SYSTEMIQ

CRITICAL RAW MATERIALS FOR THE ENERGY TRANSITION IN THE EU:

HOW CIRCULAR ECONOMY APPROACHES CAN INCREASE SUPPLY SECURITY FOR CRITICAL RAW MATERIALS

SUMMARY PRESENTATION OCTOBER 2022

STUDY OVERVIEW

PURPOSE:

The EU is committed to the clean energy transition. This transition will require significant amounts of raw materials to create the infrastructure for electrification and clean energy production. This study highlights the importance and the opportunities for circular economy approaches to enable this transition. It demonstrates the increased resilience that can be gained in the context of ongoing geopolitical crises.

METHODOLOGY:

- Synthesis of published research on international value chain dependencies of the EU with particular focus on materials (raw and processed) that are crucial for the green energy transition. (Lithium, Nickel, Cobalt, Copper, Graphite, Silicon, Platinum Group Metals, Rare Earth Elements).
- Synthesis of published research on circular economy practices and legislative intervention points to ensure sustainable use of these raw materials and their continued stewardship in the European economy.

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Achim Teuber, **Leonardo Buizza** (Systemiq)

KU Leuven for their 2022 milestone study "Metals for Clean Energy: Pathways to solving Europe's raw materials challenge". Besides countless other sources that were used in the making of this work, this report stands out as particularly relevant.

Date: June – September 2022

PREFACE

JANEZ POTOCNIK

Systemiq partner and Co-Chair of the International Resource Panel

We urgently need to decouple our well-being from greenhouse gas emissions and resource consumption. Metals and minerals are critically needed for the energy transition, but science is also clear that without a deep system change of the current economy leading to an important reduction in overall resource consumption, in particular in high-income countries,, the Paris Climate Goals are out of reach. We need to move from an economy considering humans as external and superior to nature to an economy acknowledging that we are embedded with nature. As this study describes, Circular Economy strategies can help us achieve the mentioned goals and make our economy more resilient.

JOSS BLÉRIOT

Head of Institutions and Governments, Ellen MacArthur Foundation

The urgent and necessary move to a low carbon economy is as much a hardware story as it is an energy source one. Given the material impact of revamping power generation and mobility systems, it is imperative to include a broad set of circular economy strategies in the transition plan, to reduce demand pressure and decrease supply risks.

SUMMARY

1

Fossil fuels have powered human progress in the last 200 years - **but Europe now has a pathway and commitment to transition to clean energy and mobility and reach net-zero greenhouse gas emissions by 2050.**

2

New mining and refining of minerals and metals will be required to enable the transition to renewable energy and mobility systems in Europe – **but the overall environmental footprint and resource demand in this new system will still be far lower than our current fossil-fuel intensive system.**

3

There are ample deposits of minerals globally to power the energy and mobility transition – **but the mining and processing of these minerals is generally happening outside Europe** (e.g. Lithium, Nickel, Cobalt, Copper, Graphite, Silicon, Platinum Group Metals, Rare Earth Elements).

4

Supply chain resilience and domestic production of critical metals are key priorities to enable the transition to net zero in Europe, already recognised in the forthcoming European Critical Raw Materials Act.

5

In addition, circular economy approaches can play a critical role by "flattening the curve" of demand for primary metals:

- **Rethink**: Promote access over ownership and create demand-side reduction through systemic change
- **Reduce**: Substitute and optimise resources and material
- **Reuse**: Extend product life to keep materials in longer circulation
- **Recycle**: Invest in high-quality recycling to bring the material back into circulation

6

The research carried out for this study has identified critical gaps in research and knowledge on the potential for circular economy approaches to reduce demand for primary raw materials, and how policy changes and industry actions could scale-up these approaches to enable the clean energy and mobility transition in Europe.

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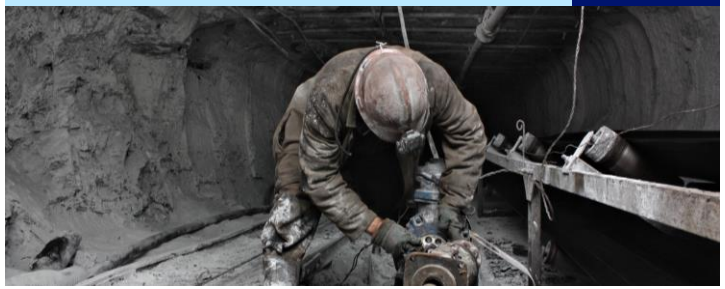
OUR CURRENT SYSTEM IS BASED ON FOSSIL FUELS – BEARING HIGH CONSEQUENCES FOR HUMANS, NATURE & THE ECONOMY

RAW MATERIAL SOURCING

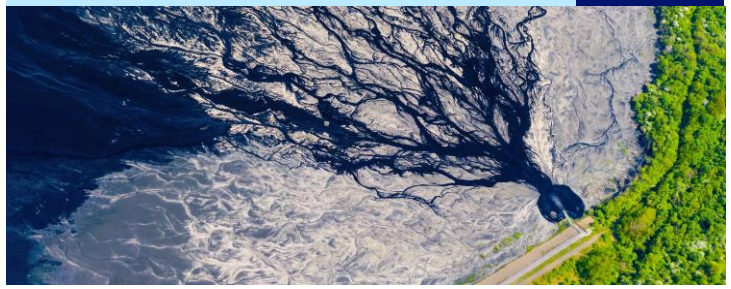


- Per year we extract 4 billion metric tons of oil (2020), 8 billion tons of coal (2020) and 3.85 trillion cubic meters of gas (2020)[1]
- Extraction and trading of oil, coal and gas is associated with well document geopolitical and security risks as well as social, human rights, economic and environmental impacts in source countries worldwide

RAW MATERIAL NEED FOR ENERGY PRODUCTION

- Fossil fuels account for ~84% of global energy consumption (oil 33%, coal 27%, gas 24%)
- Burning of fossil fuels generates ~137,000 TWh of energy each year
- Two sectors consuming large shares of fossil fuel based energy are transportation (28%) and industry (26%)

SYSTEM CONSEQUENCES



- Burning fossil fuels emit about 36 giga tonnes of CO2 in 2021
- 5 million deaths are caused by air pollution each year
- The financial costs stemming from air pollution were estimated at USD $2.9 trillion due to e.g., work absence or healthcare costs

WE URGENTLY NEED TO TRANSITION TO A CLEAN ENERGY AND MOBILITY SYSTEM BASED ON RENEWABLES

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1: This does not include additional materials needed for the fossil industry
Source: Our world in data (2021), Energy mix; IEA (2021), Coal 2021; Statista (2022), Leading countries based on natural gas production in 2020; EIA (2021), Top producers and consumers of oil; Statista (2022), Consumption of primary fossil fuel energy in the United States from 1990 to 2021, by sector; Energy & Clean air (2020), Quantifying the Economic costs of air pollution from fossil fuels; IEA (2022), Global energy review

AN ENERGY & MOBILITY SYSTEM BASED ON RENEWABLES IS BETTER THAN THE CURRENT FOSSIL FUEL BASED SYSTEM

FOSSIL FUEL-BASED SYSTEM

- Inputs in the current, linear system are lost entirely after use, creating the need to extract ever more resources to secure production
- Growth is dependent on finite resources; high material demand overall
- Highly polluting (e.g., high carbon footprint)
- EU dependency on fossil fuel producing countries (potentially creating a supply risk and capability/talent shortage)
- High financial investment needed to cover future demand

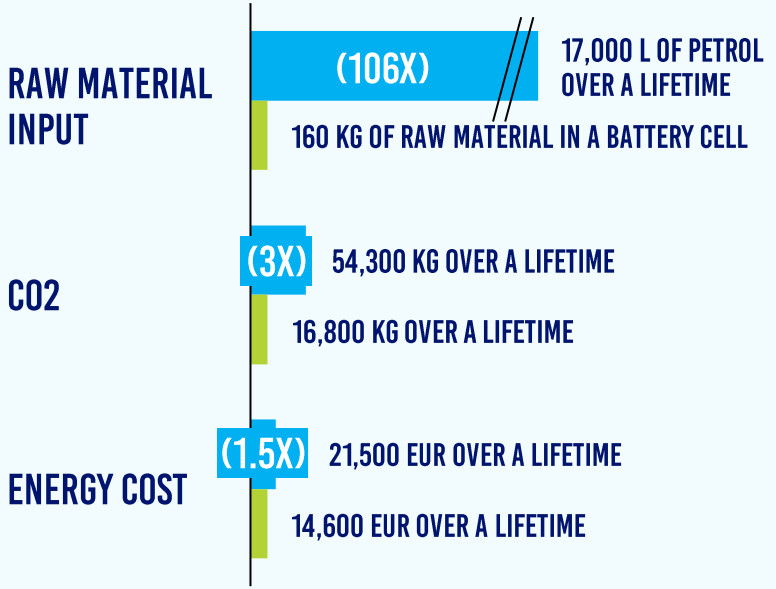
RENEWABLE ENERGY SYSTEM

- Renewable energy system has potential to operate indefinitely by keeping materials in circulation longer, reusing them in other applications or recovering them at end of life
- Potential to decouple growth from finite resources and reduce material demand overall
- Lower carbon footprint
- Creating EU autonomy in terms of producing raw materials domestically and creating skills/capabilities within the EU
- Significantly lower cost to cover future energy demand

INTERNAL COMBUSTION ENGINE VEHICLE (ICEV)

BATTERY ELECTRIC VEHICLE (BEV)

Use case: Mobility / passenger vehicles[1]



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Note: 1. For a medium car, e.g. Volkswagen Golf where the battery is made in the EU and the car is driven within the EU compared to a gasoline powered car driven over 225,000 km, 2. Demand for cathode materials lithium, cobalt, nickel only

Source: Systemiq; Transport & Environment (2021), Batteries vs oil: A comparison of raw material needs; Transport & Environment (2022), How clean are electric cars?

SHARE OF RAW MATERIALS NEEDED FOR ELECTRIC VEHICLES

MATERIAL NEEDED FOR ELECTRIC VEHICLE BATTERIES

Absolute amount of material needed in 400kg sample weight single battery and relative share, including functions

32% ALUMINIUM (126KG)
Used i.e. for battery packaging

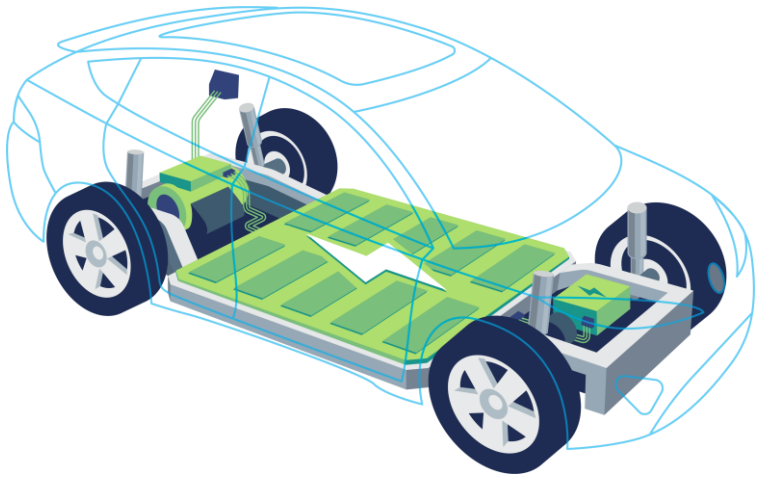
18% GRAPHITE (71KG)
Important for anode electrode material

10% NICKEL (41KG)
Used i.e. as hydroxide compounds in batteries

9% ELECTROLYTE (37KG)
Used inside batteries as transporting substance

6% COPPER (22KG)
Mostly used in wires and as collector foil at anode

5% PLASTIC (21KG)
Used in various applications



3% MANGANESE (12KG)
Used in cathode materials

2% COBALT (9KG)
Used in cathode materials

2% ELECTRONICS (9KG)
Used for managing the battery system

2% LITHIUM (8KG)
Used as lithium-cobalt inside Li-ion batteries

1% STEEL (3KG)
Used for battery packaging

10% RESIDUAL (41KG)

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1: assuming same material share for 2050 as for 2020, Evolving metals demand
Source: KU Leuven (2022): Metals for clean energy – Policymaker summary; Clean Energy Wire (2021): Green resources, r3euse and recycling are key to cleaner e-car batteries – Volkswagen Group Components. https://www.cleanenergywire.org/factsheets/green-resources-reuse-and-recycling-are-key-cleaner-e-car-batteries; European Commission (2020): Critical Raw Materials for Strategic Technologies and Sectors in the EU – A Foresight Study, https://rmis.jrc.ec.europa.eu/uploads/CRMs_for_Strategic_Technologies_and_Sectors_in_the_EU_2020.pdf; Picture: Laserax (2022): Electric Vehicle Battery Cells Explained, https://www.laserax.com/blog/ev-battery-cell-types; Dragonfly Energy (2021): What is Battery Electrolyte and How Does it Work?, https://dragonflyenergy.com/battery-electrolyte/. ; Markets and Markets (2020): Plastics for Electric Vehicle Market, https://www.marketsandmarkets.com/Market-Reports/electric-vehicle-plastic-market-219387183.html; American Iron and Steel Institute (2021): Steel industry role in the future of electrified vehicles, https://www.steel.org/wp-content/uploads/2021/04/2021-Electrification-White-Paper-final-4-14-21.pdf

SHARE OF (CRITICAL) RAW MATERIALS NEEDED FOR SOLAR PVS

MATERIAL NEEDED FOR SOLAR PVS

Absolute amount of material needed in 24kg sample weigh Solar PV and relative material share, including function

SHARE OF MATERIAL NEEDED IN C-SI-PV PANEL

74% GLASS COVER (17.8KG)
Used to protect components and strengthen the module

10% ALUMINIUM FRAME (2.4KG)
Because of its light weight used to strengthen the solar PV

7% ETHYLENE VINYL ACETATE (1.7KG)
Used as laminator for vacuuming cells

4% PLASTIC BACKING (0.96KG)
Used to i.e. protect the solar module

CONSTRUCTION OF SOLAR PV

SHARE OF MATERIAL NEEDED IN C-SI-PV PANEL

92%

3% SOLAR CELL (0.72KG)
Used to convert sunlight into electrical energy

2.7% SILICON (0.66KG)
Used as semiconductor in solar cell because of its cost- and energy-efficiency

1% ADHESIVE, POTTING COMPOUND (0.24KG)
Used to glue together lass and metal

1% COPPER (0.24KG)
Used in PV panel for i.e. cabling

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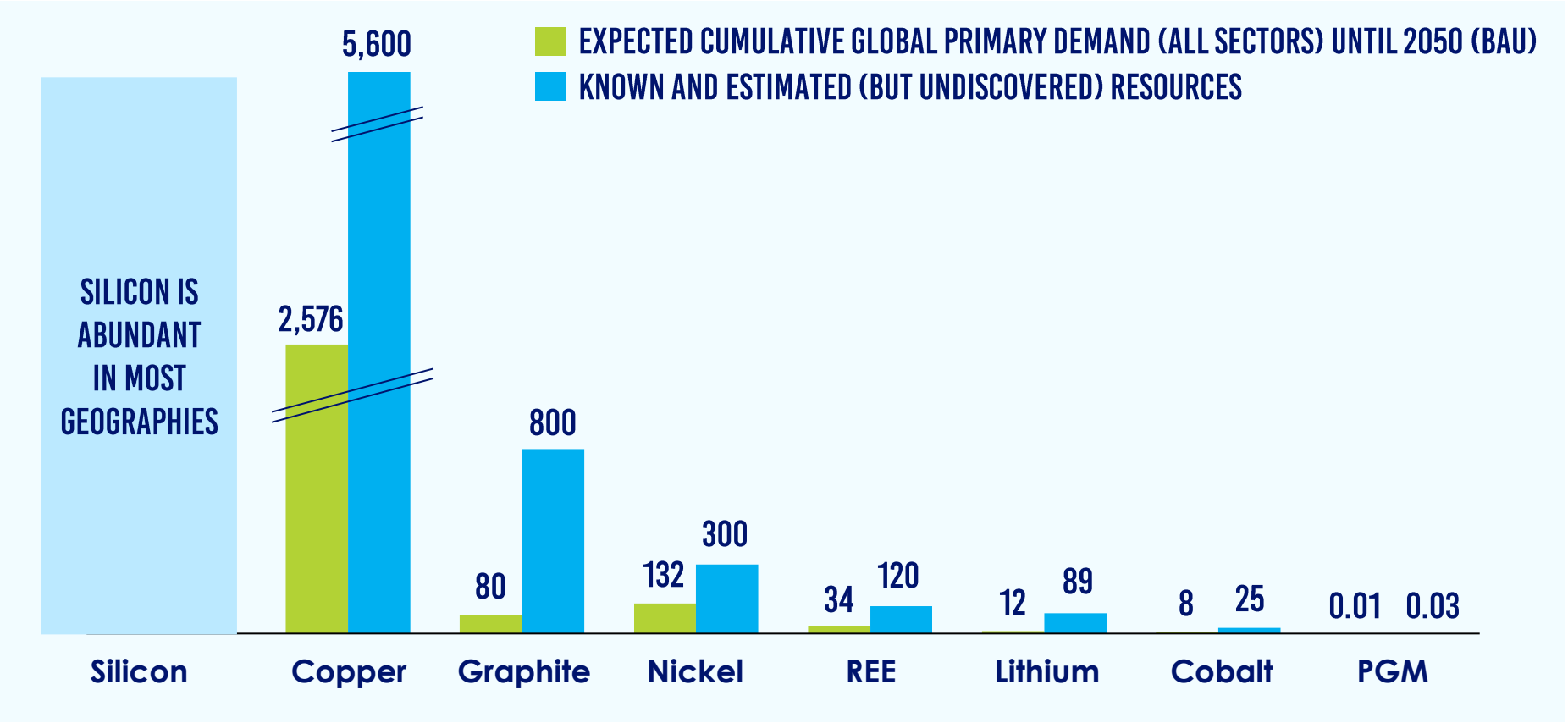
Source: Picture: solar choice: How are Solar Panels made? What are they made of? List of Solar Panel components, https://www.solarchoice.net.au/solar-power/how-are-solar-panels-made/. Freeing Energy (2019): Do we have enough silver, copper and other materials to keep up with the growth of solar?, https://www.freeingenergy.com/do-we-have-enough-materials-to-make-the-solar-panels-needed-for-a-clean-energy-future/; Clean Energy Wire (2021): Resources and recycling needs for Germany's solar panels, https://www.cleanenergywire.org/factsheets/resources-and-recycling-needs-germanys-solar-panels; SinoVoltaics: EVA Film: composition and application, https://sinovoltaics.com/learning-center/materials/ethylene-vinyl-acetate-eva-film-composition-and-application/; Solartechadvisor (2021): Glass used in Solar Panel Manufacturing, https://solartechadvisor.com/solar-panel-glass/; Ilias, A. (2018): Integration& assessment of recycling into c-Si photovoltaic module's life cycle, https://www.researchgate.net/publication/322825662_Integration_assessment_of_recycling_into_c-Si_photovoltaic_module's_life_cycle; Antala Speciality Chemicals (2020): Case Study: Adhesives for Solar Panel Manufacturing & Installation, https://www.antala.uk/adhesives-for-solar-panels/

RENEWABLE BASED SYSTEMS RELY ON METALS THAT ARE PLENTIFUL IN EARTH'S CRUST…

WORLD RESOURCES KNOWN AND UNDISCOVERED REMAINING RESOURCES IN EARTH'S CRUST, IN METRIC MEGATONS



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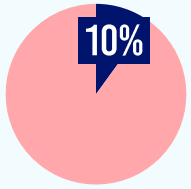
1 Excl. 120 million tons on the floor of the Atlantic, Indian and Pacific oceans; 2 Depending on element. 6 is for Praseodymium, 28 is for Dysprosium
Source: US Geological Survey, KU Leuven, EU Commission: Critical Raw Materials Resilience, S&P Global; Estimates for 2050 are based on KU Leuven (2022)

…BUT THE EU SOURCES LITTLE OF ITS DEMAND DOMESTICALLY, HEIGHTENING ITS IMPORT RISKS AND DEPENDENCIES

EU AUTONOMY TODAY & OUTLOOK

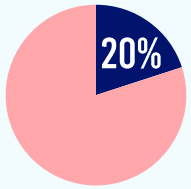
Share of domestic extraction or refinery for the EU (whichever is lower), in %

COBALT



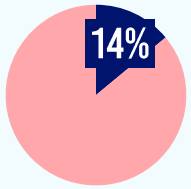
- EU supplies **10% of demand** from domestic mining. **No new mining projects** planned.
- **No expansion to refining** (70% of demand) planned.

NICKEL



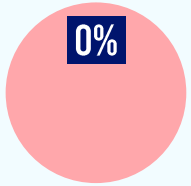
- EU supplies **20% of demand** from domestic mining.
- Mine **depletion, too few new projects, and future demand** increase will worsen autonomy.

COPPER



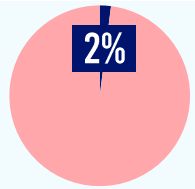
- EU supplies **14% of demand** from domestic mining.
- **Depletion outstrips new project development**. Growing **future demand** will worsen autonomy.

RARE EARTH ELEMENTS



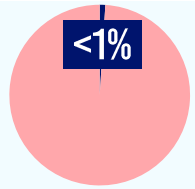
- **No mining** and minimal refining in the EU.
- **Strategic priority**, new projects in pipeline could **supply 20-80% of EU demand by 2030**.[1]

PGM



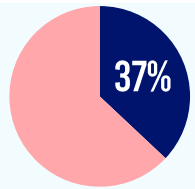
- EU only refines **2% of PGM demand**.
- **No capacity additions** and **growing future demand** will worsen autonomy.

LITHIUM



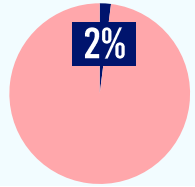
- **Minimal mining** and refining today in Portugal.
- **Strategic priority**, new projects announced, could **supply up to 55% of demand by 2030**.

SILICON



- **EU** mines 70% but **only refines 37% of its domestic demand**.
- **No new projects** and **growing future demand** will worsen autonomy.

GRAPHITE



- EU only **mines 2% of domestic demand**.
- **No new projects and strong demand growth** will worsen autonomy.

2020 OUTLOOK

2020 OUTLOOK

1 Projects in Sweden Norway and Greenland. % of demand depends on the specific REE.
Source: US Geological Survey, KU Leuven, EU Commission: Critical Raw Materials Resilience (for Silicon, Graphite, PGM)

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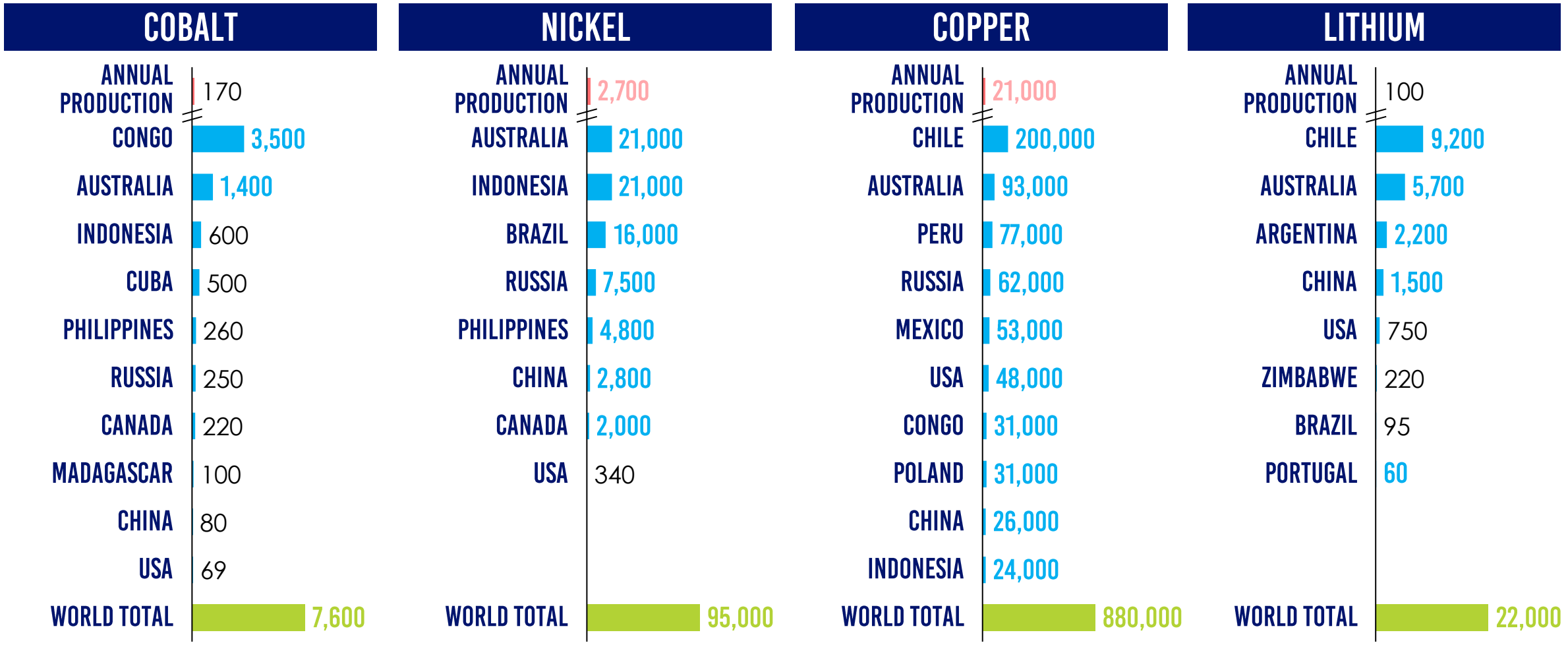
MATERIAL DISTRIBUTION PER COUNTRY (1/2)

TOP 10 COUNTRIES WITH AVAILABLE RESOURCES (IDENTIFIED AND ACCESSIBLE), 2021, IN KILOTONS



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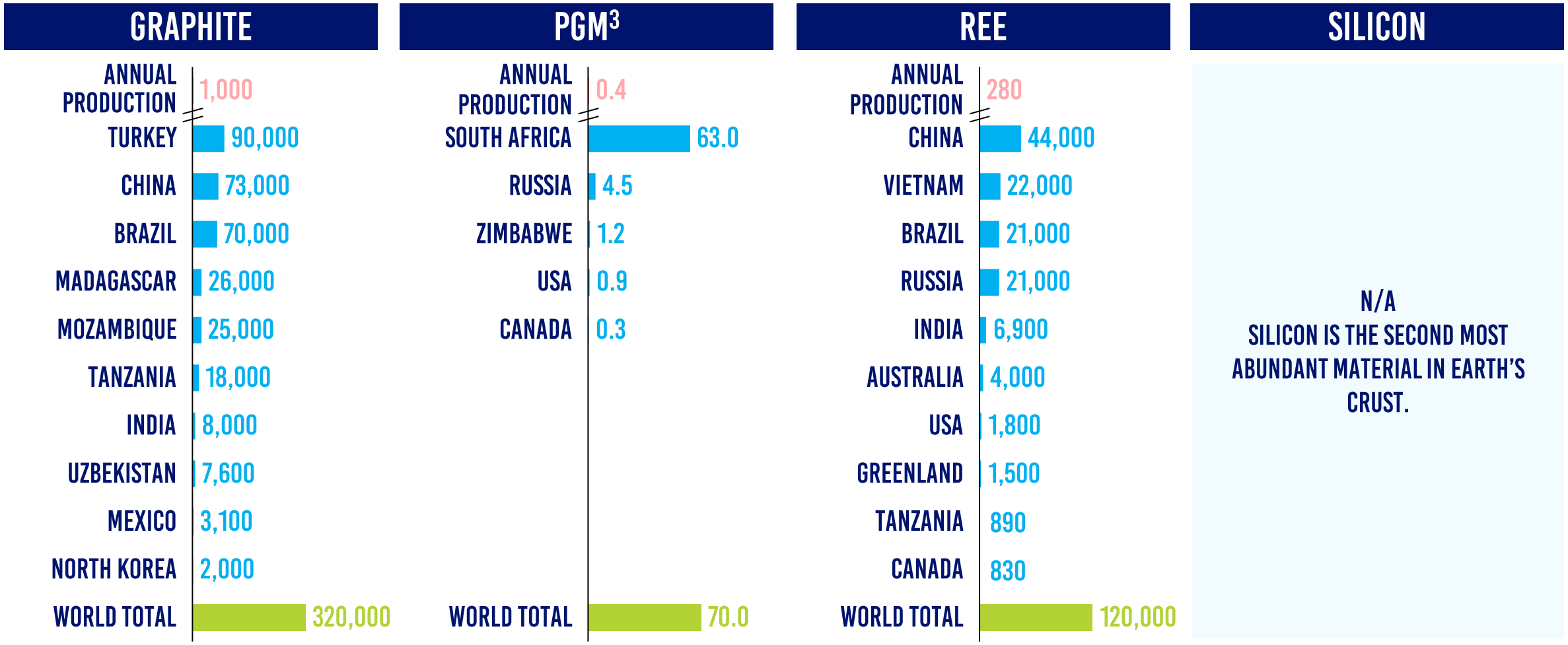
Source: US Geological Survey

MATERIAL DISTRIBUTION PER COUNTRY (2/2)

TOP 10 COUNTRIES WITH AVAILABLE RESOURCES (IDENTIFIED AND ACCESSIBLE), 2021, IN KILOTONS



1 For Carbon; 2 Depends highly on the individual element – some very common, others are extremely rare; 3 For Platinum and Palladium
Source: US Geological Survey

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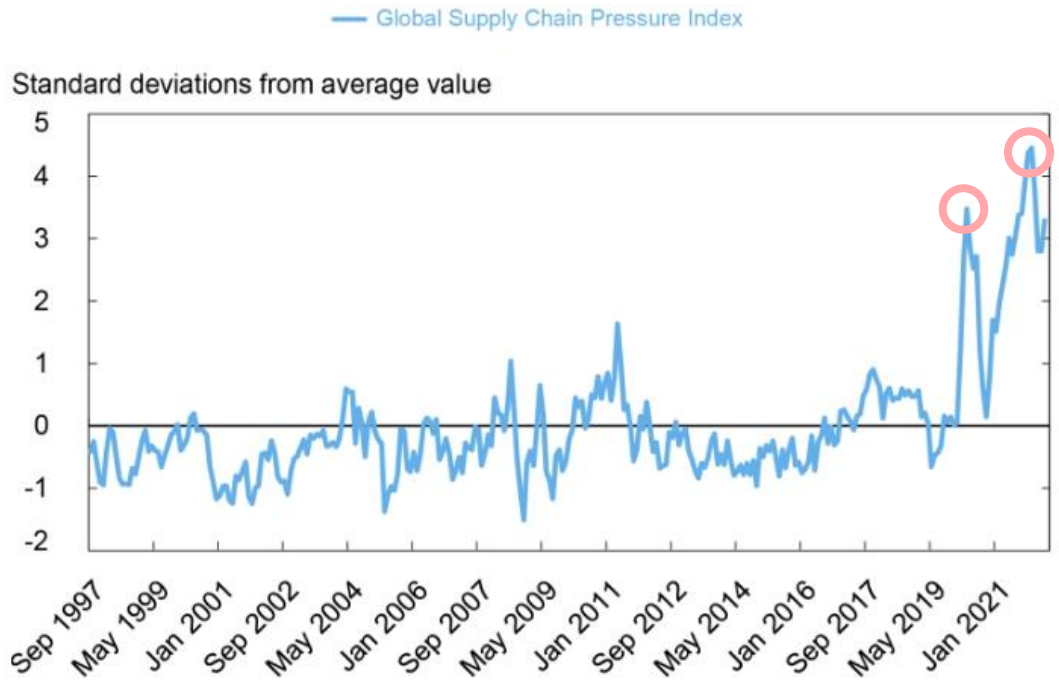
GLOBAL SUPPLY CHAINS HAVE FACED SERIOUS DISRUPTIONS - INCREASING NEED FOR SUPPLY CHAIN RESILIENCE & STOCK MANAGEMENT IN THE EU



Sources: Bureau of Labor Statistics; Harper Petersen Holding GmbH; Baltic Exchange; IHS Markit; Institute for Supply Management; Haver Analytics; Bloomberg L.P.; authors' calculations.

Note: Index is scaled by its standard deviation.

- The Covid-19 pandemic, the Suez canal blockage, a rise in geopolitical tension, and lastly Russia's invasion into Ukraine have shown the **fragility of global supply chains**
- The **Global Supply Chain Pressure Index** (GSCPI) shows the spikes in pressure during the pandemic in 2020 - with a relaxation between December 2020 and March 2022
- **In April 2022 new strains on global supply chains emerged** related to the renewed COVID-19 measures in China and the consequences of the Russian war for supply chains in Europe
- Hence, **supply chain resilience**, i.e., the "ability to continue to operate even when hit by shocks" comes stronger in focus
- **Different strategies can be applied to increase resilience and autonomy**: reshoring foreign production, diversification of suppliers, increase of inventory and application of circular economy (CE) levers

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Note: GSCPI is based on global transportation costs, delivery times, backlogs and purchased stocks for manufacturing firms from China, European area, Japan, South Korea, Taiwan, UK and US
Source: SYSTEMIQ; Liberty Street Economics (2022), Global Supply Chain Pressure Index: May 2022 Update; IMF (2022), The stretch of supply chains

INDUSTRY RESEARCH HAS IDENTIFIED 5 PILLARS TO SECURE THE NECESSARY RAW MATERIALS FOR A RENEWABLE ENERGY AND MOBILITY SYSTEM IN THE EU

Eurometaux

KU LEUVEN

1	2	3	4	5
FULFIL DOMESTIC MINING POTENTIAL	**MAINTAIN AND INCREASE DOMESTIC REFINING OUTPUT**	**SECURE SUSTAINABLE IMPORTS FROM RELIABLE PARTNERS**	**MAXIMISE RECYCLING, INCLUDING NEW STREAMS**	**DRIVE TECHNO-LOGICAL AND BEHAVIOURAL CHANGE**
			FOCUS: CIRCULAR ECONOMY STRATEGIES	
• Take forward viable domestic mining projects in Europe[1] • Set high ESG standards	• Prevent further closures of existing capacity • Support new refineries for battery metals & rare earths	• Diversify trade partners while driving ESG • Source from certified, responsible suppliers	• Remove current bottlenecks on collection, sorting and retention • Invest into new recycling for batteries, PV, magnets	• Ensure continued R&D leadership on optimization • Investigate how to evolve consumption patterns in the transport sector

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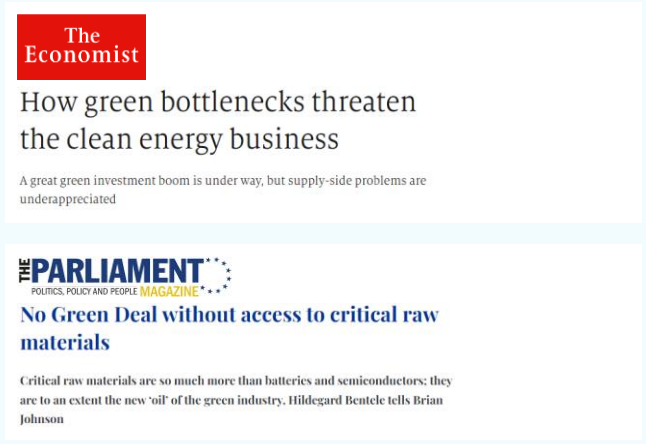
1: Projects in Sweden Norway and Greenland. European projects also tend to have lower GHG emissions than international supplies (KU Leuven: Metals for clean energy); apply mining standards as set by "Initiative for Responsible Mining Assurance", "Towards Sustainable Mining" (both Multi-Stakeholder) and "International Council on Metals & Mining" (Industry); KU Leuven (2022): Metals for Clean Energy, Policymaker summary

Source: Based on Eurometaux/KU Leuven: Metals for Clean Energy

KNOWLEDGE OF GEOPOLITICAL RESOURCE DEPENDENCIES IN THE SUPPLY CHAINS HAS REACHED POLITICIANS AND MEDIA

THE CRITICALITY OF CERTAIN RAW MATERIALS FOR THE GREEN ENERGY TRANSITION HAS REACHED MASS MEDIA


The Economist

How green bottlenecks threaten the clean energy business

A great green investment boom is under way, but supply-side problems are underappreciated

THE PARLIAMENT MAGAZINE
POLITICS, POLICY AND PEOPLE

No Green Deal without access to critical raw materials

Critical raw materials are so much more than batteries and semiconductors: they are to an extent the new 'oil' of the green industry. Hildegard Bentele tells Brian Johnson

THE EU RECOGNISES THE NEED TO MOVE FROM LINEAR TO CIRCULAR USE OF MATERIALS TO MINIMIZE SUPPLY CHAIN DEPENDENCIES

Ursula von der Leyen, 2021

"Green and digital technologies currently depend on a number of scarce raw materials. […] This is not sustainable. We **must diversify our supply chains**. And at the same time, we must **invest in circular technologies** that re-use resources instead of constantly extracting them. This is the goal of our Action Plan on Critical Raw Materials."

RESEARCH SHOWS THAT CIRCULAR ECONOMY AND SUPPLY CHAINS CAN AND NEED TO BE CLOSELY LINKED

- **Think Long-term:** Decisions about the supply and use of critical materials that we make today will impact our long-term supply in the future
- **Make use of the timing:** The combined business need for raw materials and the political will to enable circular economy mean that now is the time to "get this right"
- **Go from theory to practice:** Ambitious circular economy strategies are needed that go beyond recycling

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Sources: The Parliament Magazine(2021): No Green Deal without access to critical raw materials. https://www.theparliamentmagazine.eu/news/article/the-new-oil ;The Economist (2021): How green bottlenecks threaten the clean energy business, https://www.economist.com/leaders/2021/06/12/how-green-bottlenecks-threaten-the-clean-energy-business?giftId=41208026-7716-4d98-b523-85324613d6ab ; European Commission (2021): Opening speech by President von der Leyen at the EU Industry Days 2021, https://ec.europa.eu/commission/presscorner/detail/fr/speech_21_745;

TO CURB DEMAND FOR VIRGIN RAW MATERIALS AND INCREASE EU AUTONOMY, FOUR CIRCULAR ECONOMY STRATEGIES SHOULD BE EMPLOYED

KU LEUVEN/ EUROMETAUX CATEGORY	STRATEGY	DESCRIPTION
5. DRIVE TECHNOLOGICAL AND BEHAVIOURAL CHANGE	RETHINK	Create demand side reduction through systemic change of critical infrastructure, utility delivery, design of business models and supply chains, ownership models and product use to make the product redundant or use it more intensively. Move from "owning" to "using".
	REDUCE	Substitute and optimise resources and material need in manufacturing or use through, e.g., redesign, substitution, material efficiency.
	REUSE	Extend product life to keep materials in longer circulation, e.g. through product design, repairing and maintenance, refurbishment, remanufacture or repurposing.
6. MAXIMISE RECYCLING, INCLUDING NEW STREAMS	RECYCLE	Close the material loop by bringing the material back into circulation with same or lower grade quality through reprocessing materials / waste; energy recovery.

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Source: adapted from Potting et al. 2017, 9R's framework

CASE EXAMPLES (1/2): CE LEVERS ARE ALREADY APPLIED IN MOBILITY TODAY

RETHINK	Companies like Miles and WeShare offer free-floating carsharing schemes in major cities, thereby reducing the need for individual car ownership.	MILES, We share.
REDUCE	Tesla already uses cobalt-free Lithium Iron Phosphate (LFP) batteries in almost 50% of its new cars. It announced to switch all of its standard range cars to this technology over the next years. LFP's components are non-toxic and abundant.	TESLA
REUSE	RWE and Audi installed an energy storage system in Herdecke, North Rhine-Westphalia, using 60 used lithium-ion batteries from Audi EVs that provide temporary storage for about 4.5 MWh.	RWE, Audi
RECYCLE	US-based Redwood Materials claims to be able to recycle 95% of the metals used in lithium ion batteries, at lower cost than virgin materials. VW USA, Toyota, Ford and Volvo are its main sources of supply.	REDWOOD MATERIALS

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Source: : RWE (2021), Second life for EV batteries: RWE and Audi create novel energy storage system in Herdecke; CNBC (2021), Tesla will change the type of battery cells it uses in all its standard-range cars; Redwood Materials(2022); Redwood Materials and Volkswagen Group of America partnership – Redwood to recycle all batteries from Volkswagen and Audi electric vehicle; BatteryBay (2022): LFP Batteries Are Coming to Europe – Why Now?

CASE EXAMPLES (2/2): SOLAR PV IS AT THE CUSP OF TECHNOLOGICAL IMPROVEMENTS THAT ENHANCE EFFICIENCY AND REDUCE MATERIAL DEMANDS

RETHINK

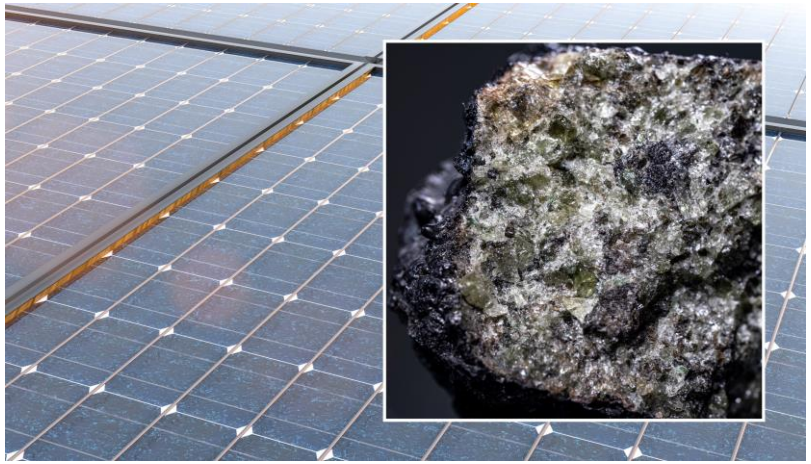
SOLAR OVER WATER

- Solar PV benefits from being installed on water or just above, due to cooler temperatures on water which raise the productivity of PV panels. Cooler temperatures **boost the production of electricity by up to 3% on average**.[1]
- **Additional benefits** are **reduced evaporation** of water in drought-afflicted regions, lower lifetime costs due to **avoided land take**, and aquatic **weed mitigation**.

REDUCE

SUBSTITUTING SILICON SOLAR CELLS WITH PEROVSKITE

- Substituting silicon with **perovskite** could result in solar cells that are **cheaper and easier to manufacture, requiring 20x less material than conventional solar cells**.[2]
- Perovskites also increase the energy efficiency of solar cells. Silicon-based solar cells are currently at ~25%, while **perovskite solar cells already reach 29% efficiency**.
- Remaining **technological issues around durability** need to be resolved before commercialisation.



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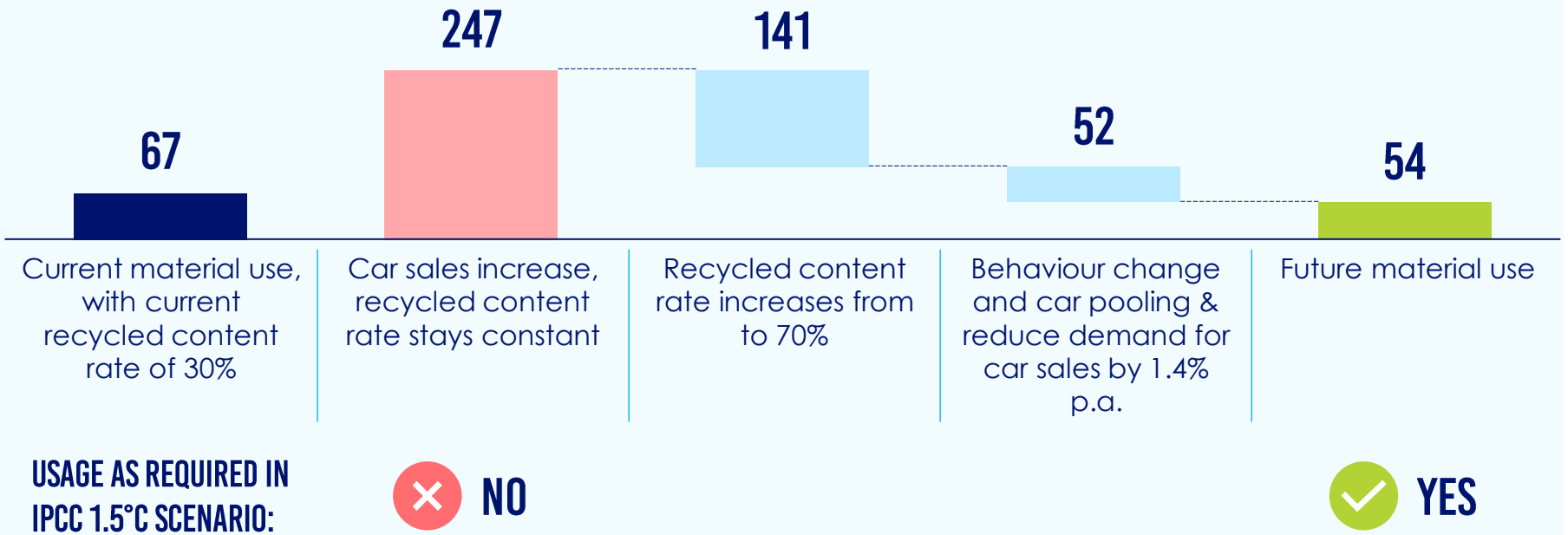
Source: 1 https://ieeexplore.ieee.org/document/8634893; 2 https://undecidedmf.com/episodes/perovskite-solar-cells-may-be-the-future-of-energy; https://www.browndailyherald.com/article/2021/06/brown-researchers-shine-new-light-on-solar-cell-design

CE LEVERS HAVE THE POTENTIAL TO CURB MATERIAL DEMAND: RECYCLING ALONE IS ALREADY GOING A LONG WAY – WE CAN ACHIEVE EVEN MORE BY APPLYING ALL CE LEVERS

GLOBAL ANNUAL VIRGIN MATERIAL USE FOR THE PRODUCTION OF PASSENGER CARS (EXCL. USE) ICE AND BEV VEHICLES, IN MT BY 2050



AMBITIOUS CIRCULAR ECONOMY MEASURES ARE ABLE TO FLATTEN THE DEMAND CURVE FOR MATERIALS AND HELP TO RETURN TO A 1.5°C COMPLIANT PATHWAY.

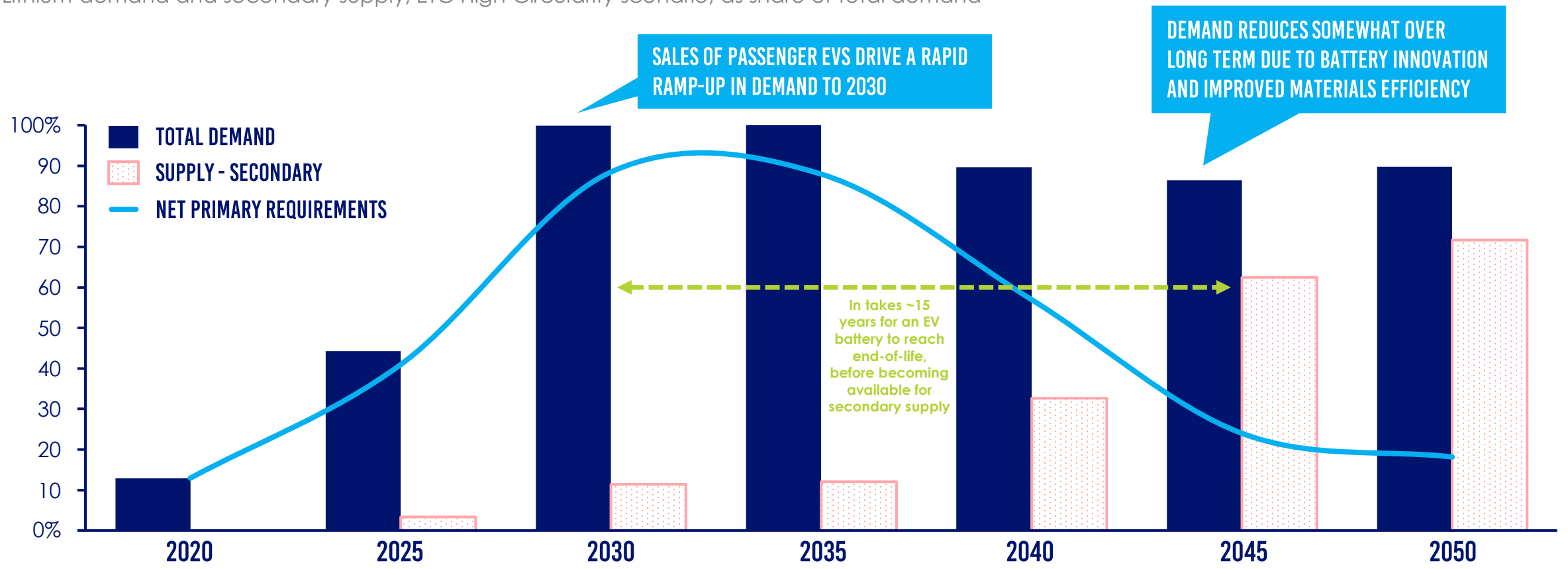
Assumptions: vehicle sales and stock as per the IEA (2022) Global EV Data Explorer. Average European vehicle mass as reference weight factor from ICCT (2021): European Vehicle Market Statistics Pocketbook 2021/22; To reach the IPCC LED scenario, absolute virgin material consumption needs to decrease by close to 20% (850 mio. vehicles in stock by 2050) and hence is assumed as target line.
Recycled material increase modelled with increase from 20% by 2010 to 30% by 2021 to 50% by 2030 and steady increase to 70% until 2050

PRIMARY MATERIALS DEMAND WILL CONTINUE TO GROW UNTIL MID-2030, WHEN SECONDARY SUPPLY BECOMES MORE SIGNIFICANT

NOTE: NUMBERS ARE PURELY ILLUSTRATIVE

DEMAND FOR MATERIALS COULD RISE RAPIDLY, DRIVEN BY SALES OF ELECTRIC VEHICLES; RECYCLING CAN MITIGATE PRIMARY MATERIALS REQUREMENTS BUT ONLY FROM THE MID-2030S ONWARDS

Lithium demand and secondary supply, ETC High Circularity scenario, as share of total demand



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Source: Systemiq analysis for the ETC

POLICY ACTIONS ARE NEEDED TO MAKE CE-LEVERS COME TRUE – OVERARCHING RECOMMENDATIONS FOR POLICY MAKERS

OVERARCHING FOR CLEAN TECH MATERIALS	
RETHINK	• For consumer products: Introduce demand-side instruments to slow the increase in overall resource consumption in the EU. Specifically: make producer ownership models ('as-a-Service' models) more attractive than linear models for both companies and customers. • Create and mandate design criteria and standards so that all producers design and manage their products as durable / reusable / recyclable rather than short-lived / disposable products. • Introduce mandatory supply chain due diligence (including end customer transparency to proposed chain of custody logic) to address social and environmental risks related to raw material extraction, processing and trading.
REDUCE	• Educate consumers on environmental performance of end products and provide them with relevant full-lifecycle information to enable informed choices. • Roll out digital product passports across major product categories (based on new Batteries Regulation and Ecodesign Regulation draft). • Complement energy and GHG-related targets by introducing science-based resource use (absolute) decoupling targets following sufficiency principles.
REUSE	• Introduce mandatory secondary life requirements (e.g. repairability, reusability) for all use cases and mandatory recycling quotas at end of life.
RECYCLE	• Introduce mandatory levels of recycled content for major use cases from 2030 onwards.
OTHER	• Develop environmentally and socially sound mining projects in the EU for all required critical raw materials to reduce import dependencies and support responsible mining practices. • Diversify imports to minimize import-dependencies, while increasing environmental and social standards.

LEGISLATIVE LANDING POINTS

- EGD - Directive as regards empowering consumers for the green transition through better protection against unfair practices and better information, COM(2022) 143
- EGD – Regulation on Ecodesign for Sustainable Products 2022/0095(COD)
- EGD – Regulation minimising the risk of deforestation and forest degradation, COM(2021) 706
- EGD – New Batteries Regulation 2020/0353(COD)
- EGD – Substantiating Green Claims (legislative proposals)
- EU Industrial Strategy revisions
- Introduce in new Commission Work Programme from 2025 onwards

POLICY RECOMMENDATIONS DEEP DIVE FOR MOBILITY SECTOR

EV AND OTHER BATTERIES

RETHINK

- Decrease the subjective need for individual transportation (e.g. through remote work, redesigned city structures and localised employment opportunities).
- Promote modal shift from cars (ICE or EV) to public transport, bicycles and walking.
- Increase utilisation of cars through sharing and pooling, thus decreasing individual car ownership – by increasing on-demand ride pooling, sharing platforms, and automated Mobility-as-a-Service platforms.

REDUCE

- Introduce maximum weight and size regulation for EV batteries to reduce excess material consumption.
- Harmonize methodologies for lifecycle transparency – CO2 and other impacts.
- Enact CO2- and efficiency thresholds for all stages of battery life cycles.

REUSE

- Introduce mandatory second life assessment requirements for EV batteries.
- Set and increase incentives to reuse EV batteries for stationary storage.
- Prioritise reuse over repurposing and remanufacturing over recycling – through mandatory testing of suitability for reuse, repurposing and remanufacturing prior to recycling.

RECYCLE

- Set high ambition collection targets for all types of batteries (industrial, EV, portable).
- Upcoming EV battery recycling regulation is expected to drastically increase recycling of EV batteries as long as they are in a controlled value chain. Close the remaining recycling gap when responsibility for recycling is transferred to 3rd party collectors and recyclers.
- Support collection of portable and LMT batteries through deposit-return systems or similar financial incentives.
- Set and carefully increase mandatory shares of recycled content (recyclate use) in passenger vehicles – based on post-consumer waste batteries.

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Note: based on policy development principles for automotive circularity by the Circular Cars Initiative (2021)

ACRONYMS AND EXPLANATIONS

ABBREVIATIONS

CE	Circular Economy
CO_2	Carbon Dioxide
CT	Clean Transition
ESS	Energy Storage System
EV	Electric Vehicle
PGM	Platinum Group Metals
PM	Permanent Magnet
PV	(Solar) Photovoltaic
REE	Rare Earth Elements

RARE EARTH ELEMENTS[1]

Dy	Dysprosium
Nd	Neodymium
Pr	Praseodymium

PLATINUM GROUP METALS[1]

Pd	Palladium
Pt	Platinum
Ru	Ruthenium

EUROPE AND THE EU

EU refers to the 27 Member States of the EU. Europe refers to the EU-27, plus UK and EFTA (Iceland, Liechtenstein, Norway and Switzerland).

1: Limited to the respective metals mentioned in this presentation

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