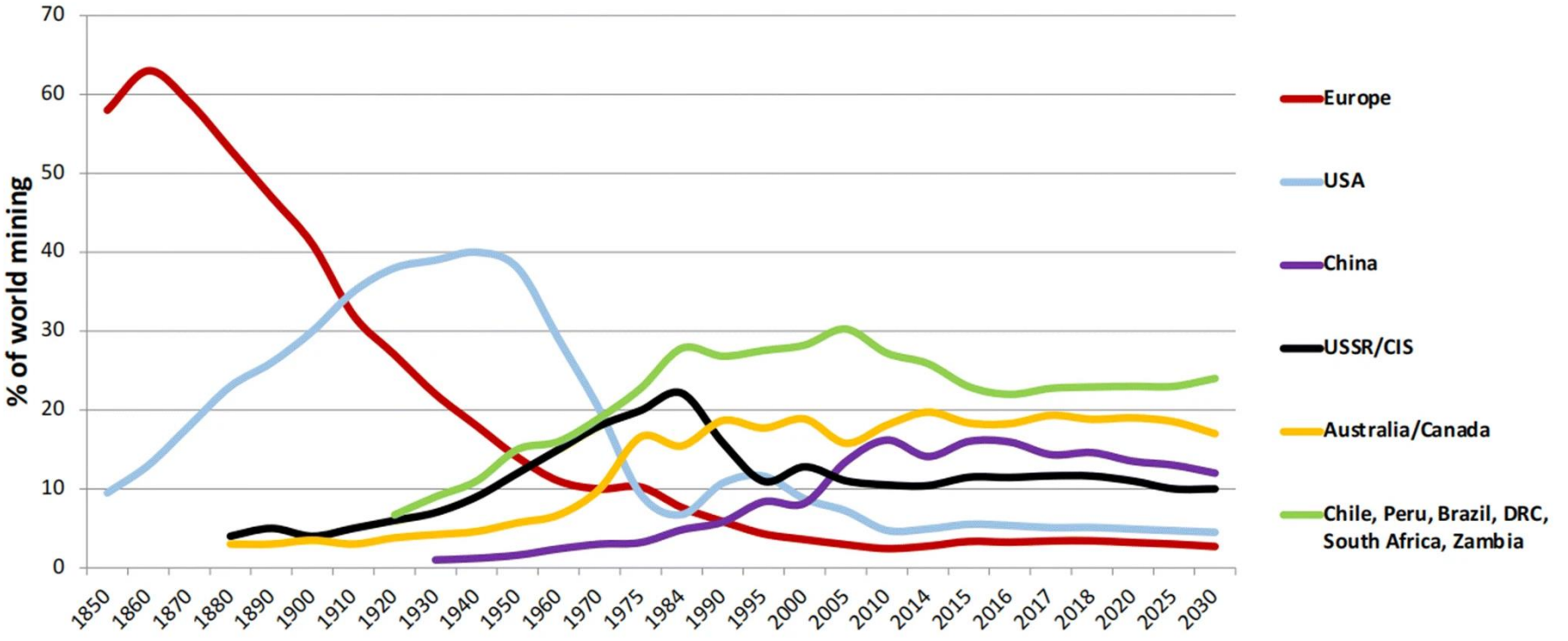
***Smelter/refinery production.*

****Represents titanium mineral concentrate production.*

ELEMENTS.VISUALCAPITALIST.COM

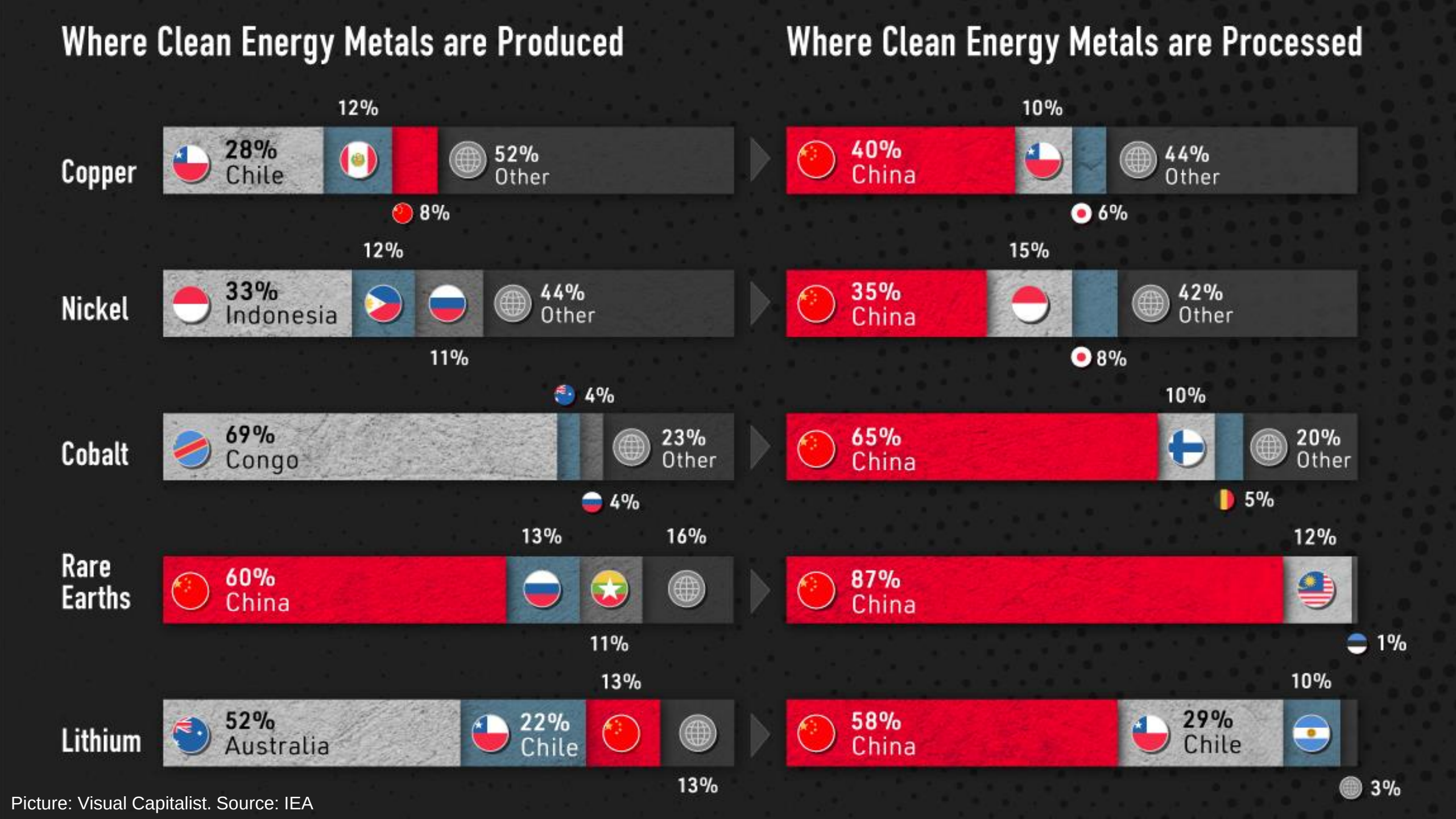
Seabed minerals of highest economical interest ★ "Energy transition minerals" ● Other

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



% of value of total production excludig coal

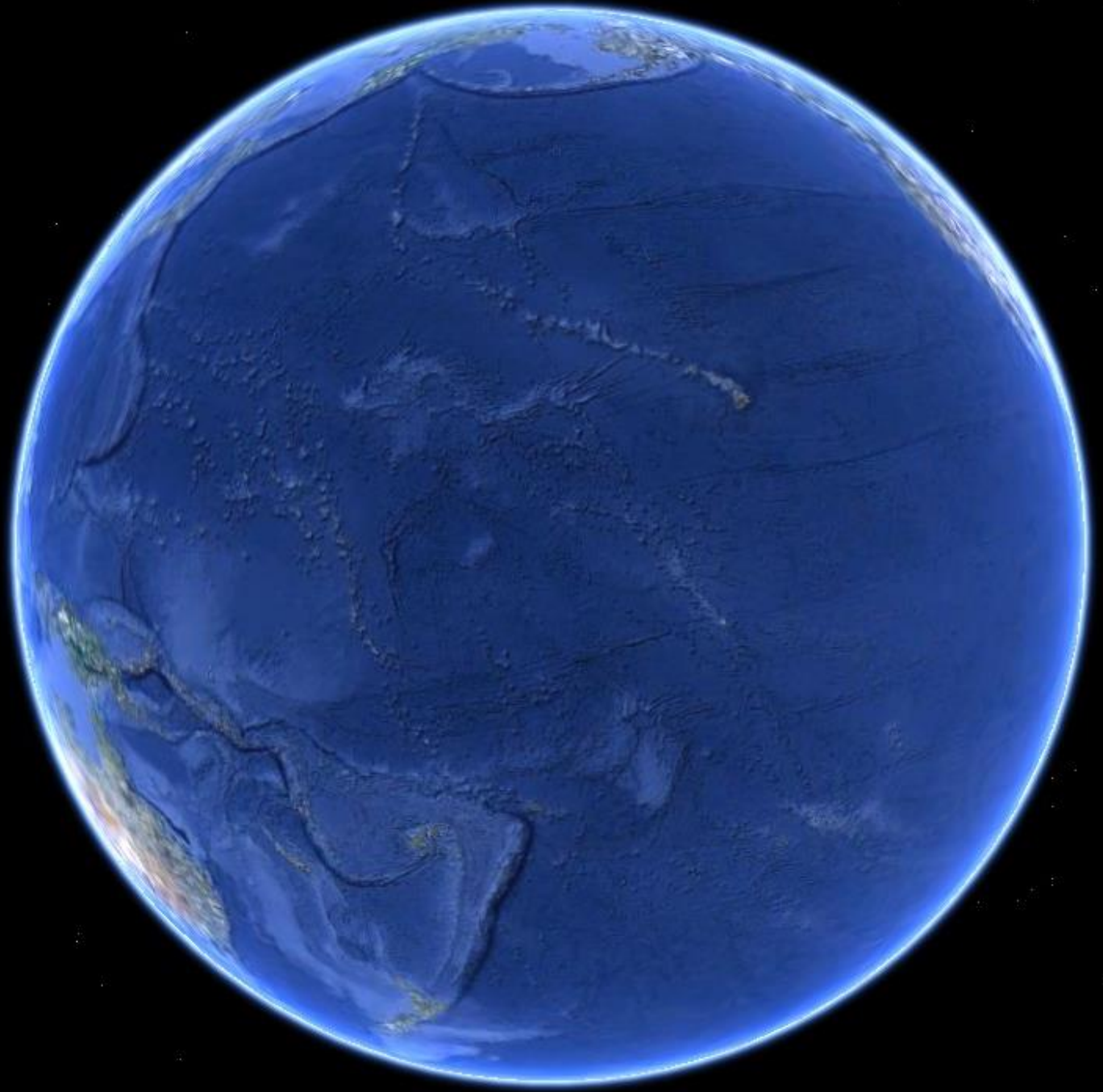
Source: RMG Consulting 2021



Picture: Visual Capitalist. Source: IEA

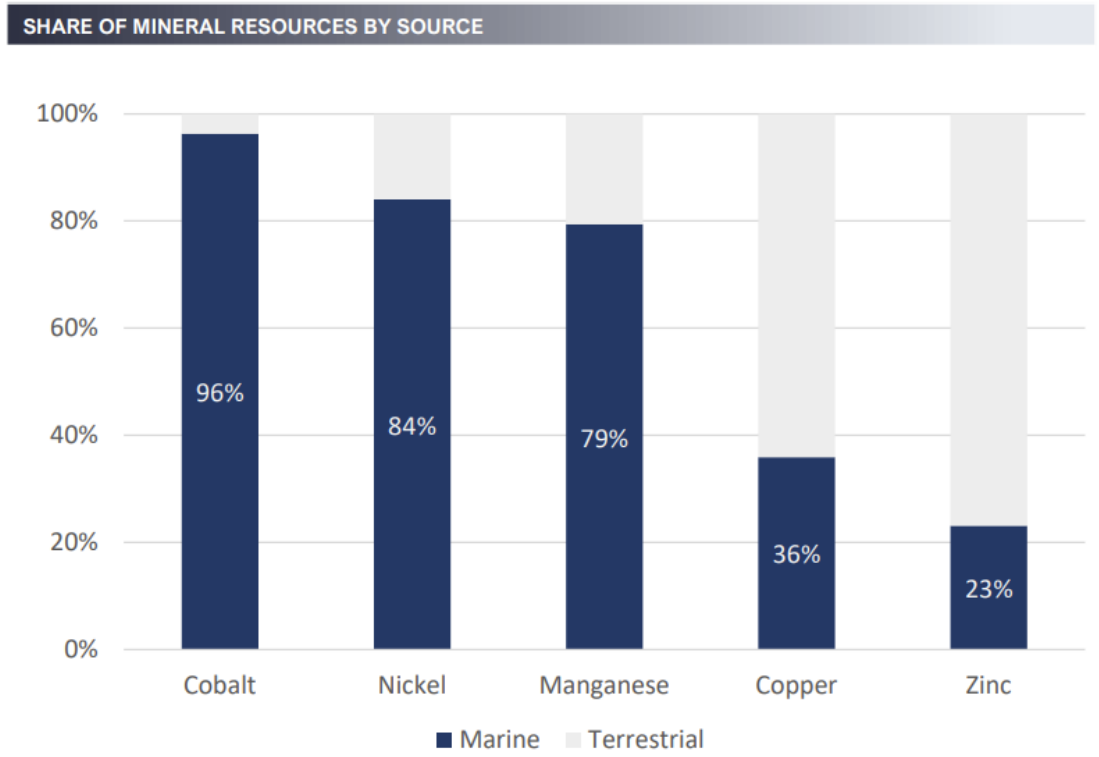
Why investigating marine minerals ?

The Earth…



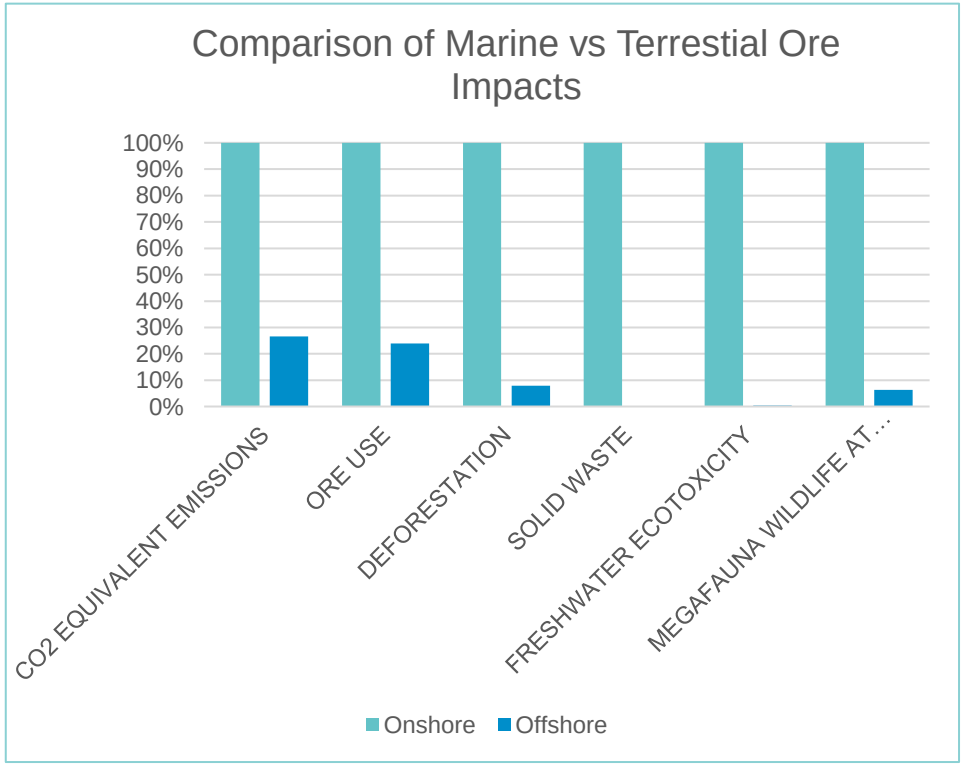
Drivers for marine minerals

- Diversification and security of supply
- Seabed minerals contain mainly “energy transition metals”



USGS

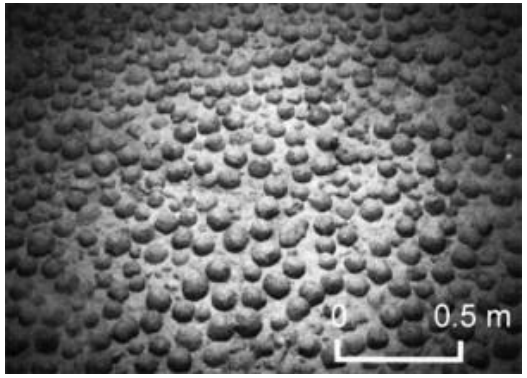
- Higher ore grad at the seabed vs. land
- Minimalize footprint, energy and waste



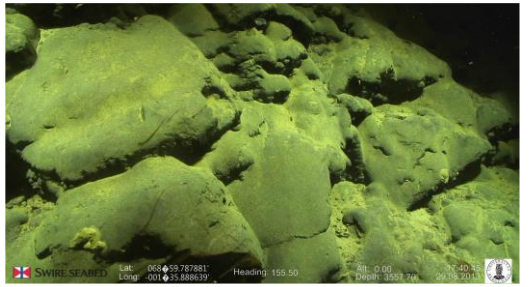
Paulikas et al, 2020 (for nodules)

Different type of deep-sea mineral deposits

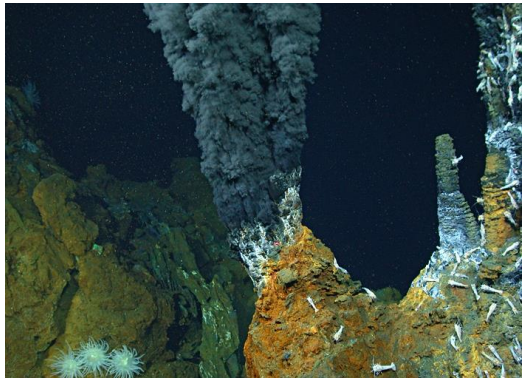
- Polymetalic Nodules
  - Metals: Ni, Co, Cu, Mn, Mo, Fe
  - Located: ~4000 – 6000m, abyssal plains in distal parts of the ocean
  - **2D** deposits in soft seabed (5-25 kg/m^2)
  - Mine size **> 70km^2** per million tons of mined ore



- 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**



Legal Status

Norwegian management of seabed minerals

OLJE- OG ENERGIDEPARTEMENTET

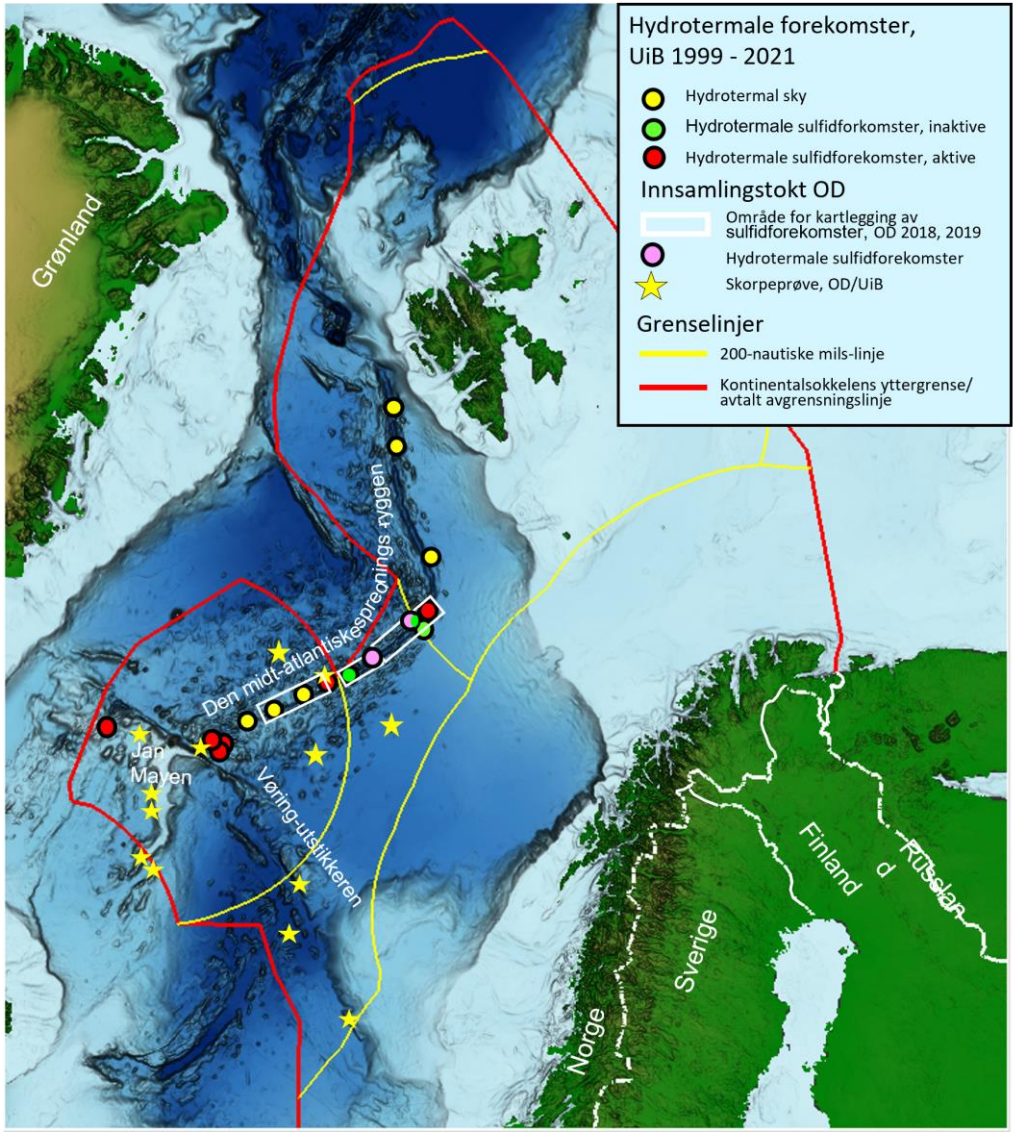
- Managed by the Ministry of Petroleum and Energy, 2017
- “Seabed Minerals Act” entered into force, 2019
- Opening process started, 2020
- Plan for impact assessment, 2021
- Impact assessment published, 2022
  - *«Utvinning av mineraler fra havbunnen kan i fremtiden bli en ny og viktig næring for Norge og samtidig bidra til å sikre den globale tilgangen på viktige metaller»*
  - *«En forutsetning for slik utvinning er at ressursene kan høstes på en lønnsom måte med akseptabel grad av miljøpåvirkning»*
- Basis for decision - Q2 2023

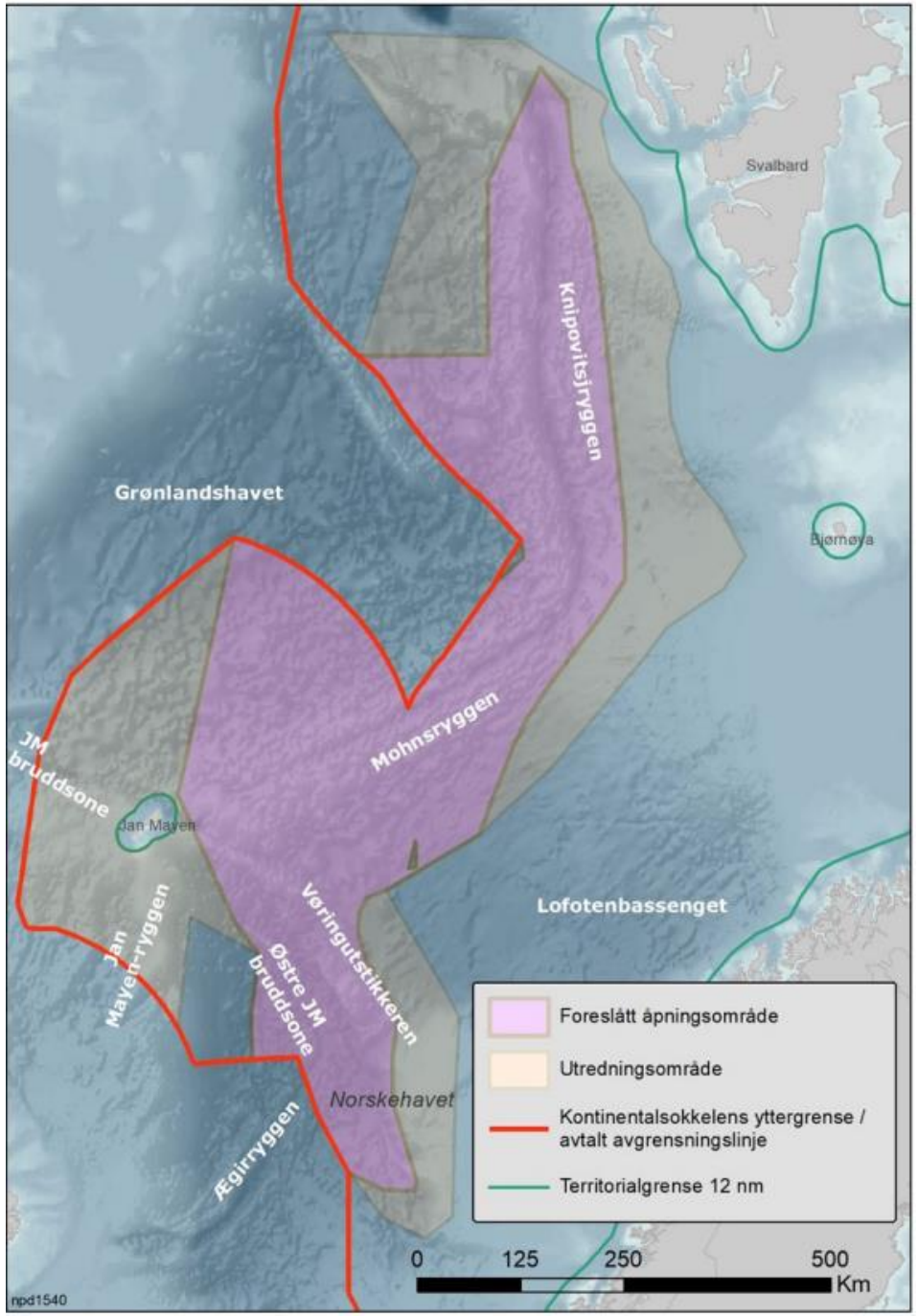
- Norway has signed UNCLOS and national requirement must as a minimum adhere to these requirements

More information: https://www.npd.no/en/facts/seabed-minerals/

Source: Norwegian Ministry of Petroleum and Energy / Norwegian Petroleum Directorate

Seabed Minerals in Norwegian water





Source: Norwegian Ministry of Petroleum and Energy / Norwegian Petroleum Directorate

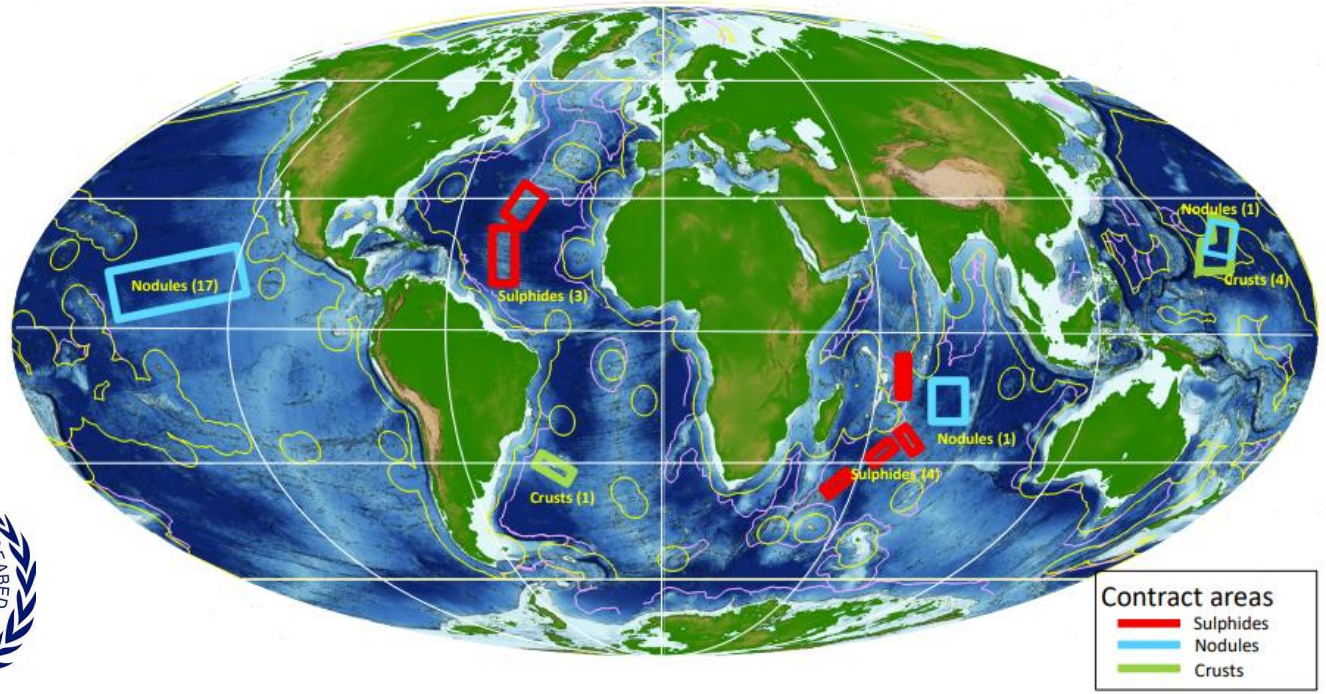
International legislation

- The International Seabed Authority (ISA) manage the seabed minerals in the Area
- ISA is mandated under the United Nations Convention On The Law Of The Sea (UNCLOS)
- 167 Members States and EU

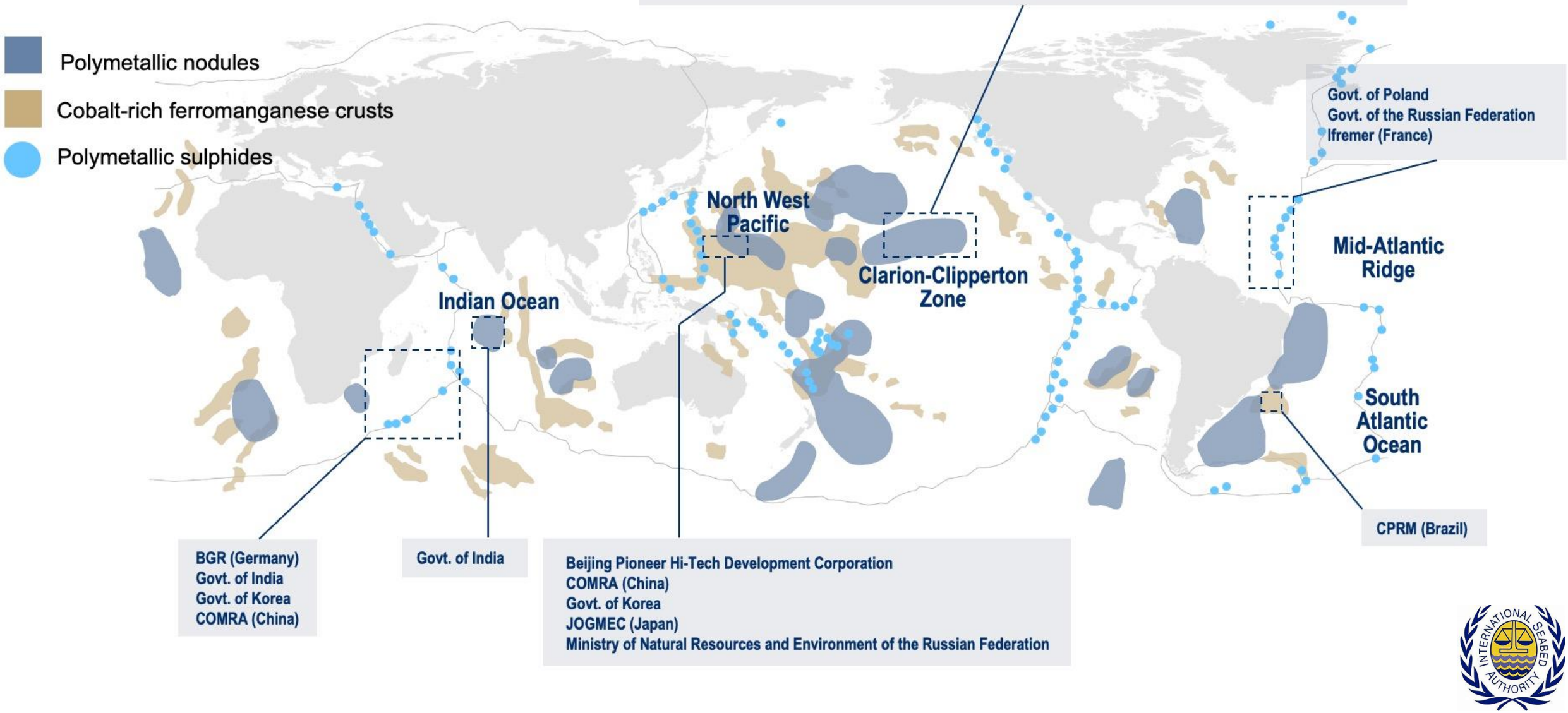
- ISA regulations for exploration put in place during 2000 – 2012
- 31 exploration licenses with 22 contractors – Each contractor backed by a sponsoring state

- Draft version of The Mining Code, June 2018
- Exploitation regulation expected finalized in 2023

- www.isa.org.jm



Exploration for minerals in the Area



Environment

Public perception tend to be

Mining = Bad

Batteries = Good

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

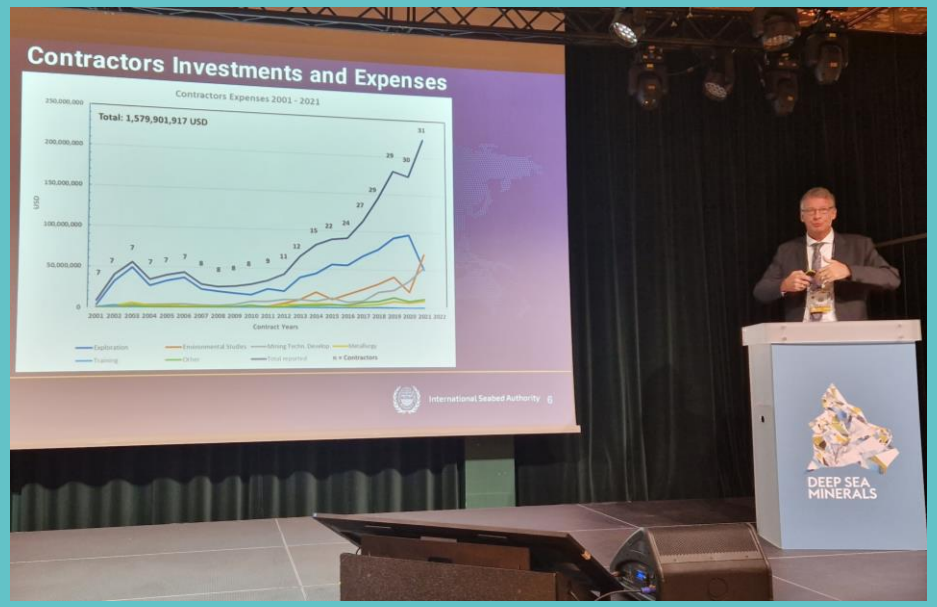
Den norske batteriprodusenten Corvus Energy vokser ut av fabrikken som ble åpnet for to år siden. Samtidig etablerer selskapet en mindre fabrikk i USA for å følge opp Joe Bidens grønne satsing.

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.

Environmental studies

- Total spending on deep-sea exploration in International Waters (“The Area”): USD 1.6 billion
- Environmental studies count for about 50% of the contractor spending
- Contractors are using independent researcher to conduct environmental baseline studies.
- 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



IMPACTS AND RISKS OF DEEP SEA MINING
MiningImpact
FUNDED THROUGH JPI OCEANS

Seabed Minerals – Positive contribution to SDG

Access to critical minirals is key for the energy transition.

The higher climate ambition – the higher need for minerals

Important to build knowledge and foster innovation to minimise environmental impact

Remote operations

Avoid ground water polutions

Supporinting skilled labor and economic growth

Key input to renewable energy and high-tech

High ore grade → more responsible production

Reduces environmental impact on land

Diversification of supply → reduce potential for geopolitical conflict

Collaboration between researcher, private and public

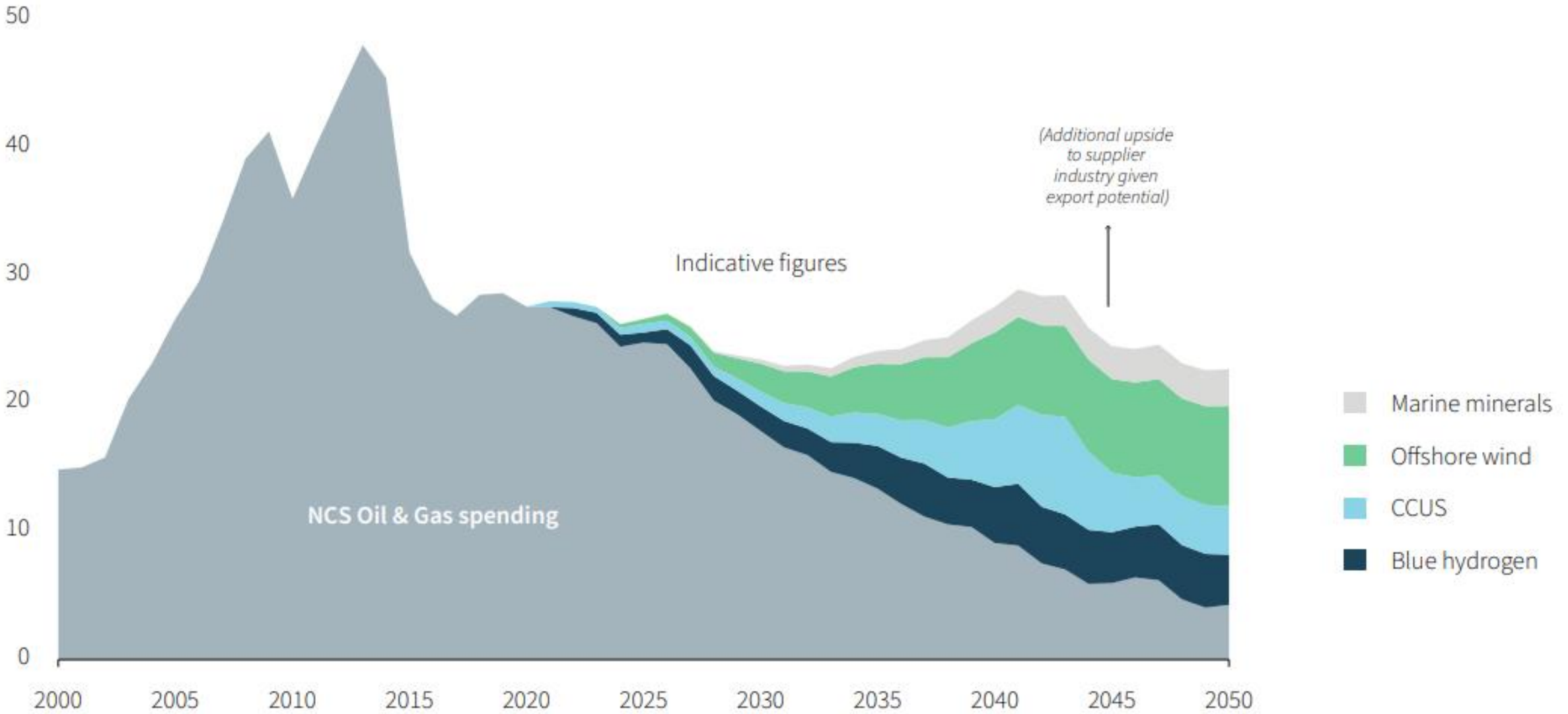
Adapted from: [ISA_Contribution_to_the_SDGs_2021.pdf]

Value creation potential

Timeline

Norway in a unique possition

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

New Value Chain Possibilities

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.

E24

Prosessindustrien kan doble eksportverdien innen 2030

Oljetopp om Norges massive mineralressurser: – Vi kan ha skutt gullfuglen igjen

180 milliarder kroner i årlige inntekter og 21.000 nye arbeidsplasser er hva Norge kan sikre seg hvis man får til utvinning av mineraler fra havbunnen. En fersk prognoserapport fra Rystad Energy spår kraftig vekst fremover.

E24

Foto: Hydro

Kilde: Prosess21

Possible timeline in Norway

Full scale production

Opening

Pilot project

Appraisal - Coring

Environmental and resources exploration

Sustainability, ESG, environmental baseline, environmental monitoring and mitigation

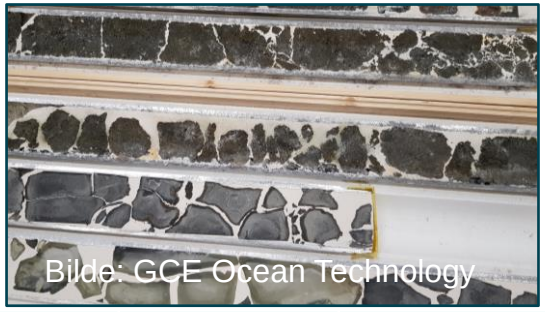

Bilde: Havforskningsinstituttet


Bilde: Oljedirektoratet


Bilde: GSR


Bilde: AllSeas

Bilde: UiB


Bilde: GCE Ocean Technology


Bilde: GSR


Bilde: Adepth Minerals

2023	2024	2025	2026	2027	2028	2029	2030	2035	2040

Norway in an unique possition

Resouces

Foto: Jon Hellevang / GCE Ocean Technology

Proven mineral resources on NCS.

Large sea areas where minerals are deposited.

Technology and knowledge

Foto: Øyvind Knoph Askeland, Offshore Norge

World-class offshore know-how.

Technology transfer opportunities.

Management

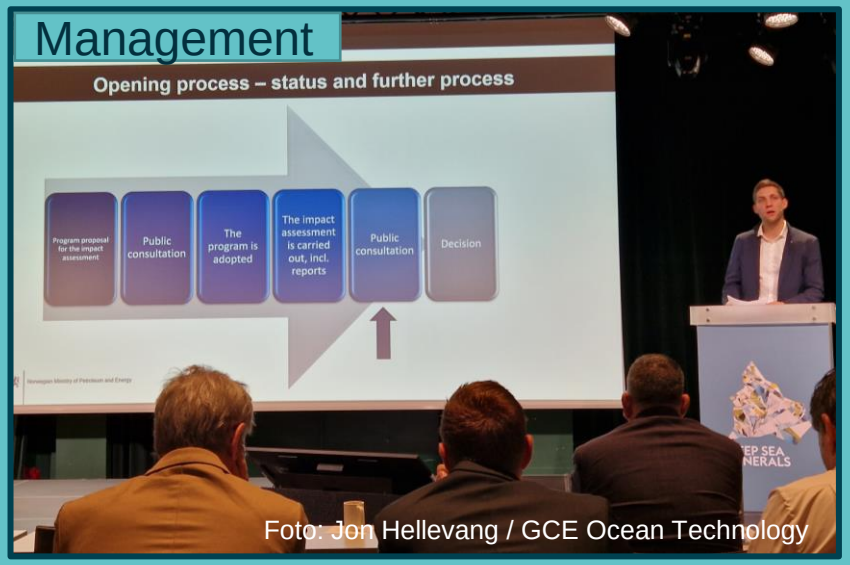


Foto: Jon Hellevang / GCE Ocean Technology

Long and good experience with management of marine resources. Established legislation.

High ESG standard.

Good HSE experience from petroleum.

Value chain

Foto: Hydro

World-class process industry. Possibility to establish an integrated and complete value chain.

Strong International Competition

- Nodules in the Pacific (CCZ) looks to be the first in the pipeline
- GSR (Belgium) - Patania II trial in 2021
- The Metals Company and Allseas pilot test Q4 2022
- Towards full scale production by the end of the decade

GSR
Global Sea Mineral Resources

Photos: GSR, Patania II test, 2021

the metals company

Allseas Transforming Drillship to Seafloor Mining Vessel

March 3, 2020, by Subsea World News

Allseas has acquired the former 228 meters long ultra-deepwater drillship Vitoria 10000 for conversion to a polymetallic nodule collection vessel.

In partnership with DeepGreen Metals, Allseas is developing a deep-sea mineral collection system to recover polymetallic nodules from the ocean floor and transfer them to the surface for transportation to shore.

The Metals Company and Allseas pilot. 3000 tonn nodules collected from NORI-licence in the Pacific, Q4-2022

Project Examples

GCE Ocean Technology

EcoSafe Ridge Mining

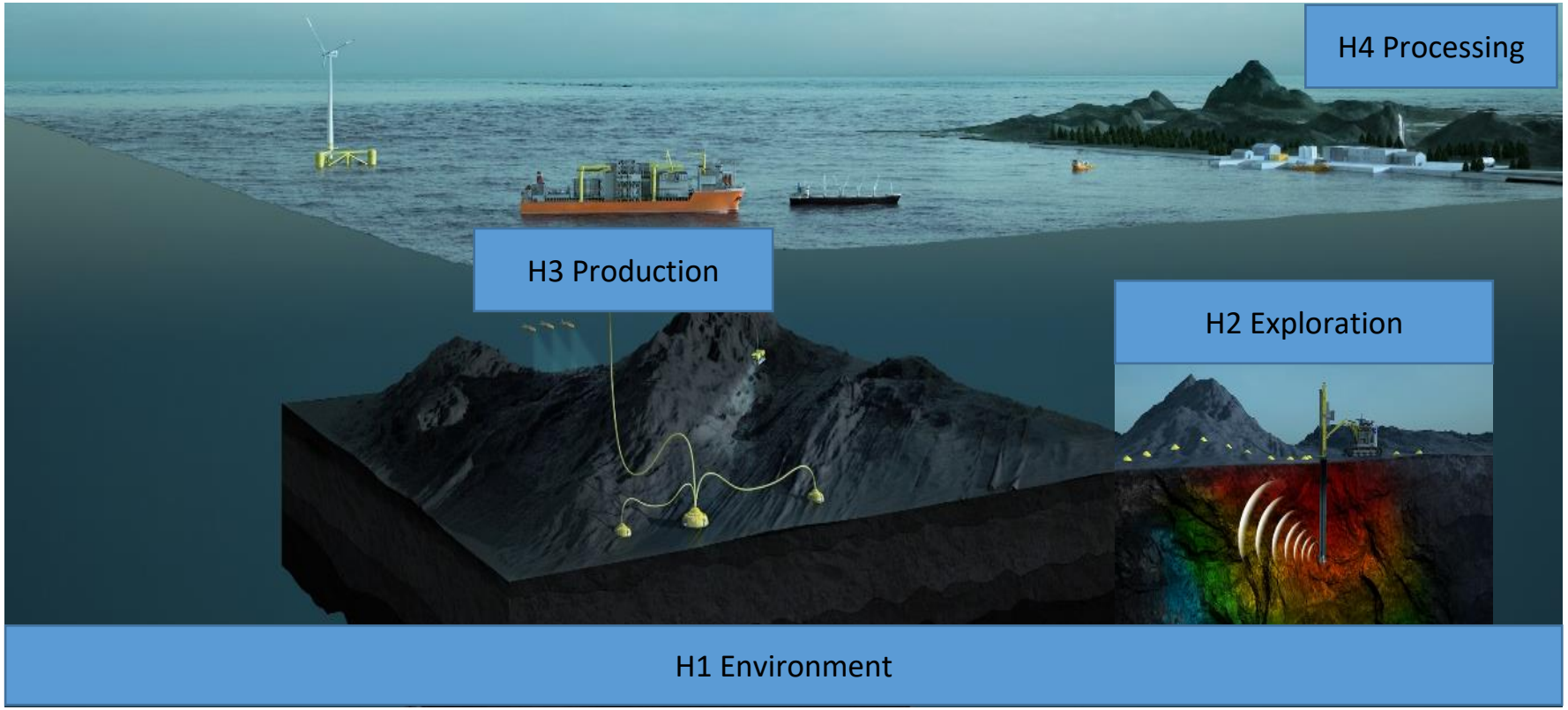
- Address knowledge gaps regarding benthic ecosystems associated with mineral deposits
- Investigate potential environmental risk and impacts from deep-sea mining
- Assess the possibility of environmentally responsible deep-sea mining in Norway

Picture: Courtesy of UiB

The Research Council of Norway

Universitas Bergensis · Universitetet i Stavanger · NORCE · NIOZ · GCE Ocean Technology · Norsk olje&gass · AANDERAA a xylem brand · equinor · LOKE Marine Minerals · Adepth minerals

Seabed Minerals – Accelerating the energy transition



Prosjektpartnere:
Adepth Minerals
DeepOcean
NOV
Future Materials Catapult
Seabed Solutions
Aker BP
ShearWater
Aanderaa/Xylem
Geoprovider
NORCE
UiB
UiT
NTNU
Akvaplan NIVA
GCE Ocean Technology

Establish the basis for an integrated value chain for seabed minerals, with the target of 80% reduced environmental footprint compared to current land-based mining.

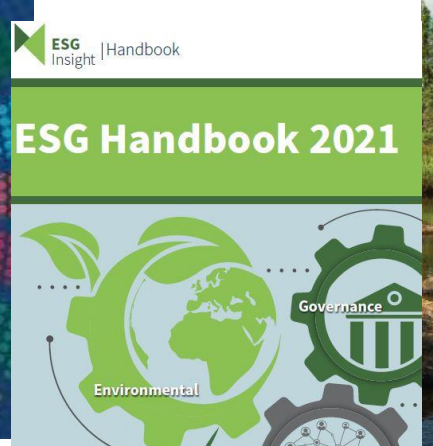
Funded: 70,8 MNOK
Total cost: 139 MNOK

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)



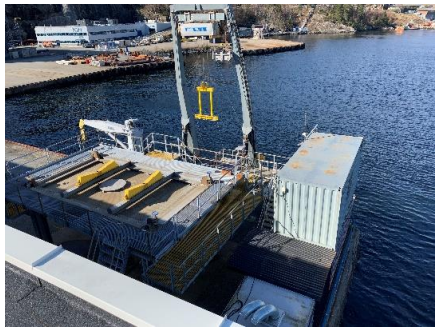
Joint test site/facilities

- Establishment basis for joint national test infrastructure for marine minerals
- Time 2022 - Q1 2023
- Project owner: Ocean Innovation Catapult
- Project manager: Jon O. Hellevang, GCE Ocean Technology
- Sub-suppliers: EY, SINTEF, NUI
- Funded by : siva

Steering group:

- Bjarte Horn (leder)
- Lars Sørum (SINTEF)
- Rolf Birger Pedersen (UiB)
- Martin Ludvigsen (NTNU)
- Rolf Røssland (NUI)
- Andries Ferla (Deep Ocean)
- Egil Tjåland (NMM)

- Stig Morgen Knutsen (OD) – Observer
- Jon Johansen (SIVA) – Observer



OCEAN INNOVATION | NORWEGIAN CATAPULT CENTRE

Recommendation for Norwegian Actions

Framework that makes it predictable and attractive to invest.

MM21

Establish a national R&D strategy with dedicated funding (*)

Integrated focus on sustainability and ESG.

Establish holistic and integrated value chains. Avoid "silos" between national strategies and ministries.

Establish world-class R&D infrastructure and test facilities.

Strengthen cooperation between environmental and resource mapping.

Strengthen international collaboration. Become an ISA sponsor state.

Establish technology transfer program. Support larger pilot projects.

Strengthen interdisciplinary collaboration between industry, research and the public sector.

(*) After model from OG21, DEMO2000 & Petromaks. France spend 3.5 billion up to 2030 – Norway should at least have similar ambitions.

From: Test infrastructure study for Siva.

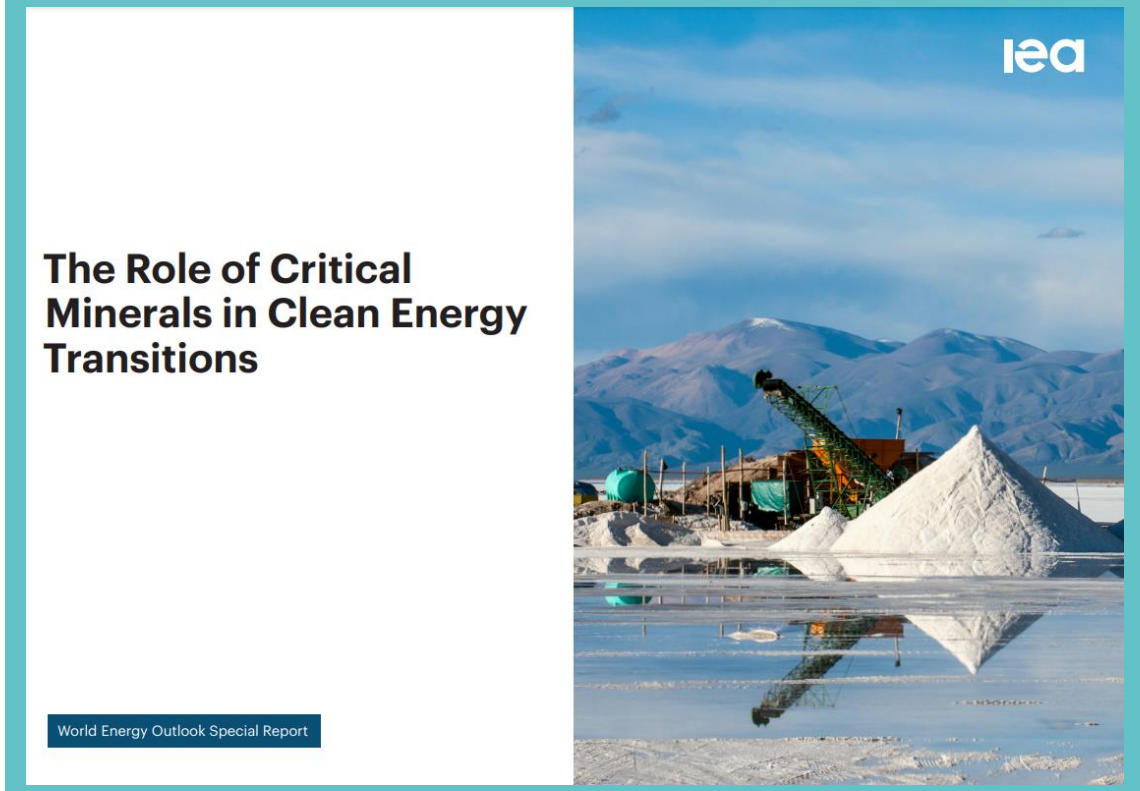
Summary

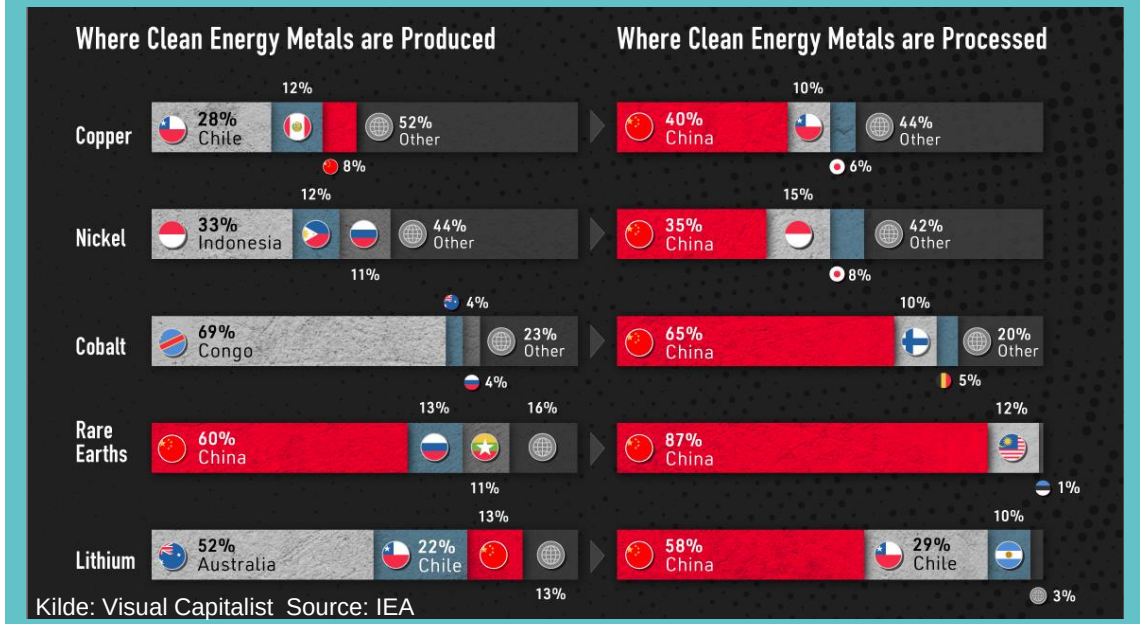
Summary

- The energy transition → Increased demand for minerals
- Diversification and security of supply → More mining in Norway/Europe
- Sustainability and ESG → Exploring better mineral sources

Drivers for seabed minerals:

- Higher ore grade of minerals critical to the energy transition at the seabed vs. land
- Critical minerals for the energy transition are abundant at the seabed
- Rapid technology development
- Environmental aspects needs to be explored further





Kilde: Visual Capitalist Source: IEA

Keep posted

- Weekly newsletter
- Invitations to all events
- Invitations to relevant cluster projects

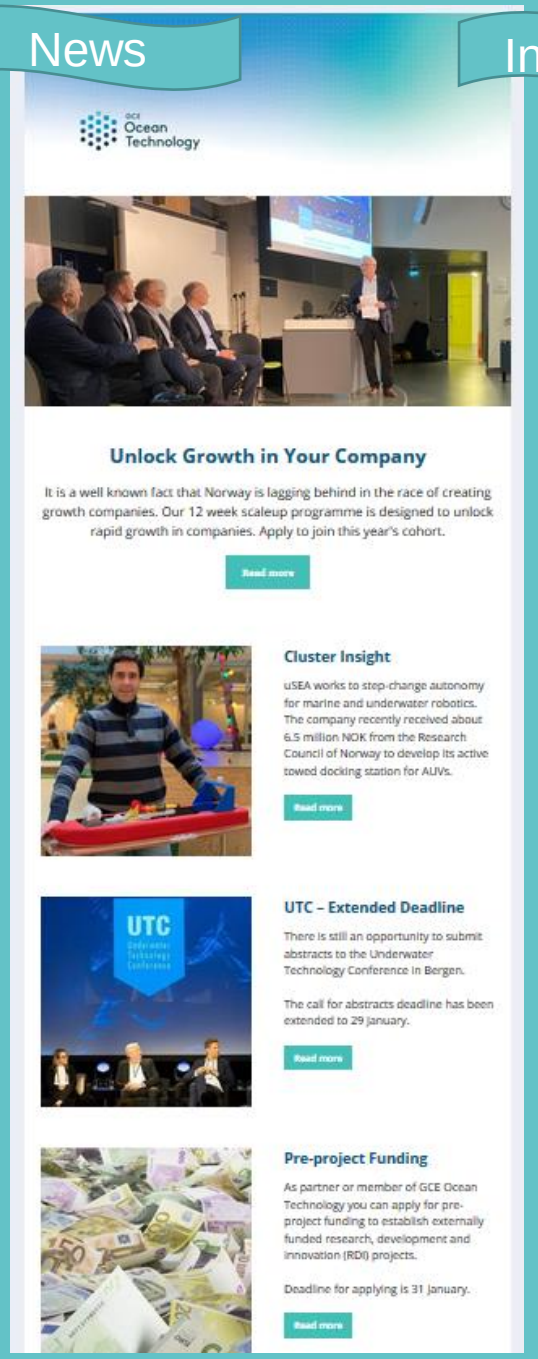
www.gceocean.no/events/
www.gceocean.no/news/newsletter/

Related event:

- Accelerating Deep Sea Exploration
- Bergen 19 April kl.09:00-16:00

https://www.gceocean.no/events/posts/2023/april/accelerating-deep-sea-exploration/

News



Invitations