Global mineral resource governance for sustainable development

Pr. Paul Ekins, University College of London

Pr. (Hon., University of College of London) Patrice Christmann

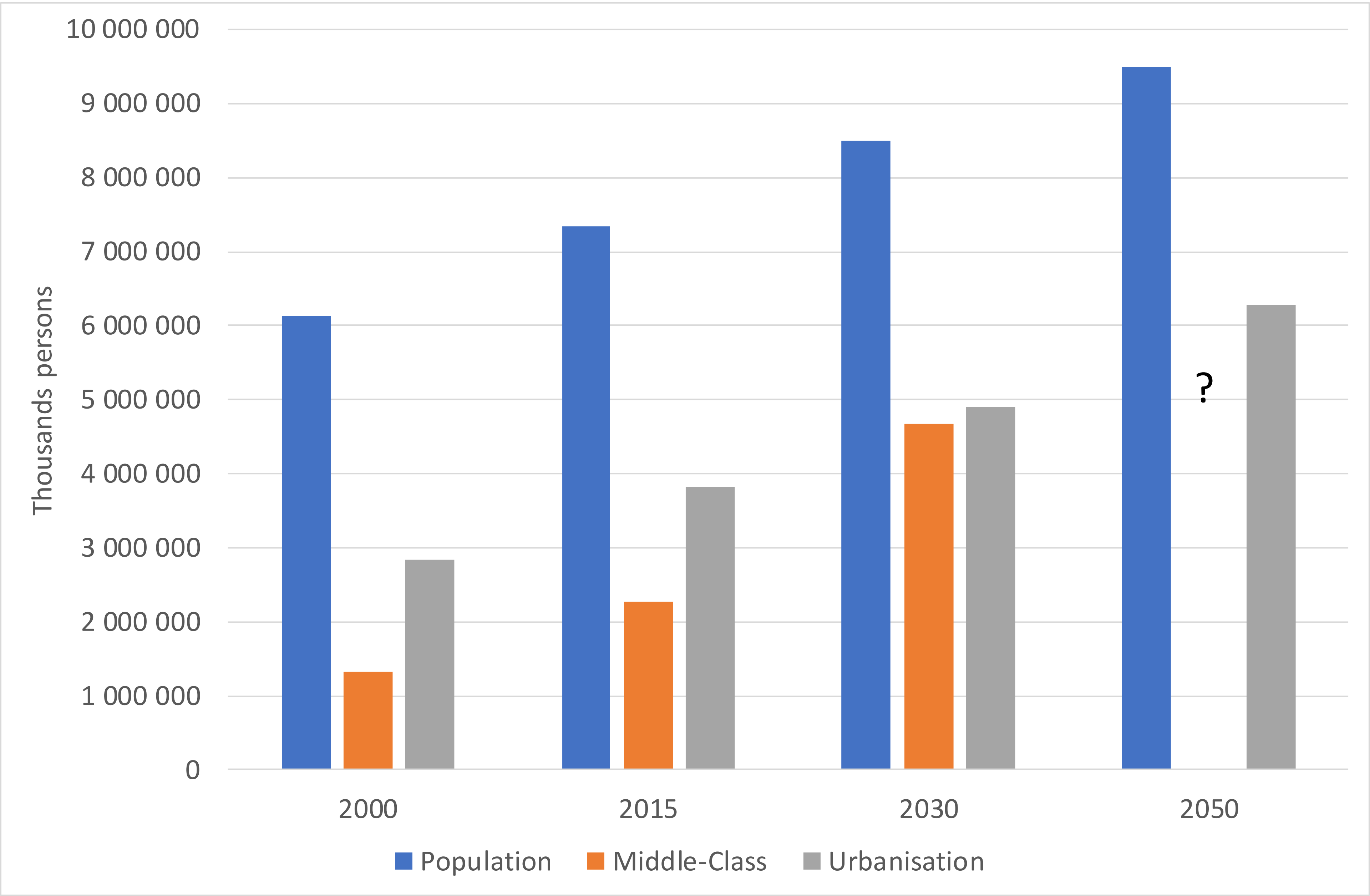
IRTC Conference, Lille (France), February 15-17, 2023

Co-funded by the European Union

This presentations elaborates on the findings of the UN International Resource Panel (IRP) « Governance » report published in 2020 and on the current preparaion by the UN IRP Mineral Resources Working Group of a new report «*Financing the Extractive Industry: Promoting a Sustainable Development Licence to Operate*» (provisional title), expected to be published in late 2023/early 2024.

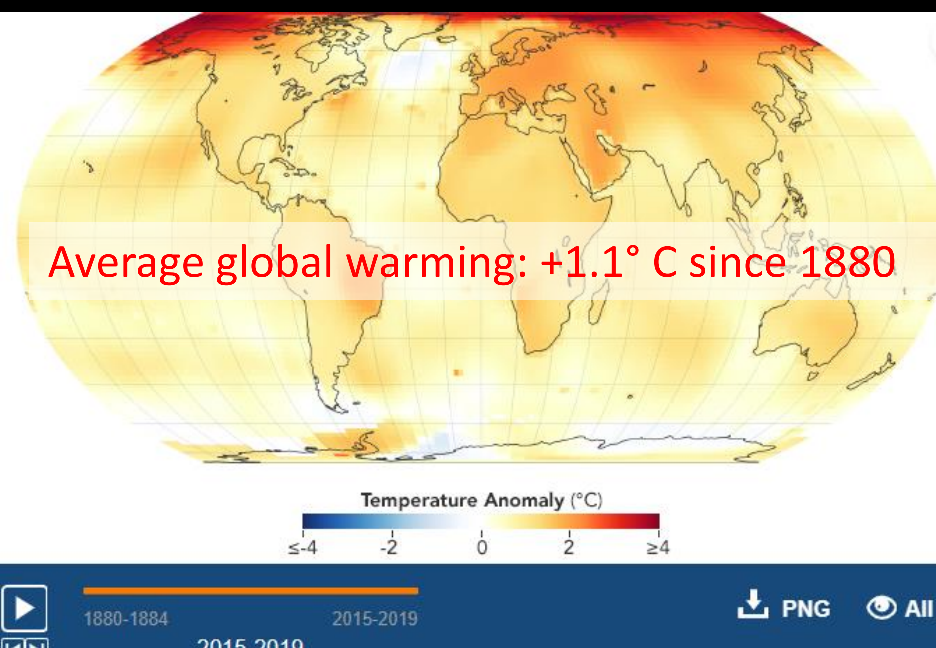
Major drivers that will shape the 21st Century

Data sources: UN Population Division, 2022; Kharas H. - 2017



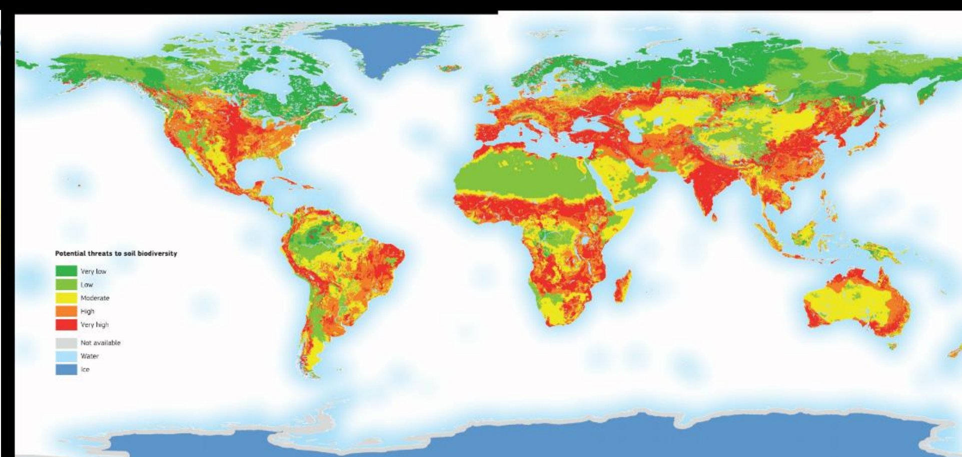
Geopolitical hotspots and Wagner Group presence in Africa (own compilation)

Some additional drivers that will shape the future, callling for global, well-coordinated mitigation strategies, including education, research and innovation



Average global warming: +1.1° C since 1880

Source: https://earthobservatory.nasa.gov/



Potential threats to soil biodiversity, and to soil ecosystemic services

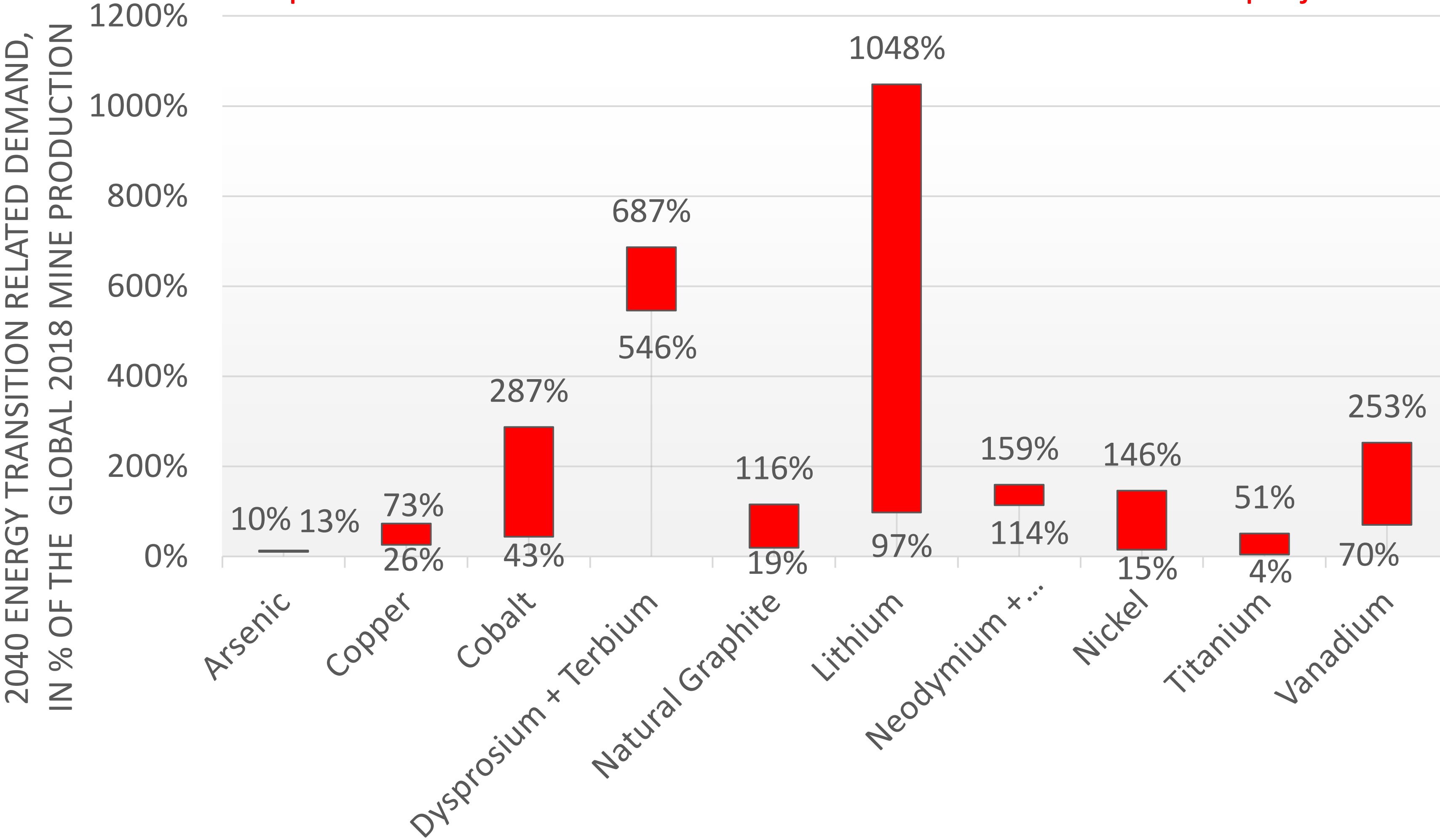
Orgazzi et al. Global Soil Biodiversity Atlas (2016). European

Minimum – maximum 2040 global demand scenarios, as compared to world 2018 production, for key « transition » metals.

Data sources:

- International Energy Agency (IEA). (2021). The Role of Critical Minerals in Clean Energy Transitions.
- Marscheider-Weidemann F. et al. (2021). Raw materials for emerging technologies 2021. Deutsche Rohstoffagentur (DERA) Berlin (Germany).

The demand outlook for Co, Cu, Li, Ni, REE and V is very challenging in view of the current production and of open issues. Innovation is needed to reduce those demand projections.



The footprint of the global minerals and metals industry: open, poorly reported, local and/ or global environmental issues call for global minerals and metals governance as a framework for a sustainable competitive playfield

According to OECD (2019) the global production of minerals and metals is the source of 16% of the global greenhouse gas emissions

According to Franks et al. (2021), the global production of minerals and metals generates 13 billion metric tonnes/ year tailings waste. Some of it can cause local/ regional threats and impacts for perpetuity. The mineralogical and geochemical nature of mining waste and of its storage conditions remains poorly reported.

The production of minerals and metals requires large amounts of water, including in regions with scarce resources and/or threatened by climate change related water deficits.

Progress on the minerals and metals industry transparency, has been made, but it remains slow and limited in scope.
Mistrust among stakeholders persists, sometimes leading to violent conflict.

The decisions that will be taken by investors to invest in mining projects hinge on a number of factors, ESG issues appearing to be the highest risk factor deterring investment decisions

Illustration source: EY. (2022). Top 10 business risks and opportunities for mining and metals in 2023. Report, 56p. EY. https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/mining-metals/mining-metals-pdfs/ey-top-10-business-risks-and-opportunities-for-mining-and-metals-in-2023.pdf. Reproduced with permission.

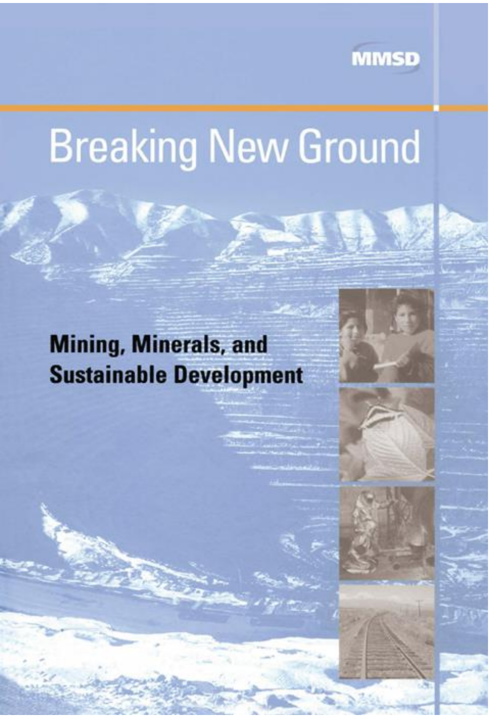
The current situation has consequences that may compromise the efforts towards the global energy transition: a look at the world's 20 largest yet undeveloped copper deposits

Ranking by Cu contained in the stated resources	Deposit	Country	Company	Discovery year	Years since discovery	Project facing important development issues	Initial CAPEX estimates (in million nominal $ US)	Mt Cu contained in the indicated and mesured resource or in the reserves
1	Pebble	USA (Alaska)	Northern Dynasty Minerals	1987	36		4 500	25,8
2	Udokan copper	Russia	Udokan copper/ USM Holding	1940	83	???	1 350	18,5
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16	Galore Creek	Canada (British Columbia)	Teck/ Newmont Mining	1955	68		2 200	5,2
17	Copper World	USA (Arizona)	Hudbay	1958	65			4,8
18	Los Azules	Argentina	Andes Corporation Minera & McEwen Mining	1998	25		2 363	4,6
19	Bougainville (Panguna mine)	Papua New Guinea	Bougainville Copper Limited	1969	54		**1 800**	4,6
20	Schaft Creek	Canada (B.C.)	Copper Fox Metals	1957	66		**2 653**	3,5

In a context of continuously rising copper demand, production from these deposits much matter to the future supply/ balance. These deposits represents a total resource of about 180 Mt Cu, nearly 9 years of the current world primary copper production.

At least 55 billion $ initial CAPEX investment will be needed to develop them.

The development of 6 deposits, representing 35% of the resource, is currently blocked due to environmental/or social issues. 2 more projects may suffer from being located in high insecurity regions (14% of the resource) and one may suffer from the Western sanctions against Russia (10% of the resource).



- In 2002 the «Mining, Minerals, and Sustainable Development » (MMSD) project was concluded with the publication of the "Breaking New Ground" report, the largest existing multi-stakeholder assessment of the complex linkages between the minerals and metals industry and of the issues to be addressed to overcome the identified issues. About 5 000 persons contributed to the project which was financed by most of the world largest companies of that time.

- Since, about 90 different voluntary initiatives were developed by NGO's and/or some part of the industry to address specific issues. None covers the full 4 dimensions of Sustainable Development (the economy, environment, governance and social dimensions) and despite some efforts there is no universally agreed, enforced, ESG reporting framework. None is universally recognised and implemented.

- Twenty years after the MMSD project, in 2022,: its former Project Director, Luke Danielson published a paper titled "MMSD – reflections on gaps remaining" about the progress made since the MMSD projects. He notes the following.

« The key issues that have limited progress are two:

- *One is the lack of industry support for rigorous research into the environmental and social and economic issues that its operations present. MMSD was a powerful voice, and a venue for better communication among stakeholders, and we would have been better off if something had replaced it when it disappeared.*

- *The other is that while there are some exceptions, industry has generally been unwilling to support (or participate in) bodies that it does not directly or indirectly control. More independent institutions, like the Responsible Mining Foundation, are needed. Such organisations have the potential to create great value for the sector, which is today largely not being captured. »*

- Capital, operating expenses
- Land
- Energy
- Water
- Chemicals

- Capital, operating expenses
- Land
- Energy
- Water
- Chemicals

- Capital, operating expenses
- Land
- Energy
- Water
- Chemicals

TPUTS

rketable
erals
metals
fits or
es

A KEY TO THE FUTURE: THE RIGHT TO KNOW, THE OBLIGATION TO INFORM

LOCAL POPULATIONS, INVESTORS, AUTHORITIES, DOWNSTREAM MINERALS AND METALS USING INDUSTRIES, NGOs, THE GENERAL PUBLIC ALL HAVE THE FUNDAMENTAL RIGHT TO KNOW ABOUT IMPACTS SITE SPECIFIC RISKS, SOCIAL AND ENVIRONMENTAL PERFORMANCE.

GOVERNMENTS AND MARKET AUTHORITIES HAVE A MAJOR ROLE TO PLAY IN FOSTERING CORPORATE TRANSPARENCY AND ACCOUNTABILITY.

- Emissions (COx, NOx, SOx, PM …)
- Waste (overburden, unused part of the ore)

- Emissions (COx, PM …)
- Waste (tailings, liquids …)

sites)

- Emissions (COx, SOx, PM …)
- Waste (slags, liquids …)

TIAL
'S ON:

- **Surface and groundwater**
- **Soil**
- **Air**
- **Biodiversity**
- **Human communities**

CONCLUSIONS: A CALL FOR THE SET-UP OF AN INTERNATIONAL MINERAL RESOURCES GOVERNANCE INSTITUTION

UN IRP (2020): « *An international coordination mechanism is needed, whereby data and knowledge are shared on economic geology, environmental conditions and issues as well as medium-/long-term mineral demand demand/supply balance scenarios, as well as mineral demand needs, alongside transparency on impacts and benefits* »

IEA (2021): « *The IEA's energy security framework could (…) serve as a template for international minerals governance, underpinned by data sharing, co-ordination mechanisms and collective actions, fostering sustainable and responsible supply chains that contribute to a low-carbon economy.* »

A support mechanism, possibly funded by a modest global ad-valorem resource tax, could not only fund this mechanism, but also fund much needed institutional capacities needed to develop/ strengthen the framework conditions needed to foster environmentally and socially responsible minerals and metals production activities, including the public geoscientific and environmental baseline conditions databases.

References (as presented):

- Slide 2: UN International Resources Panel (UN IRP) (2020). Mineral Resource Governance in the 21st Century: Gearing extractive industries towards sustainable development. Ayuk, E. T., Pedro, A. M., Ekins, P., Gatune, J., Milligan, B., Oberle B., Christmann, P., Ali, S., Kumar, S. V, Bringezu, S., Acquatella, J., Bernaudat, L., Bodouroglou, C., Brooks, S., Burgii Bonanomi, E., Clement, J., Collins, N., Davis, K., Davy, A., Dawkins, K., Dom, A., Eslamishoar, F., Franks, D., Hamor, T., Jensen, D., Lahiri-Dutt, K., Petersen, I., Sanders, A. R. D. - A Report by the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya - https://www.resourcepanel.org/file/1484/download?token=902uRy2h

- Slide 3:
  a) United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Online database. https://population.un.org/wpp/
  b) Kharas H. (2017) - The unprecedented explosion of the global-middle class - An update - Brookings Institute, Global Economy & Development Working Paper 100

- Slide 4: Orgiazzi, A., Bardgett, R.D., Barrios, E., Behan-Pelletier, V., Briones, M.J.I., Chotte, J-L., De Deyn, G.B., Eggleton, P., Fierer, N., Fraser, T., Hedlund, K., Jeffery, S., Johnson, N.C., Jones, A., Kandeler, E., Kaneko, N., Lavelle, P., Lemanceau, P., Miko, L., Montanarella, L., Moreira, F.M.S., Ramirez, K.S., Scheu, S., Singh, B.K., Six, J., van der Putten, W.H., Wall, D.H. (Eds.), 2016, Global Soil Biodiversity Atlas. European Commission, Publications Office of the European Union, Luxembourg. 176 pp. https://www.researchgate.net/publication/303699867_Global_Soil_Biodiversity_Atlas

- Slide 5:
  a) International Energy Agency (IEA). (2021). The Role of Critical Minerals in Clean Energy Transitions. World Energy Outlook Special Report, 287 p. https://iea.blob.core.windows.net/assets/24d5dfbb-a77a-4647-abcc-667867207f74/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf
  b) Marscheider-Weidemann F., Langkau S., Baur S.-J., Billaud M., Deubzer O., Eberling E., Erdmann L., Haendel M., Krail M., Loibl A., Maisel F., Marwede M., Neef C., Neuwirth M., Rostek L., Rückschloss J., Shirinzadeh S., Stijepic D., Tercero Espinoza L., Tippner M. (2021). Raw materials for emerging technologies 2021. Report, 350 p. DERA Rohstoffinformationen 50: Editor: Deutsche Rohstoffagentur (DERA) Berlin (Germany). https://www.deutsche-rohstoffagentur.de/DE/Gemeinsames/Produkte/Downloads/DERA_Rohstoffinformationen/rohstoffinformationen-50-en.pdf?__blob=publicationFile&v=2

- Slide 6:
  a) OECD. (2019). Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences - Report, 214 p. - OECD Publishing, Paris. https://doi.org/10.1787/9789264307452-en
  b) Franks, D.M., Stringer, M., Torres-Cruz, L.A., Baker, E., Valenta, R., Thygesen, K., Matthews, A., Howchin, J. and Barrie, S. (2021). Tailings facility disclosures reveal stability risks. Scientific Reports, [online] 11(1). Available at: https://www.nature.com/articles/s41598-021-84897-0 [Accessed 28 Mar. 2021].

References (continued):

- Slide 8: EY. (2022). Top 10 business risks and opportunities for mining and metals in 2023. Report, 56p. EY.

- Slide 10:
    a) Mining, Minerals, and Sustainable Development Project (MMSD). (2002). Breaking New Ground, 476 p. Report , (London, UK). http://pubs.iied.org/9084IIED
    b) Danielson L. (2022). MMSD – reflections on gaps remaining. Online article. Responsible Mining Foundation. https://www.responsibleminingfoundation.org/research/mmsd-reflections/

Elements and
Social Risk Assessment

Tatiana V Vakhitova

Manager, Academic Development Ansys Ltd.

February, 2023

Agenda

→Introduction to Ansys Academic / Acknowledgments

→Background Project FlyZero

→Elements & Social Risk (*work – in – progress*)

Ansys

©2022 ANSYS, Inc.

Acknowledgements

→James Minshull, GKN Aerospace & ATI

→Mike Ashby, University of Cambridge

→Academic Development, Data & CR&D Teams @Ansys

Useful links:

Ansys Education Resources – Teaching Materials

FlyZero Reports Archive - Aerospace Technology Institute (ati.org.uk)

Articles and Expert Reports - Life Cycle Initiative

Materials and Sustainable Development - 2nd Edition (elsevier.com) (2015)

Materials and Sustainable Development - 1st Edition (elsevier.com) (2022)

Transition Minerals | Business & Human Rights Investment Trackers (business-humanrights.org)

Critical raw materials (europa.eu) the OECD, Responsible Minerals Initiative, Responsible Steel and the Aluminium Stewardship Initiative.

Ansys

©2022 ANSYS, Inc.

Introduction

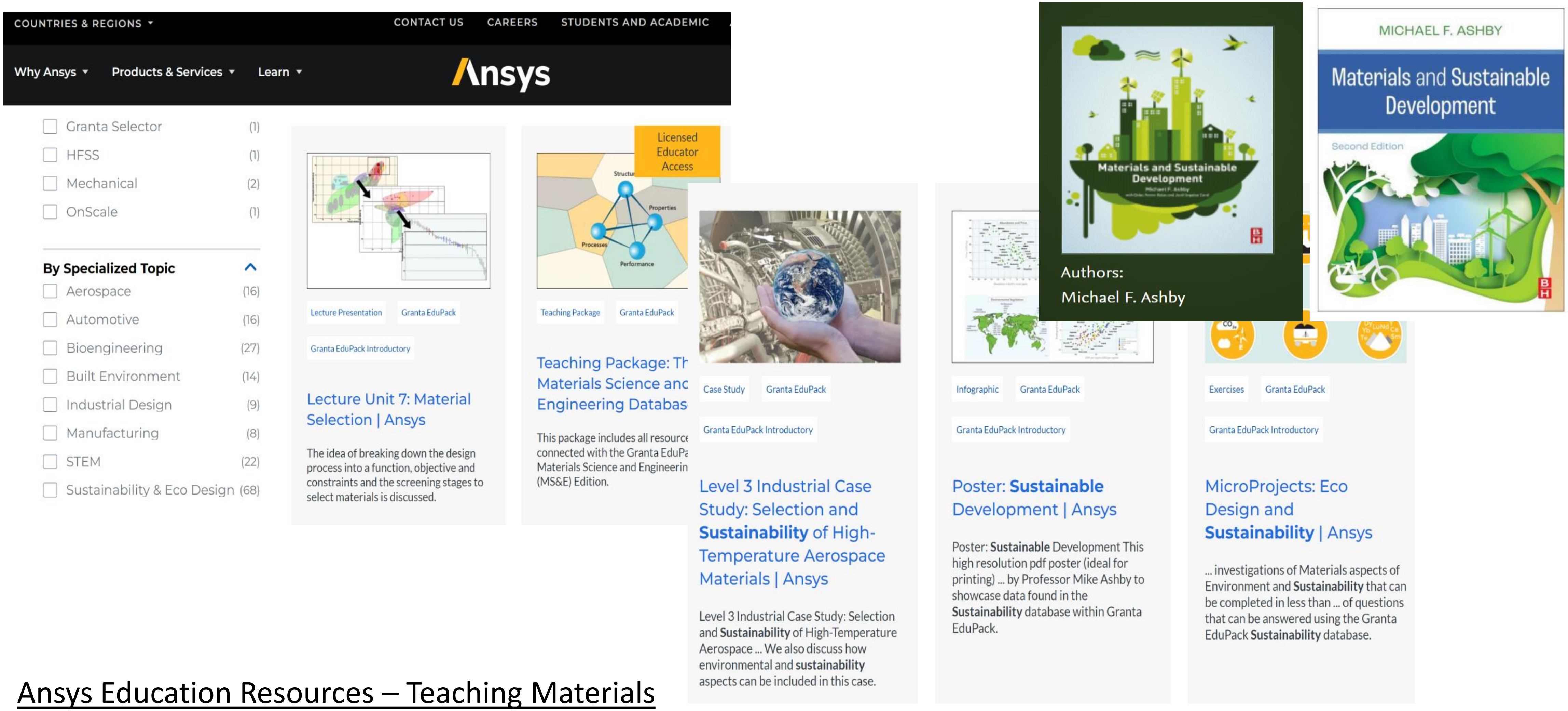
1994 — **Granta Design** founded by Professors Mike Ashby and David Cebon to commercialize digitalised materials data and selection

2011 — **Education Division** founded to focus on academic collaborations and education content development

2019 - today — Granta Design acquired by **ANSYS**, Inc.

©2022 ANSYS, Inc.

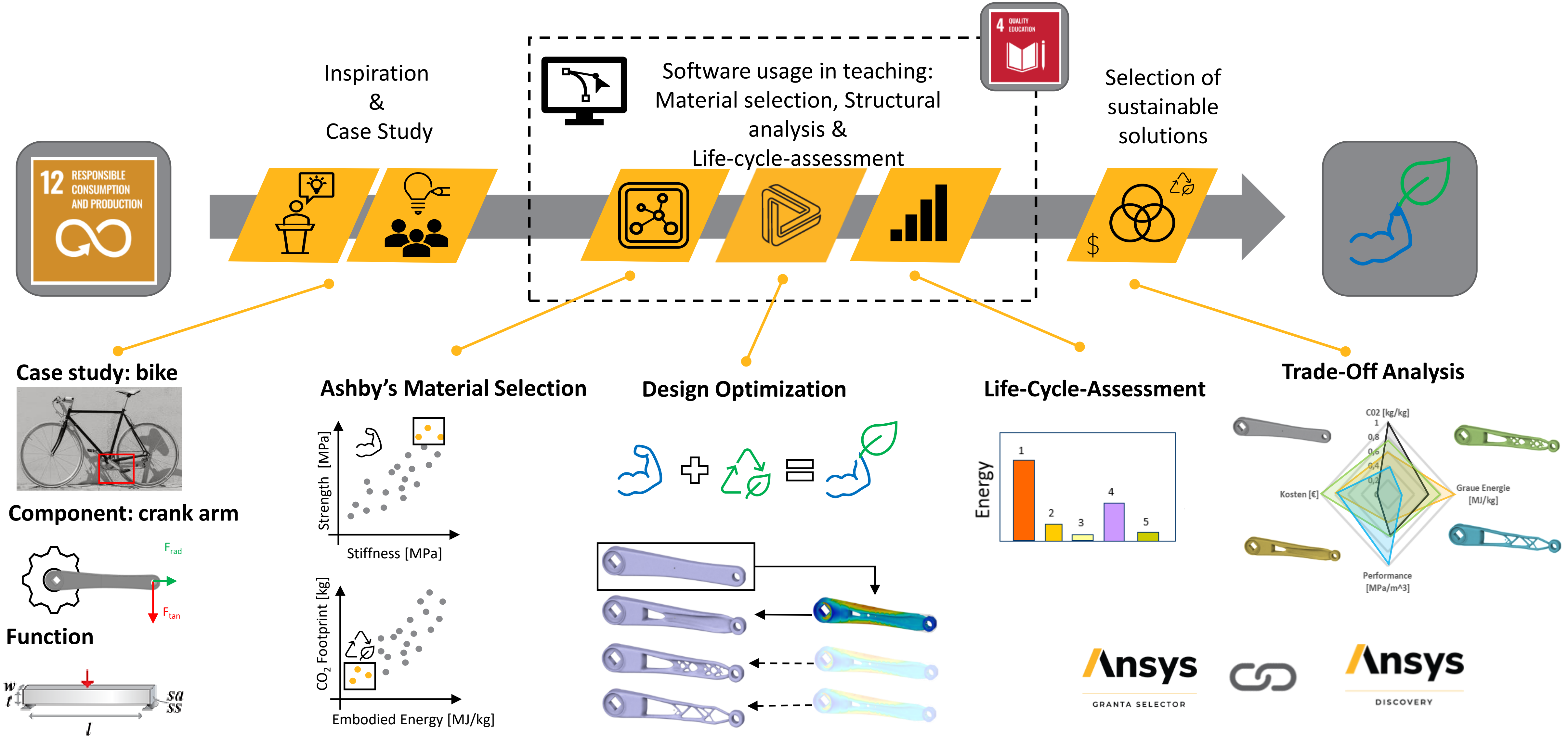
Education Resources Development



Ansys Education Resources – Teaching Materials

©2022 ANSYS, Inc.

Case Study example: Sustainable Product Design



Ansys

©2022 ANSYS, Inc.

Agenda

→Introduction to Ansys Academic / Acknowledgments

→**Background FlyZero Project**

→**Elements & Social Risk *(work-in-progress)***

Ansys

©2022 ANSYS, Inc.

Goal

→FlyZero is developing **concept aircraft with zero in-flight carbon emissions** to support the commercial aerospace industry to meet emission reduction targets.

→The objective of the **ATI FlyZero Aircraft Eco-Design Assessment project with Ansys** was to understand the sustainability impact of the three FlyZero concept aircrafts

©2022 ANSYS, Inc.

Design for sustainability with Ansys

Material selection	Identify Restricted Substances	Design optimization and validation	Concept assessment	Optimal design

Tool to manage and select materials
+
Streamlined E-LCA

Comprehensive library of materials information

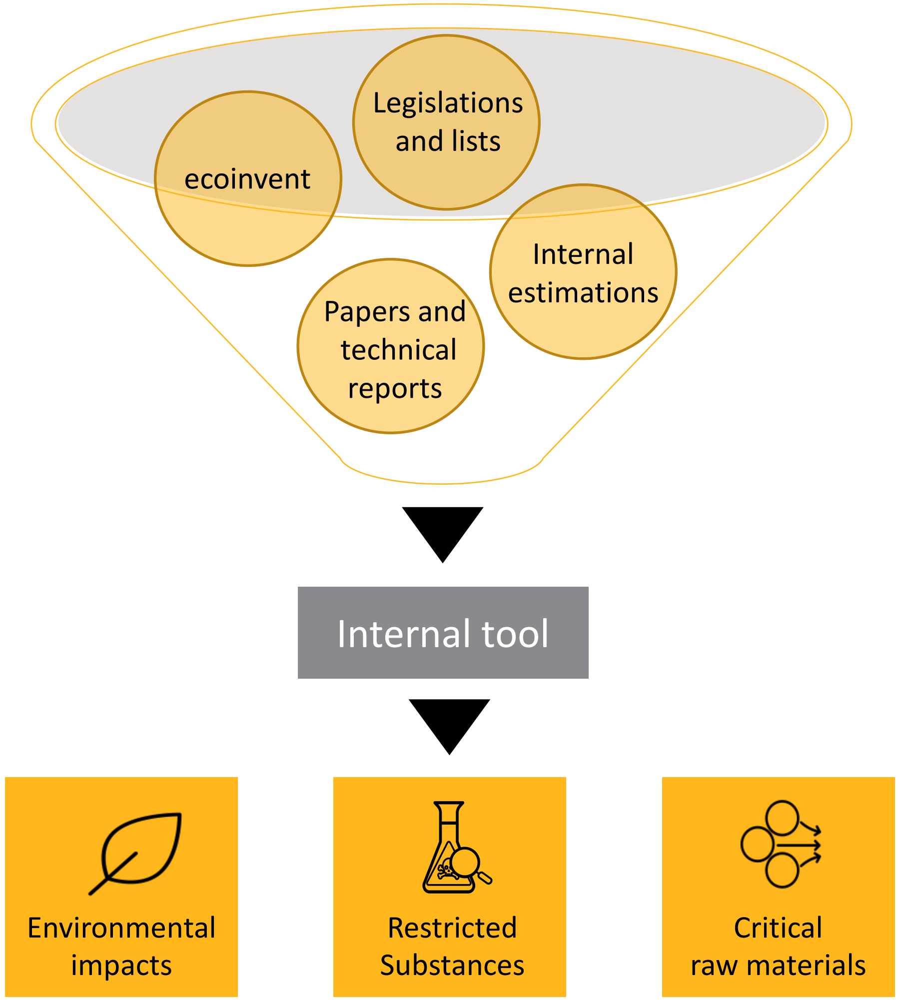
Value

Assess technical, economic and environmental performance	Quick understanding of legislation impact	Design more sustainable materials, products and parts	Savings in time and money

©2022 ANSYS, Inc.

Comprehensive library of materials information

MaterialUniverse™ | focus on sustainability



Aluminium, 7075, O

Primary production energy, CO2 and water

Embodied energy, primary production (virgin grade)	* 180	-	198	MJ/kg
Sources: Estimated from sources including Institute for Prospective Technological Studies, 2005; Hekkert, 2000; Norgate, Jahanshahi, Rankin, 2007; Hammond and Jones, 2008; Ecoinvent v3.7.1; Sullivan and Gaines, 2010; Dhingra, Overly, Davis, 1999; Fthenakis, Wang, Kim, 2009				
Embodied energy, primary production (typical grade)	* 110	-	128	MJ/kg
CO2 footprint, primary production (virgin grade)	* 12.7	-	14	kg/kg
Sources: Estimated from sources including Voet, van der and Oers, van, 2003; Hammond and Jones, 2008; Ecoinvent v3.7.1; Norgate, Jahanshahi, Rankin, 2007; Tharumarajah and Koltun, 2007				
CO2 footprint, primary production (typical grade)	* 7.89	-	9.21	kg/kg
Water usage	* 1.07e3	-	1.19e3	l/kg

Processing energy, CO2 footprint & water

Roll forming, forging energy	* 2.66	-	2.94	MJ/kg
Roll forming, forging CO2	* 0.199	-	0.22	kg/kg
Roll forming, forging water	* 2.69	-	4.03	l/kg
Extrusion, foil rolling energy	* 5.03	-	5.56	MJ/kg
Extrusion, foil rolling CO2	* 0.377	-	0.417	kg/kg
Extrusion, foil rolling water	* 3.7	-	5.55	l/kg
Wire drawing energy	* 18.1	-	20	MJ/kg
Wire drawing CO2	* 1.36	-	1.5	kg/kg
Wire drawing water	* 6.81	-	10.2	l/kg

Restricted substances risk indicators

RoHS 2 (EU) compliant grades?	✓
REACH Candidate List indicator (0-1, 1 = high risk)	0
SIN List indicator (0-1, 1 = high risk)	0

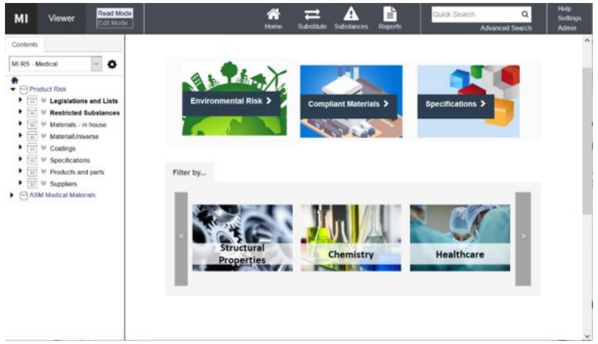
Critical materials risk

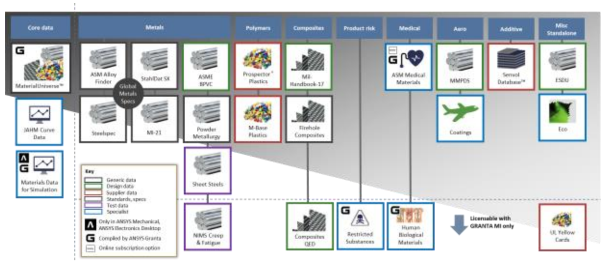
Abundance risk level	Medium	Highest risk elements: Copper, Zinc
Sourcing and geopolitical risk level	High	Highest risk elements: Magnesium
Environmental country risk level	Very high	Highest risk elements: Magnesium
Price volatility risk level	Low	Highest risk elements: Zinc
Conflict material risk level	Caution	Highest risk elements: Copper, Zinc

©2022 ANSYS, Inc.

Ansys solutions used in FLyZero project

Granta MI





MaterialUniverse™

SOLUTION

Easy data management that integrates with CAD, CAE, PLM, …

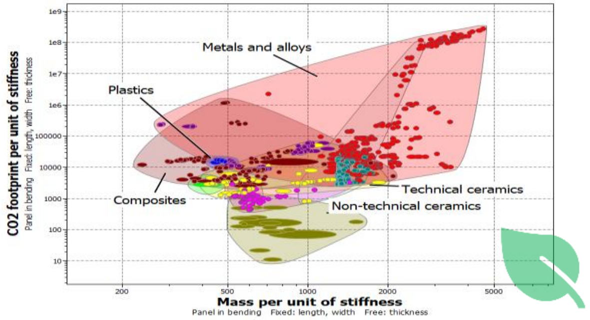
Select compliant and sustainable materials

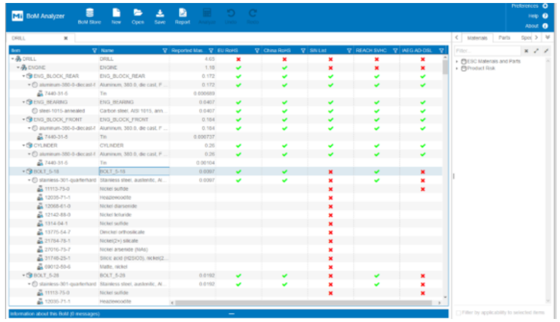
Ansys
GRANTA MI

Comprehensive library of data: Materials | Specification | Legislation | Substances

De-risk designs and fulfil reporting obligations

Granta Selector





Restricted Substances

Ansys

©2022 ANSYS, Inc.

Agenda

→Introduction to Ansys Academic / Acknowledgments

→Background FlyZero Project

→Elements & Social Risk (work-in-progress)

Ansys

©2022 ANSYS, Inc.

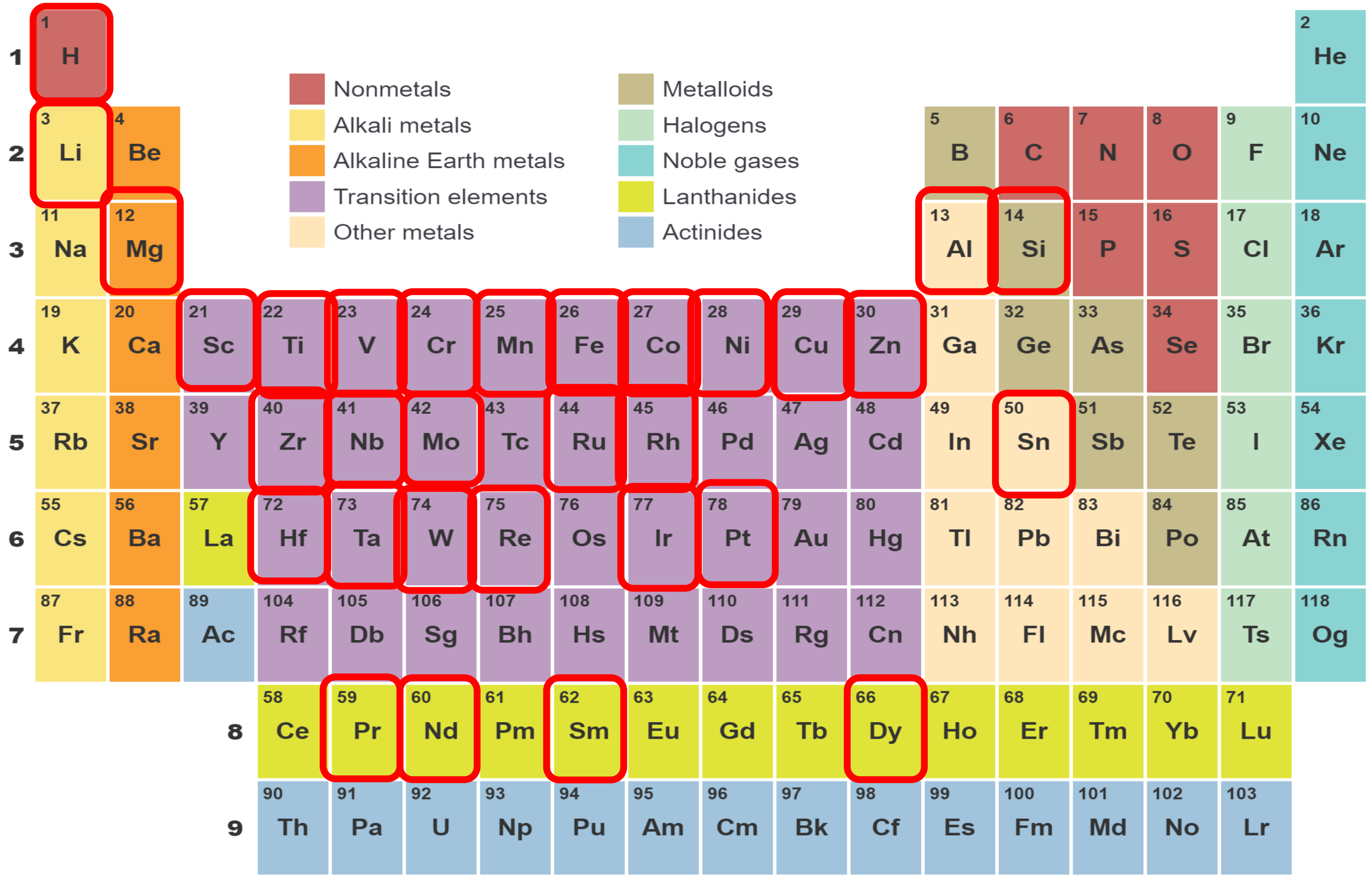
Motivation

→A simplified assessment (screening) of social risk related to elements, which are typically used in aerospace industry

→Such an assessment could aid risk management and support decision-making regarding supply chain management

©2022 ANSYS, Inc.

Elements typically found in aerospace materials



©2022 ANSYS, Inc.

Methodology I

For this assessment we have used several indices, such as:

→**criticality status** (if material is on EU critical materials list)

→**sourcing and geopolitical risk** (HHI index)

→**UN Human development index**

→**child labour** (hours/week on country level – main mining/processing country)

PLUS a **data from a tracker** of human rights allegations in mining operations worldwide.

©2022 ANSYS, Inc.

Methodology II

The indicator used in this work is a **qualitative ranking of Low, Medium or High risk.**

→(!) elements with **Low risk** do not necessarily have a sustainable supply chain, as each case depends on more granular details than are available from a country level assessment for each element.

→(!) Similarly, **High risk** does not mean that supply of the element from a specific country or region is discouraged, but it indicates there are possible risks that must be mitigated or eliminated.

©2022 ANSYS, Inc.

Social risk analysis of elements typically found in aerospace materials

Element	In FlyZero BoM?	In EU list?	Main mining area	Sourcing and geopolitical risk	Ranking
Aluminium	Yes	Yes	China	Low	Low risk
Chromium	Yes		South Africa	Low	Low risk
Cobalt	Yes	Yes	Congo	Medium	High risk
Copper	Yes		Chile	Very low	Medium risk
Dysprosium		Yes	China	Very high	High risk
Hafnium	Yes	Yes	Australia	Very low	Low risk
Hydrogen			USA		Low risk
Iridium		Yes	Russia	High	High risk
Iron	Yes		Australia	Low	Low risk
Lithium	Yes	Yes	Australia	Very low	Medium risk
Magnesium	Yes	Yes	China	High	High risk
Manganese	Yes		South Africa	Very low	Medium risk
Molybdenum	Yes		China	Low	Low risk
Neodymium	Yes	Yes	China	Very high	High risk
Nickel	Yes		Indonesia	Very low	Medium risk
Niobium	Yes	Yes	Brazil	Very high	High risk
Platinum	Yes	Yes	Russia	Medium	Medium risk
Praseodymium	Yes	Yes	China	Very high	High risk
Rhenium	Yes		Chile	Low	Low risk
Rhodium		Yes	Russia	High	High risk
Ruthenium	Yes	Yes	Russia	High	High risk
Samarium		Yes	China	Very high	High risk
Scandium		Yes	China	Very high	High risk
Silicon	Yes	Yes	China	Medium	Low risk
Tantalum	Yes	Yes	Congo	Very low	High risk
Tin	Yes		China	Low	Low risk
Titanium	Yes	Yes	China	Very low	Low risk
Tungsten	Yes	Yes	China	High	High risk
Vanadium	Yes	Yes	China	Low	Medium risk
Zinc	Yes		China	Very low	Medium risk
Zirconium	Yes		Australia	Very low	Low risk

The elements ranked as **High risk and their application** include: **Cobalt** (batteries), **Dysprosium** (electric motors, neodymium magnets), **Iridium** (fuel cells, hardening agent for platinum alloys), **Magnesium** (various light-weight structural applications such as window frames, impeller blades, compressor case, inner door panel, etc.), **Neodymium** (magnets for electric motors), **Niobium** (turbine blades), **Praseodymium** (alloyed with magnesium to make high strength alloys for engine components), **Rhodium** (spark plugs in aircraft, used in alloys for hardening and improving the corrosion resistance), **Ruthenium** (hardening alloy for platinum and palladium for fuel cells; electrical contacts to improve wear resistance), **Samarium** (magnets for electric motors), **Scandium** (alloying element to increase strength, lighten weight, corrosion resistance, weldability; fuel cells), **Tantalum** (turbine blades), and **Tungsten** (alloying element to improve strength and hardness found in aero engines).

©2022 ANSYS, Inc.

Overall results

→The screening approach enables identifying potential risks in order to take appropriate action at the earliest possible time in the product's life span, that is the Concept Design Phase

→There was not a strong overlap in materials ranked as high environmental impact or for restricted substances with the elements ranks as high risk for social performance

→The elements ranked High risk for social impact are in critical components for the aircraft and contribute to low-carbon technologies such as fuel cells and batteries (additional weight of an aircraft)

→Risk management of supply chains regarding social impacts along the product life cycle is required

©2022 ANSYS, Inc.

Thank you!

→ **More** FZO-STY-REP-0005-FlyZero-Sustainability-Report.pdf (ati.org.uk)

©2022 ANSYS, Inc.

Ansys

Applicability of Country Governance Indicators for Assessing Environmental and Social Criticality

IRTC 2023 – Raw Materials for a Sustainable Future
15-17 February 2023 – Lille, France

Konstantin Kühnel (BGR)
Philip Schütte (BGR)
Vanessa Bach (TU Berlin)
Gudrun Franken (BGR)
Matthias Finkbeiner (TU Berlin)

16.02.2023

Motivation & Procedure

Country governance indicators are widely used in Criticality Assessments mainly addressing political and economic supply risk issues.

Goal: Validate the applicability of various governance indicators to environmental and social supply risks.

Assumption: Good governance prevents or mitigates supply risks as it describes the general quality of the national “playing field”.

Approach: Evaluate potential relationships between the occurrence of incidents with potential supply disrupting effects and corresponding indicator values.

- World Governance Indicators (WGI)
  - Voice & Accountability
  - Political Stability & Absence of Violence
  - Government Effectiveness
  - Regulatory Quality
  - Rule of Law
  - Control of Corruption
- Environmental Performance Index (EPI)
- Human Development Index (HDI)
- Fragile State Index (FSI)
- Policy Potential Index (PPI)
- Resource Governance Index (RGI)

Foundation of the Evaluation: Incident Dataset

For further statistical evaluation a **dataset of 256 environmental and social incidents** in industrial mining was compiled, based on a keyword search for news reports filed in the S&P Global Market Intelligence database.

Category	Description
Pollution Incidents	(Explicit) Release of pollutants into the environment.
Environmental Concerns	Protests or lawsuits due to (perceived) damage to environment. Mandatory stop of operations due to water stress, e.g., due to drought.
Labor Issues	Labor strikes or protests of the work force.
Livelihood Limitations	Protest or lawsuits due to perceived curtailment of personal livelihood, conflicts on land use, resettlement or illegal mining as well as allegations of human rights violations.
Regulation Tightening	Changes in regulations with negative consequences for the mine operations.

Realization of the Evaluation: Statistical Testing

Introduction of a **semi-quantitative assessment** to differentiate the incidents based on the reported information on economic, environmental, and social impacts in three magnitude classes:

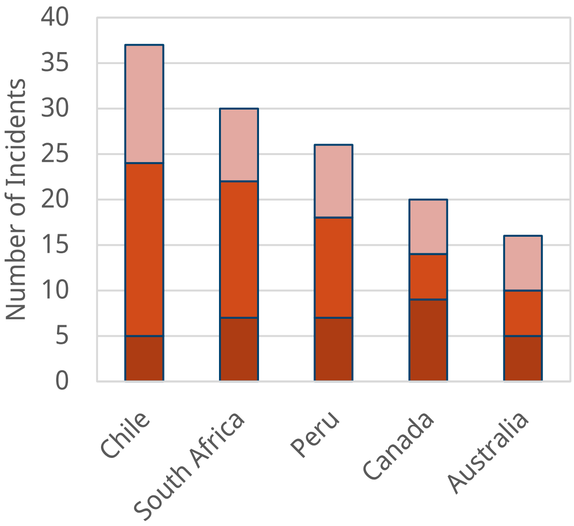
- Data availability differs greatly.
- Certain impacts are difficult to quantify.

Statistical analysis of the relationships between incident magnitude and indicator value applying a Spearman rank correlation and Mood's median test.

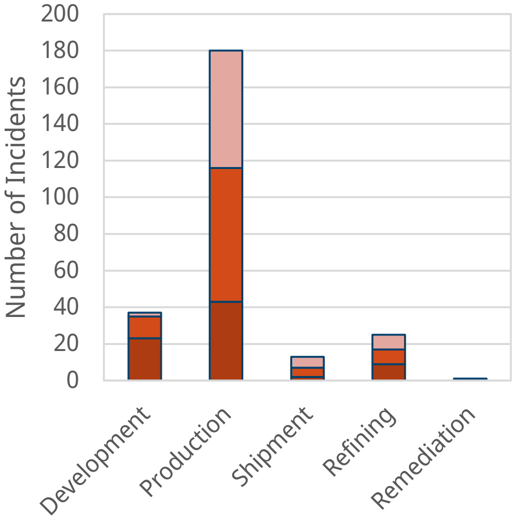
Not the probability of an incident is evaluated, but the **extent of the resulting impact**.

Magnitude Class	Economic Impact	Environmental & Social Impacts
Major	Thresholds for costs and disruption length	Permit revocation Reported fatalities
Moderate	Lower thresholds for costs and disruption length	Permit revision Reported violence
Minor	None of the other criteria is fulfilled	

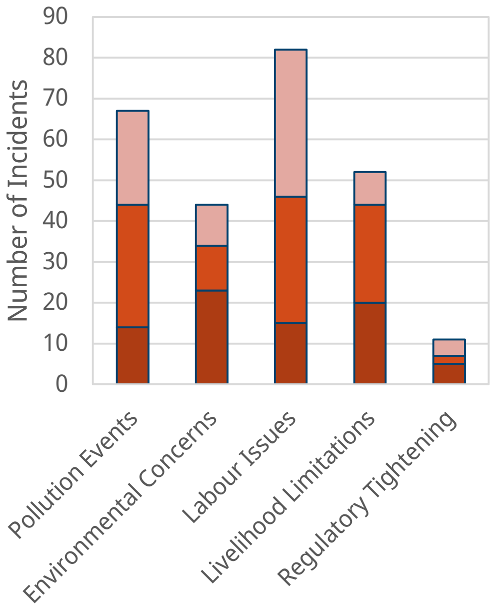
Absolute Incident Distribution by...



... TOP 5 Countries



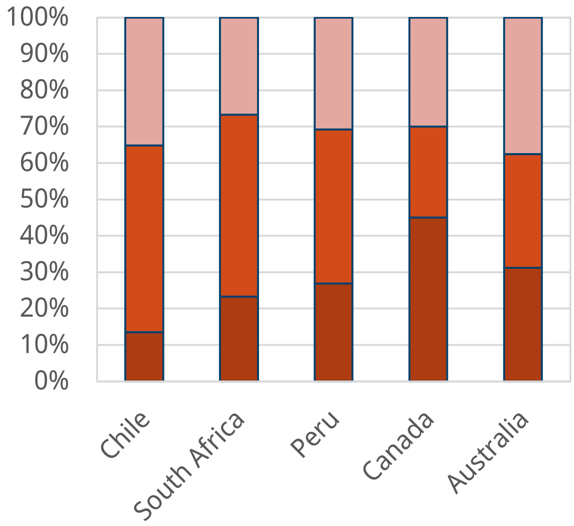
... Mining Stage



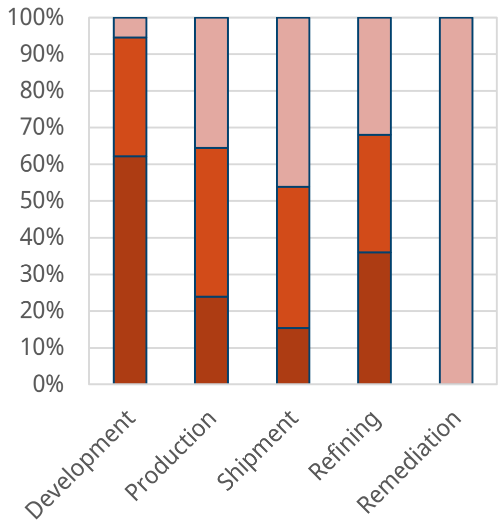
... Incident Category

Major Moderate Minor

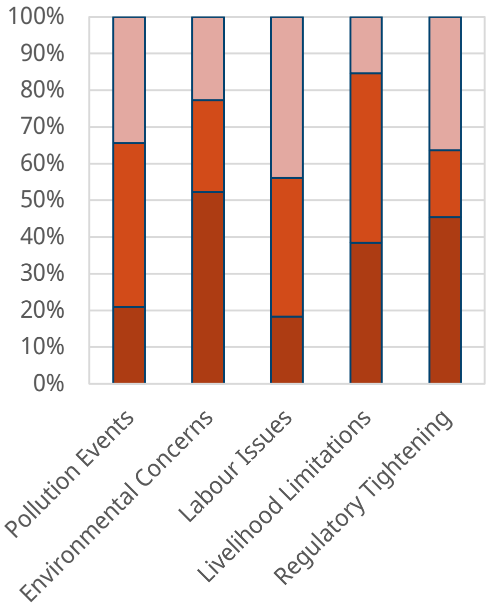
Relative Incident Distribution by...



... TOP 5 Countries



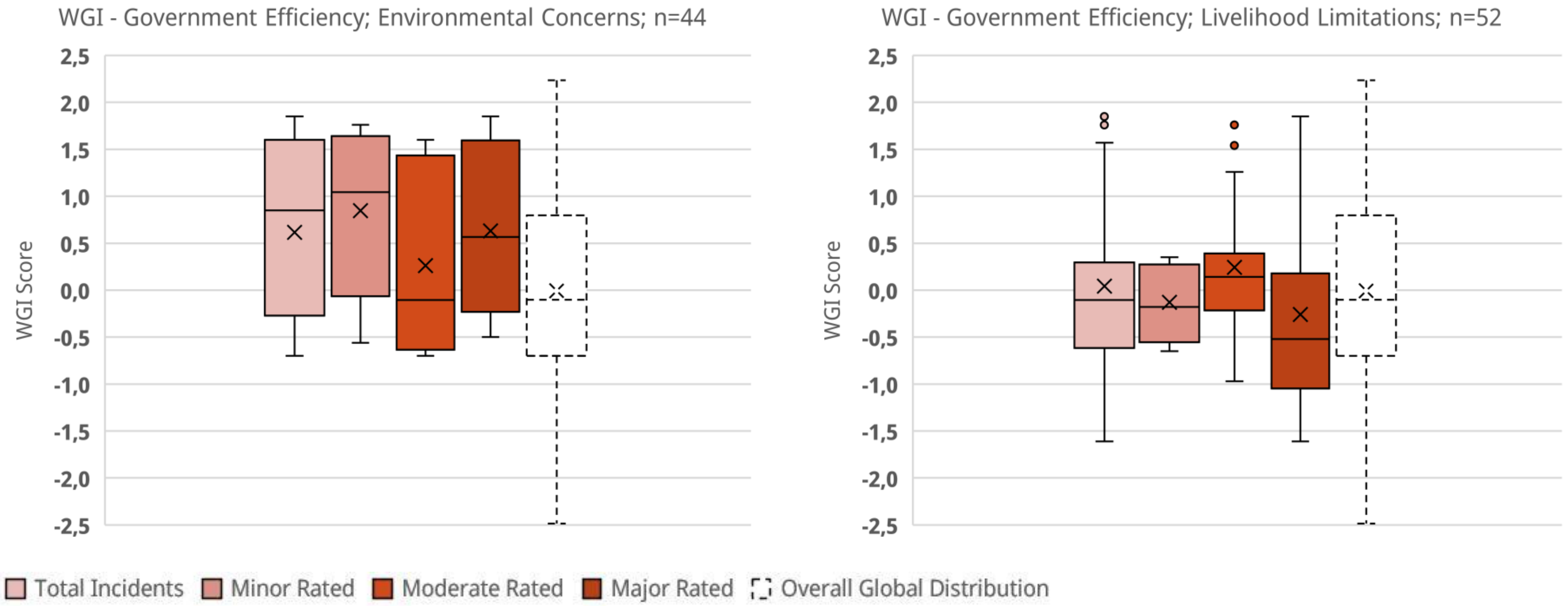
... Mining Stage



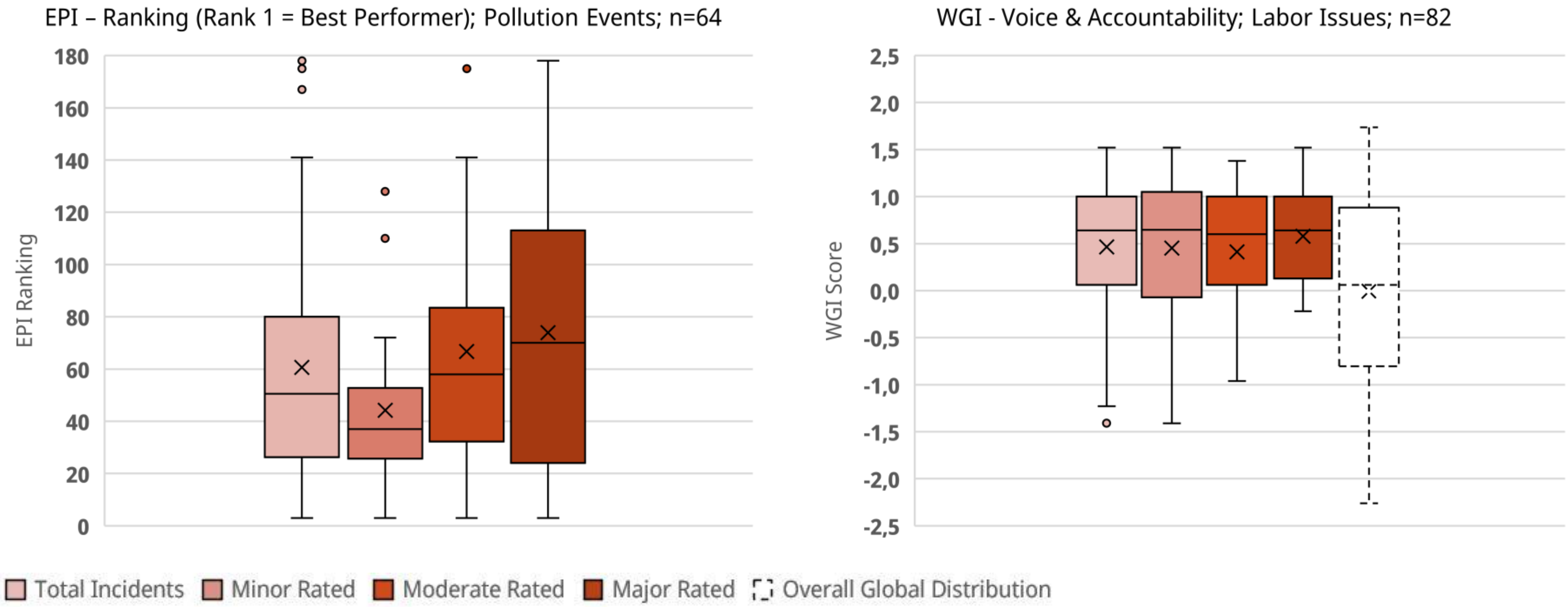
... Incident Category

Major Moderate Minor

Differentiation capacity of the indicators: Setting a Baseline?



Differentiation capacity of the indicators: Predicting the Magnitude?



Results of the Statistical Evaluation

Indicator	Pollution Events				Environmental Concerns				Labor Issues				Livelihood Limitations			
		Spearman		Mood's		Spearman		Mood's		Spearman		Mood's		Spearman		Mood's
	n	ρ	p	p	n	ρ	p	p	n	ρ	p	p	n	ρ	p	p
WGI - V & A	64	-0.13	0.30	0.29	44	-0.17	0.28	0.64	82	0.01	0.95	0.92	52	-0.19	0.18	0.04
WGI - PS & AV	64	-0.09	0.50	0.29	44	-0.12	0.45	0.64	82	-0.05	0.65	0.67	52	-0.03	0.81	0.20
WGI - GE	64	-0.17	0.18	0.29	44	-0.05	0.75	0.67	82	-0.01	0.94	0.28	52	-0.24	0.09	0.05
WGI - RQ	64	-0.18	0.15	0.29	44	-0.03	0.83	0.64	82	-0.08	0.45	0.53	52	-0.25	0.07	0.04
WGI - RL	64	-0.09	0.50	0.29	44	-0.14	0.35	0.64	82	-0.06	0.58	0.71	52	-0.11	0.44	0.25
WGI - CC	64	-0.13	0.29	0.29	44	-0.07	0.65	0.64	82	-0.02	0.88	0.44	52	-0.12	0.39	0.16
WGI - Average	64	-0.16	0.21	0.29	44	-0.06	0.70	0.64	82	-0.02	0.89	0.58	52	-0.21	0.14	0.19
EPI - Rank	64	0.23	0.07	0.01	44	0.23	0.13	0.25	81	0.03	0.79	0.59	49	0.08	0.60	0.40
HDI	67	-0.18	0.15	0.39	44	-0.07	0.64	0.64	82	-0.12	0.26	0.19	52	-0.16	0.25	0.94
FSI	65	0.16	0.19	0.48	42	0.08	0.62	0.63	82	0.05	0.64	0.58	46	0.23	0.12	0.05
PPI	58	-0.20	0.14	0.16	32	0.02	0.91	0.50	74	-0.09	0.43	0.30	39	-0.04	0.81	0.84
RGI - Mining	30	0.01	0.98	0.76	18	-	-	-	59	-0.21	0.11	0.09	31	-0.07	0.69	0.92

|ρ| ≥ 0.2 ; p ≤ 0.05 – Thresholds for a weak correlation...

|ρ| ≥ 0.1 ; p ≤ 0.1 – ... more generous thresholds to emphazise the tendency.

Conclusion & Outlook

Only **limited suitability** of the evaluated country governance indicators could be demonstrated. Possible Reasons:

Methodology: Not well suited enough – maybe…

Indicator Specifity: Indicators too generalized to picture the specific conditions in mining sector.

Indicator Resolution: Country level not precise enough for actual conditions at the project Site.

„Playing Field“ Assumption: Country governance not (alone) relevant in the first place.

Addressing **complexity** of environmental and social risks should go beyond the „playing field“.

Precondition: To exclude less relevant risks and focus on the important risks.

Handling: Actual risk management at company or project level finally crucial for risk manifestation.

But: Data acquisition for a global criticality assessment will be, at least, challenging.

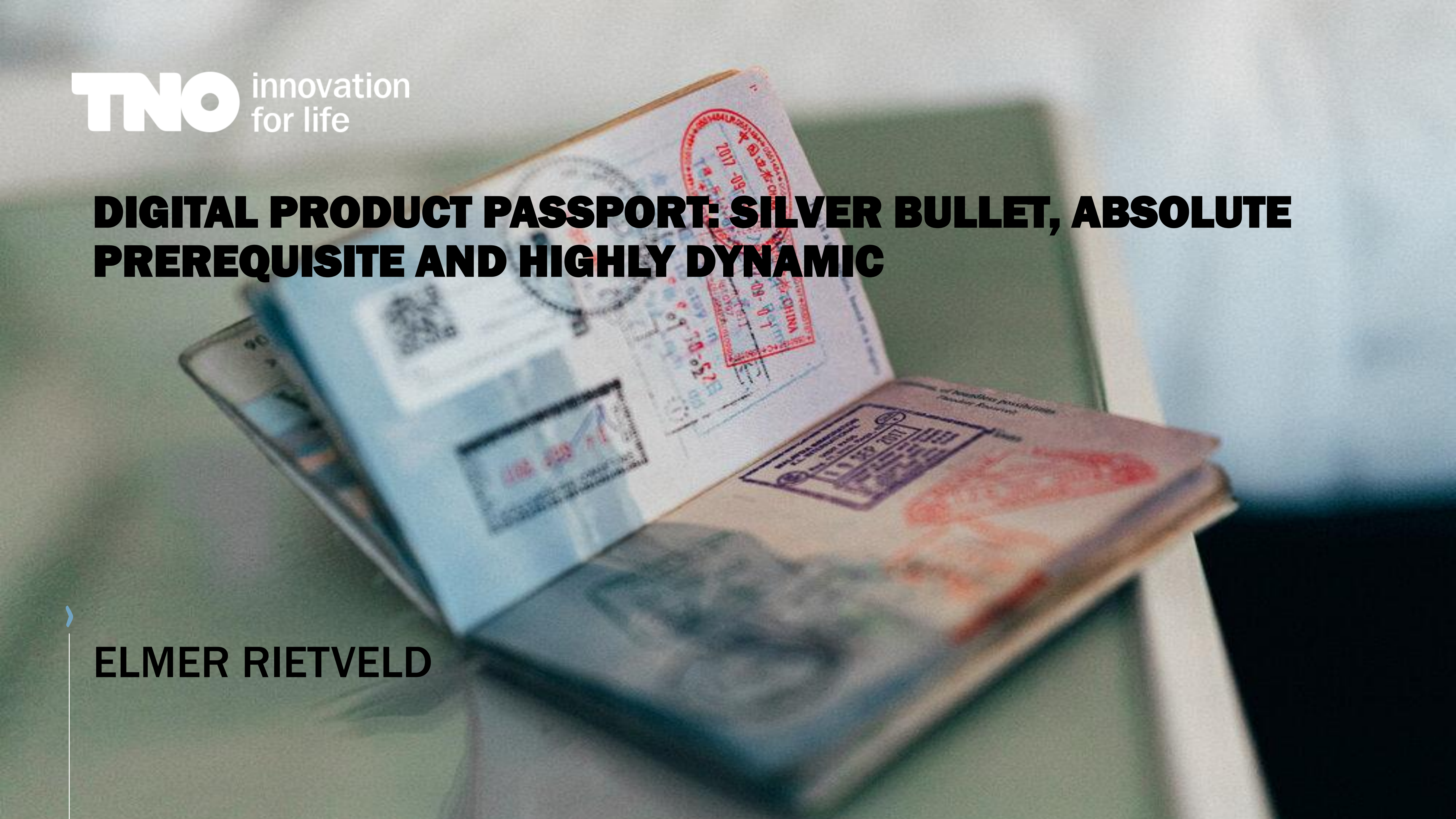
(Future) **Indicator Candidates**: ESG- / CSR-Rating

Thank you for your attention!
Glückauf!

Contact:

Konstantin.Kuehnel@bgr.de

+49 (0) 511 643 3932



TNO innovation for life

DIGITAL PRODUCT PASSPORT: SILVER BULLET, ABSOLUTE PRERQUISITE AND HIGHLY DYNAMIC

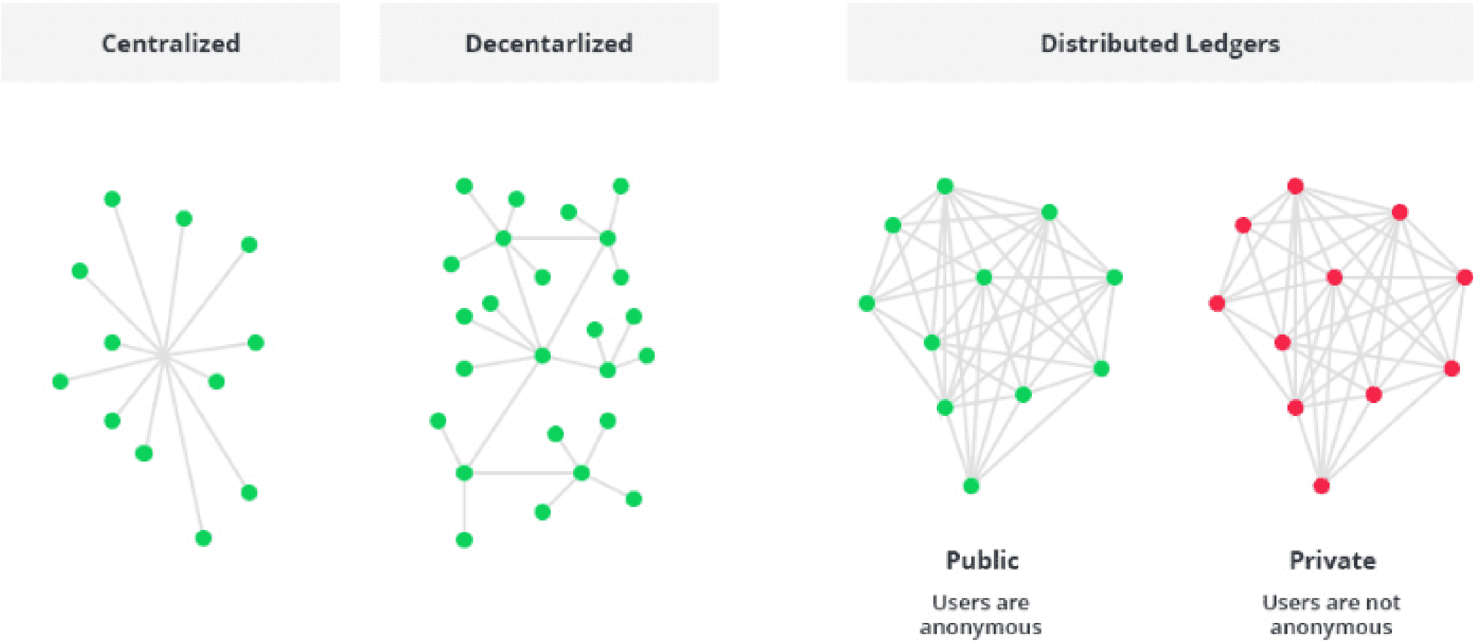
ELMER RIETVELD

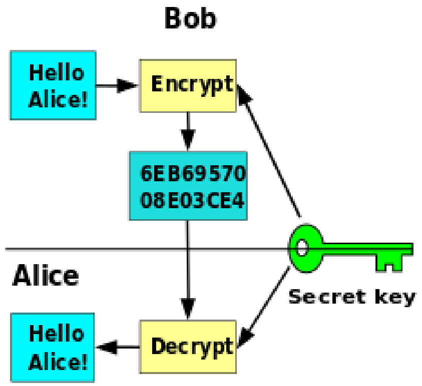
SOCIETY DEMANDS SUSTAINABLE SOURCING

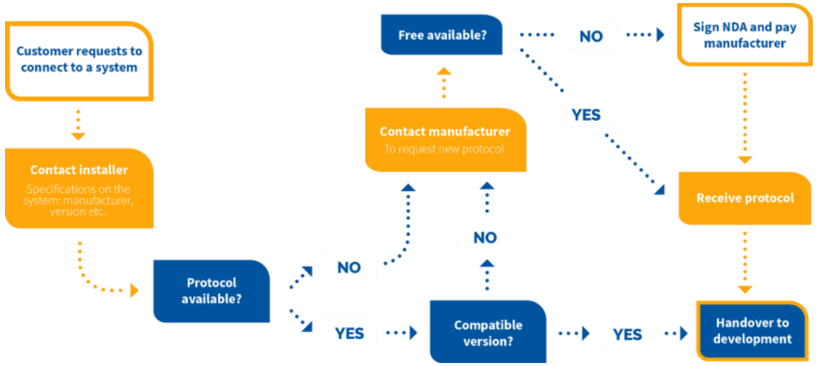
“tectonic geoplitical shift and Twin Transition”

(EU) Policy	Focus
International Reporting Standards (IFRS)	Reliable data for ESG (Environment Sustainability Governance) reporting
EU Green Taxonomy	Generic
Global Reporting Initiative (GRI)	Generic
UPCE Netherlands	Public procurement
European & Circular Economy Action Plan (CEAP)	Making CE politically relevant
Sustainable Product Initiative (SPI)	DPP (DG GROW, DG RTD) –legislation expected Q1 2022
EU Dataspace for Smart Circular Applications	Supply of ICT solutions
REACH	Keep the toxic bogeyman away
GAIA-X , Catena –X, SCSN | Industrial Data Space	Supply of ICT solutions
EU Battery Regulation	Battery Passport
IPCEI Micro-elektronica / Cloud / Waterstof	Iconic projects

WE'RE LIVING IN AN INFORMATION REVOLUTION

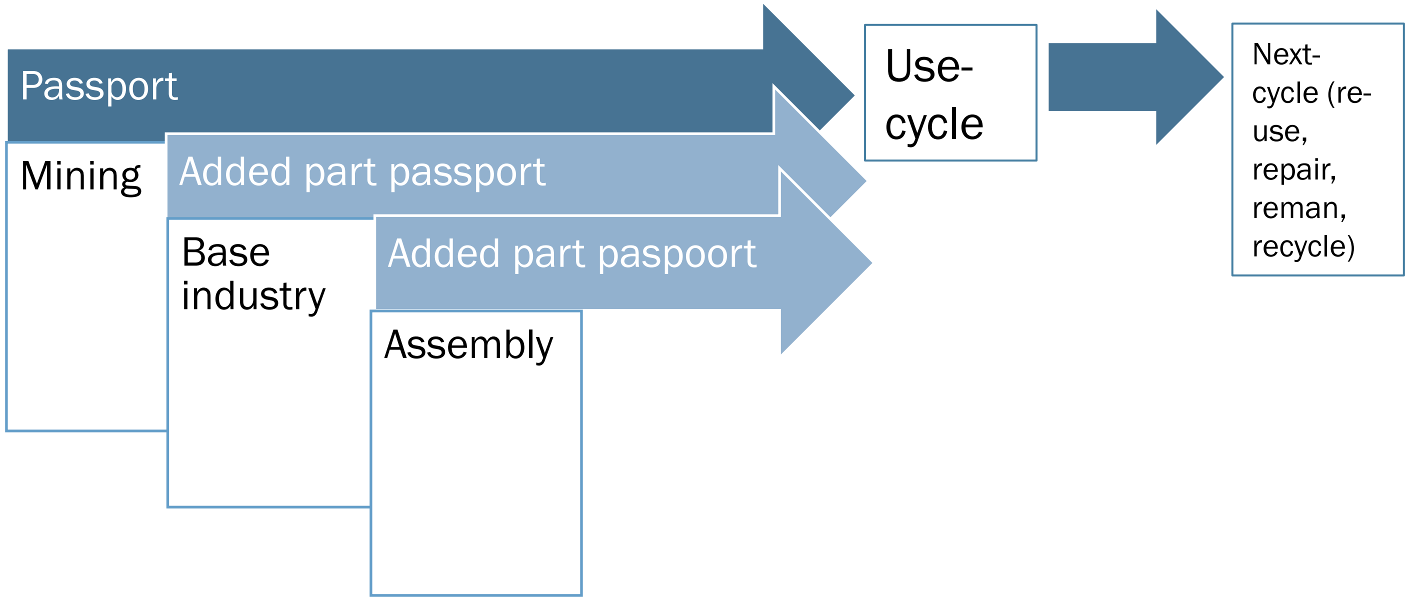






UNIVERSAL PROPERTIES
BUILDING UP OVER THE SUPPLY CHAIN

Unique identifier, information about producer, production location, production, transport and date of sale, administrative product code(s) internal, administrative product code(s) external (sector, ISO, PEF, certificates, etc.), statistical codes, codes relevant to HazSub (CAS), **environmental impact of production process (ILCD standard),** social impact of the product (SLCA standard), GDPR aspects, access authorizations for all parts of DPP, declaration of ownership. And all relevant codes from previous versions of the product (management of versions/legacy/vintage/stock related to product)



TOPICS RAISED BY STAKEHOLDERS FROM INDUSTRY AND POLITICS

Why

- Incentive: Clear incentive(s) for companies to participate in a DPP, a “killer app” is needed in the short term
- Obligation: In the long run you will have to make certain elements of a product passport mandatory, the question is what and when

What

- Existing: Clear view of possibilities using existing data
- Scalability: How region and/or sector specific product passports can connect to a universal part of a product passport
- Foreclosure: Availability of all options for foreclosure and/or unambiguous ownership situation data
- Verification: ICT must build in control mechanisms so that incorrect information can be identified quickly
- Fact vs. Assessment: Distinction between assembly data on the one hand and assembly data and meta data on the other.
- Table of contents: Clarity as soon as possible about the universal properties of products described in each product
- Chain dependency: How to build the DPP across the chain, including operational data in use phase
- Material & Process: The difference between the composition of a product and the method of manufacture, assembly and metadata

Who

- The Hague: A coordinating role between companies and the EU is needed, as is an incremental set of agreements regarding product passport systems
- ICT Supplier: Opting for the ICT Supplier market model and preventing lock-in and network dependence
- Brussels: Role of national and European governments in defining the universal part of the passport
- Arbiter: Verification of data for effective use in 3rd party verification
- Circulariser: The repairer, waste processor, maintenance engineer and lease service provider can all benefit above all

How

- Interoperability: Technical development of interoperability between different systems via generic communication protocol
- Enforcement: Enforcement of quality DPP by governments, inclusions determine reward and punishment
- Growth model: Which growth model can lead to DPP coverage of large parts of the economy in the coming years
- Cost price: Acceptable cost price product passports for entrepreneurs
- Generation: When can you add a new product and how long does an old product remain in the system
- Privacy: GDPR compliance must be guaranteed

CONCLUSIONS

1. DPP WILL BE CREATED, WHEN AND HOW IS THE QUESTION
2. DATA SECURITY IS KEY AS EVER, A CHALLENGE MET BY DATA SOVEREIGNTY CONCEPTS
3. ICT SOLUTIONS FROM OTHER FIELDS THAN SUPPLY-CHAIN MANAGEMENT, ESG AND DUE DILIGENCE ARE MAIN DRIVERS
4. CARROTS ARE BETTER THAN STICKS: REWARD ADOPTION OF A DPP SYSTEM RATHER THAN PUSH FOR A CERTAIN SYSTEM
5. EXPENSES FOR SME'S SHOULD BE LOW (E.G. >100EUR/MONTH), OTHERWISE DPP WILL REMAIN A MULTINATIONAL PRIVILEGE

ELMER.RIETVELD@TNO.NL
- TON.BASTEIN@TNO.NL
SAM.HELMER@TNO.NL

Rethinking State Sovereignty over the Raw Materials in the era of planetary boundaries

Daria Boklan & Chamu Kuppuawamy

1-st Argument

We need to rethink state sovereignty over natural resources in the context of planetary boundaries concept. This new context is a merger of environmental and economic elements of sustainable development.

2-st Argument

Assessments of economic development should take into account not only the benefits of <u>consumption</u> of natural resources (especially raw materials), but also the benefits from their <u>preservation</u>.

3-d Argument

Existing international law and law of the World Trade Organization (the WTO) in particular is not sufficient to protect interests of the states possessing sovereignty over the raw materials.

Content

- Is it possible to limit state sovereignty by its nature?
- How sovereignty and planetary boundaries concept are compatible with each other?
- What are the developments of the currently running WTO case *Indonesia – measures relating to raw materials*?
- Could NDCs be used as possible justification for export ban of the raw materials?

1. Can state sovereignty be limited by its nature?

Two approaches:

1. International agreements impose limits on the sovereignty

2. State sovereignty cannot be limited by nature it is an **attribute** of a state

PCIJ (*Wimbledon* case and advisory opinions, 1923)

"Restrictions on the exercise of sovereign rights accepted through treaty by the State cannot be considered an infringement of sovereignty"

WTO DSB (*China – Raw Materials, 2012*)

"The ability to enter into international agreements, such as the WTO Agreement, is a quintessential example of the exercise of sovereignty".

Conclusion 1

Sovereignty cannot be limited by nature as it is the attribute or quality of a state.

2. How sovereignty over natural resources and planetary boundaries concept are compatible with each other?

The need to reconcile economic development with the protection of the environment is aptly expressed in the concept of sustainable development. (ICJ. *Gabčikovo-Nagymaros Project (Hungary v. Slovakia)*. Judgment of 25 September 1997 // I.C.J. Reports. 1997. P. 78. §140)

WTO jurisprudence

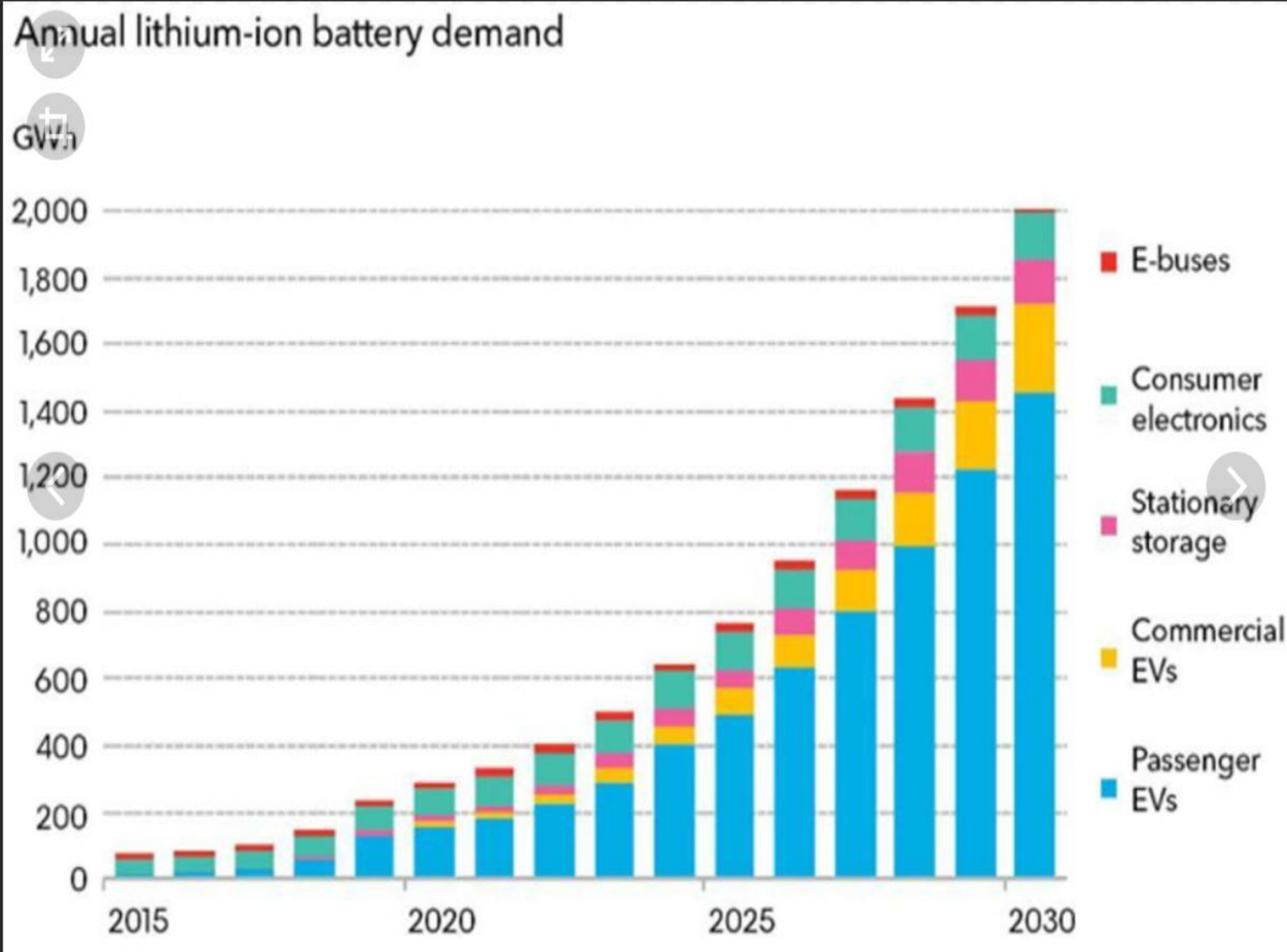
- Conservation and economic development are not mutually exclusive policy goals; they can operate in harmony. (*China – Rare Earths*)
- They are related facets of an integrated whole *(China – Raw Materials)*

Conclusion 2

The environmental and economic elements of sustainable development are merging today in the context of the planetary boundaries concept.

3. What could be possible developments of the currently running WTO case?

Indonesia – Measures Relating to Raw Materials (DS 592)



Annual lithium-ion battery demand
GWh
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
2015
2020
2025
2030
E-buses
Consumer electronics
Stationary storage
Commercial EVs
Passenger EVs

Article XX (d) of the GATT

- […]nothing in this Agreement shall be construed to prevent the adoption or enforcement […] of measures:

- d) necessary to secure compliance with laws or regulations which are not inconsistent with the provisions of this Agreement

Three key elements of Article XX (d)

(Appellate Body Report, *Thailand - Cigarettes (Philippines)*, para. 177)

- **that the measure at issue secures compliance with ‘laws or regulations’ that are themselves consistent with the GATT 1994;**
- **that the measure at issue is "necessary" to secure such compliance;**
- **that the measure at issue meets the requirements set out in the chapeau of Article XX**

Conclusion 3

The GATT is not sufficient to secure the interests of the WTO members where raw materials are deposited

Final conclusion

States combating climate change cannot protect environment and achieve energy transition at the expense of states of origin of raw materials.

Thank you very much for your attention!

LIB RECYCLING: A LIMITED YET INEVITABLE SOLUTION TO COPE WITH THE IMPACTS OF CRITICALITY

Dr Naeem ADIBI

LCA expertise start-up

Start-up since 2017 (12 colleagues)

2 offices : Lambersart & Bordeaux

SERVICES & COMPETENCES

- **Life Cycle Assessment (LCA)** environmental, social & economic
- **Eco-design**
- **Criticality assessment of** materials
- **Life Cycle Management (LCM)**
- **Circular economy and** sustainable strategies
- **Awareness raising and training** to implement LCM

SECTEURS D'ACTIVITES

Mobility

Food

Energy

Building

Electrical and electronics

Packaging

Batteries

ACTIVITIES RELATED TO BATTERIES

BATTERS

Région Hauts-de-France

Establish a roadmap to implement a circular economy in the EV battery sector in the North of France region.

Development of robust LIB recycling LCIs.

SCORELCA

TND La recherche des métaux rares

RecyBat-Li

Université de Picardie Jules Verne

LRCS Laboratoire de Réactivité et Chimie des Solides UMR 7314 · UPJV/CNRS

Life cycle assessment of a direct BM recycling process from EV batteries at laboratory phase.

Modelling of LIB recycling processes and implementation of recycled materials into the Renault battery design model.

GROUPE RENAULT

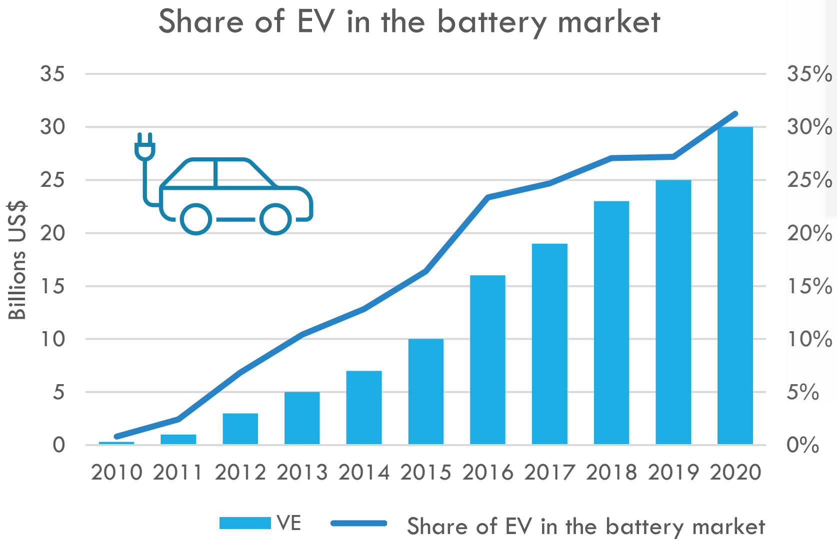
irtc International Round Table on Materials Criticality

Development of a tool to assess the criticality of metals contained in EV batteries.

LIB EV CONTEXT

1 Growth in the battery and e-vehicle market

- **90 Billion** US$ in 2020
- **115 Billion** US$ estimated in 2030
- Average growth of **8%** per year



2 European regulation evolution

- Green deal/ Circular economy action plan
- European Battery Alliance
- Ban on the sale of combustion engine vehicles by 2035
- List of critical materials (2020)

- **Proposition of regulation of the European parliament concerning batteries and waste batteries, repealing Directive 2006/66/EC**
- **Recycled content in EV batteries**

Recycled content	2032	2037	2070
Ni	6%	15%	74%
Co	16%	26%	92%
Li	6%	12%	52%

- **Efficiency of battery recycling and material recovery**

KPIs	2026	2030
Recycling efficiency (in mean weight of lithium batteries)	**50% of overall batteries Lithium: 20%**	**Lithium: 80%**

3 Three new gigafactories in Haut-de-France region

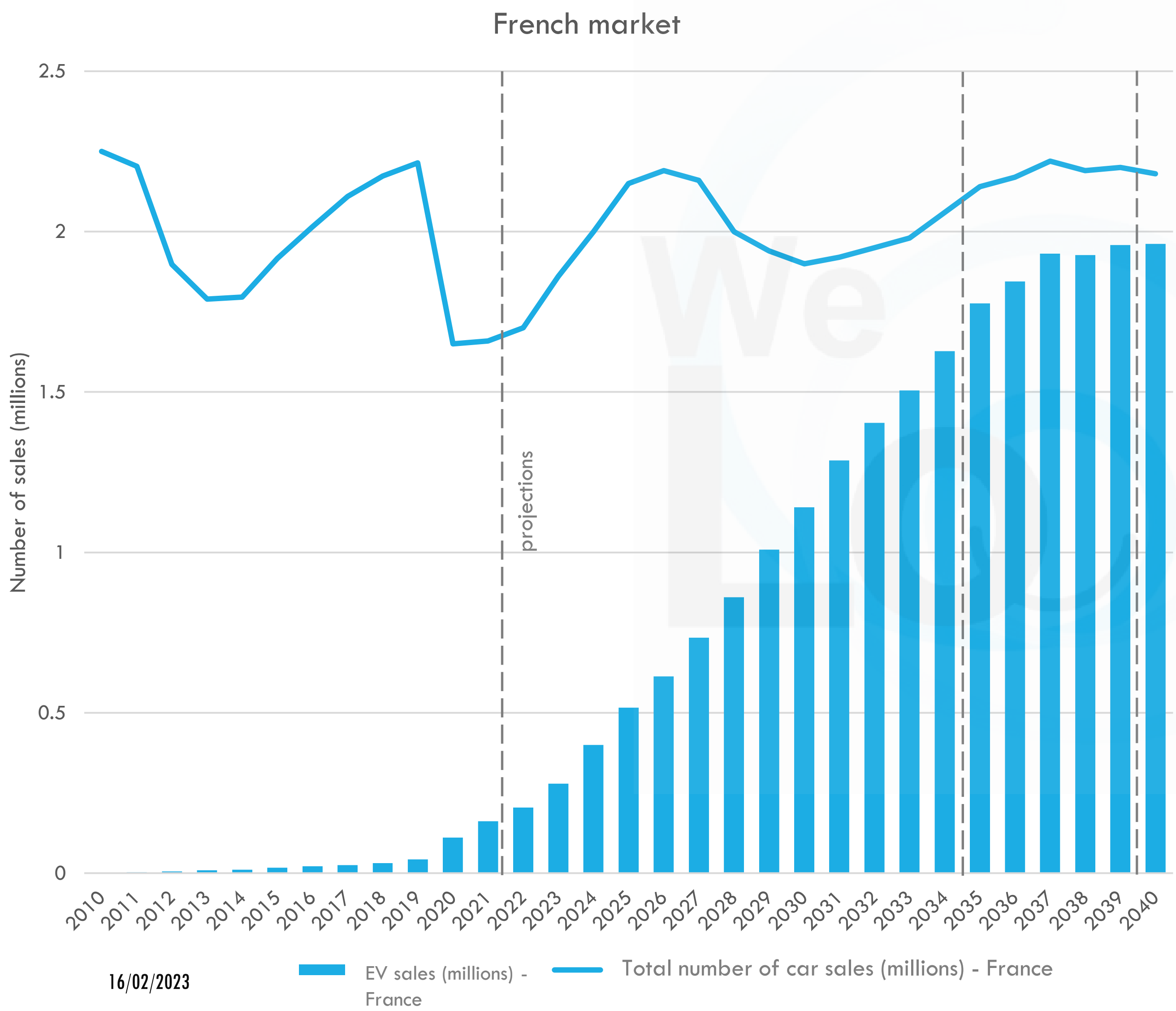
Verkor, 2025
Dunkirk
Gigafactory 16GWh
(50GWh in 2030)

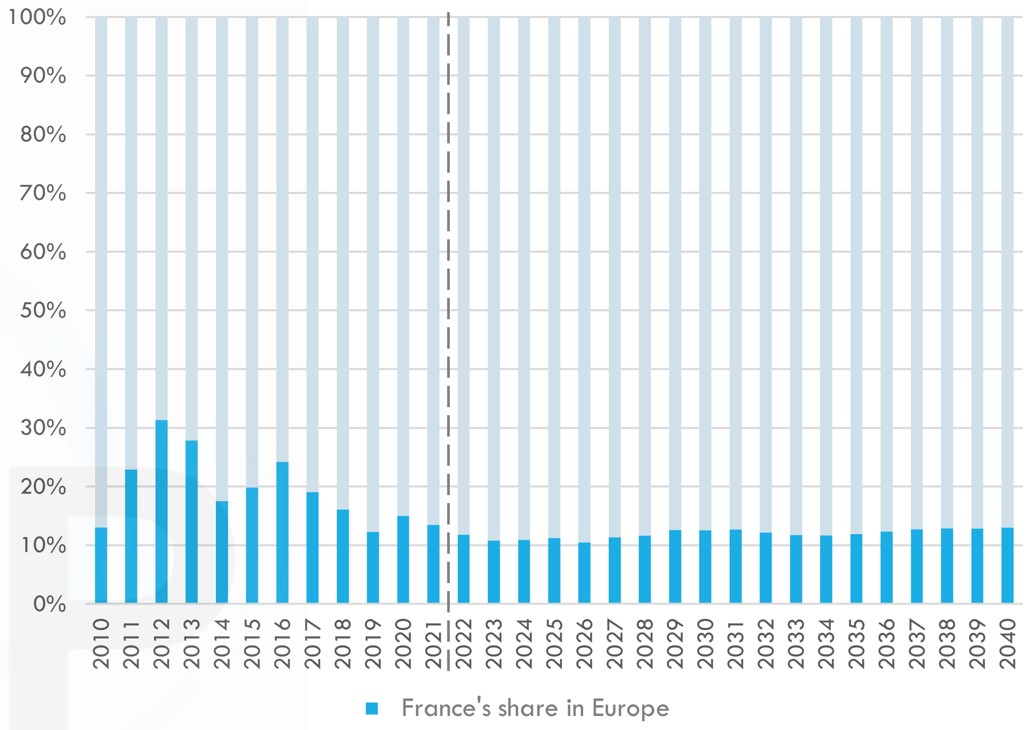
Renault-Envision, 2024
Douai
Gigafactory 9GWh,
(24 in 2030)

ACC, 2023
Douvrin
Gigafactory 8GWh,
(24-32 in 2030)
Lithium ion

BATTERY MARKET

France



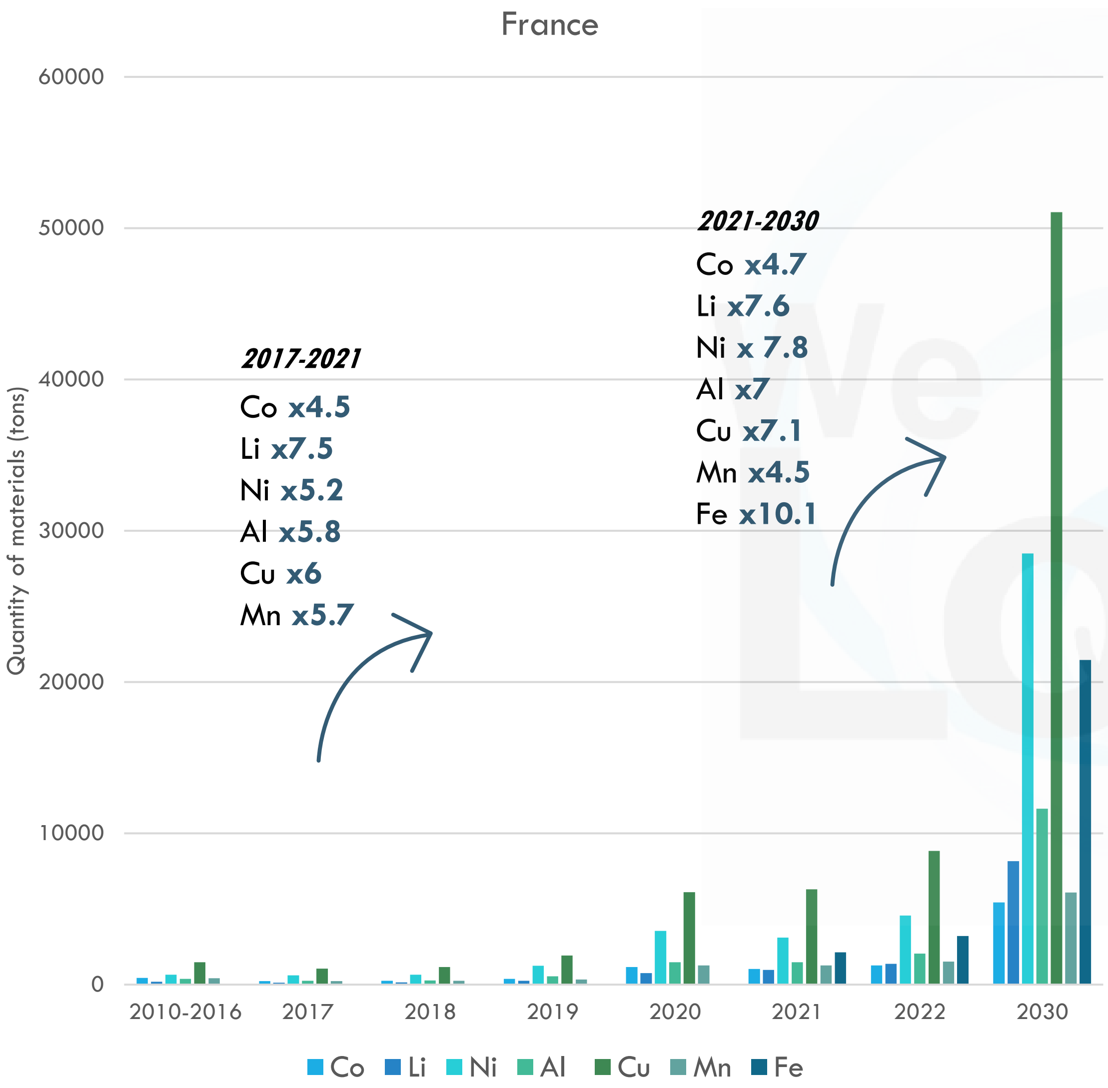


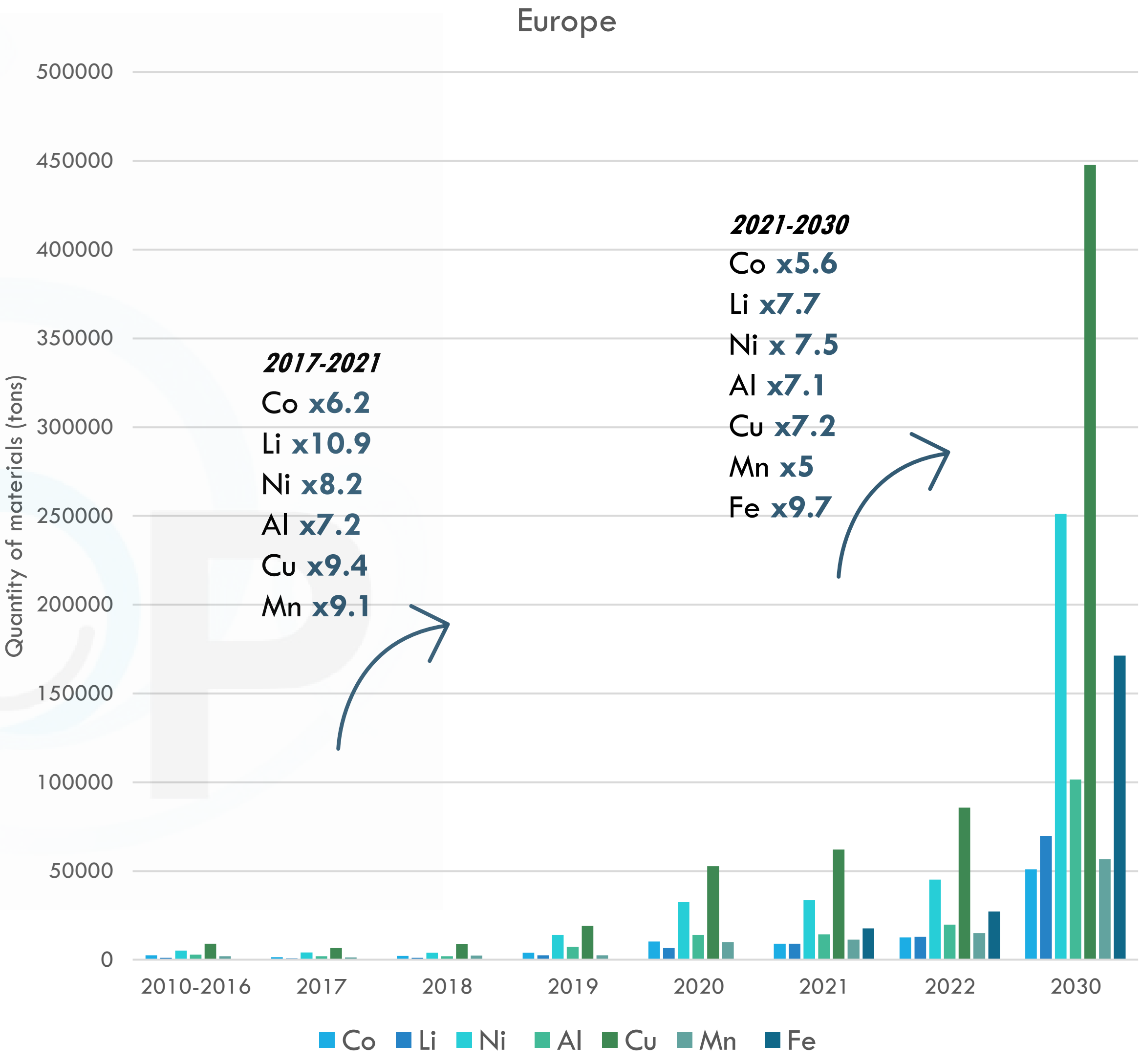
In **2020**, France accounts for **15 %** of the European market

COMPARISON OF TECHNOLOGIES

	LCO	LFP	LMO	NCA	NMC 111	NMC 622	NMC 811
Energy density							
Lifespan							
Security							
Profitability of recycling							
Criticality of materials							
Temperature sensitivity							
Price							

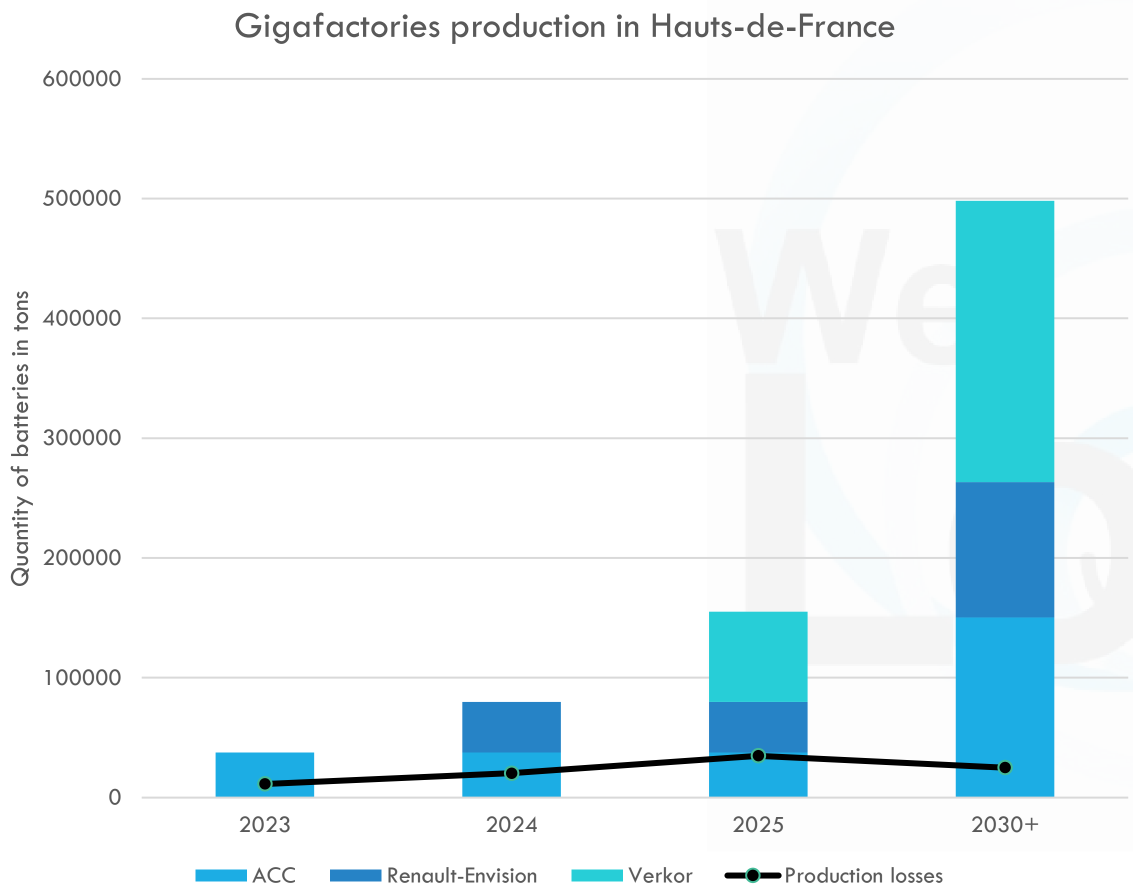
MATERIAL CONSUMPTION





BATTERY PRODUCTION

Gigafactories



→ Battery density: **4.7** kg/kWh

VERKOR — **50** GWh

acc AUTOMOTIVE CELLS Co — **32** GWh

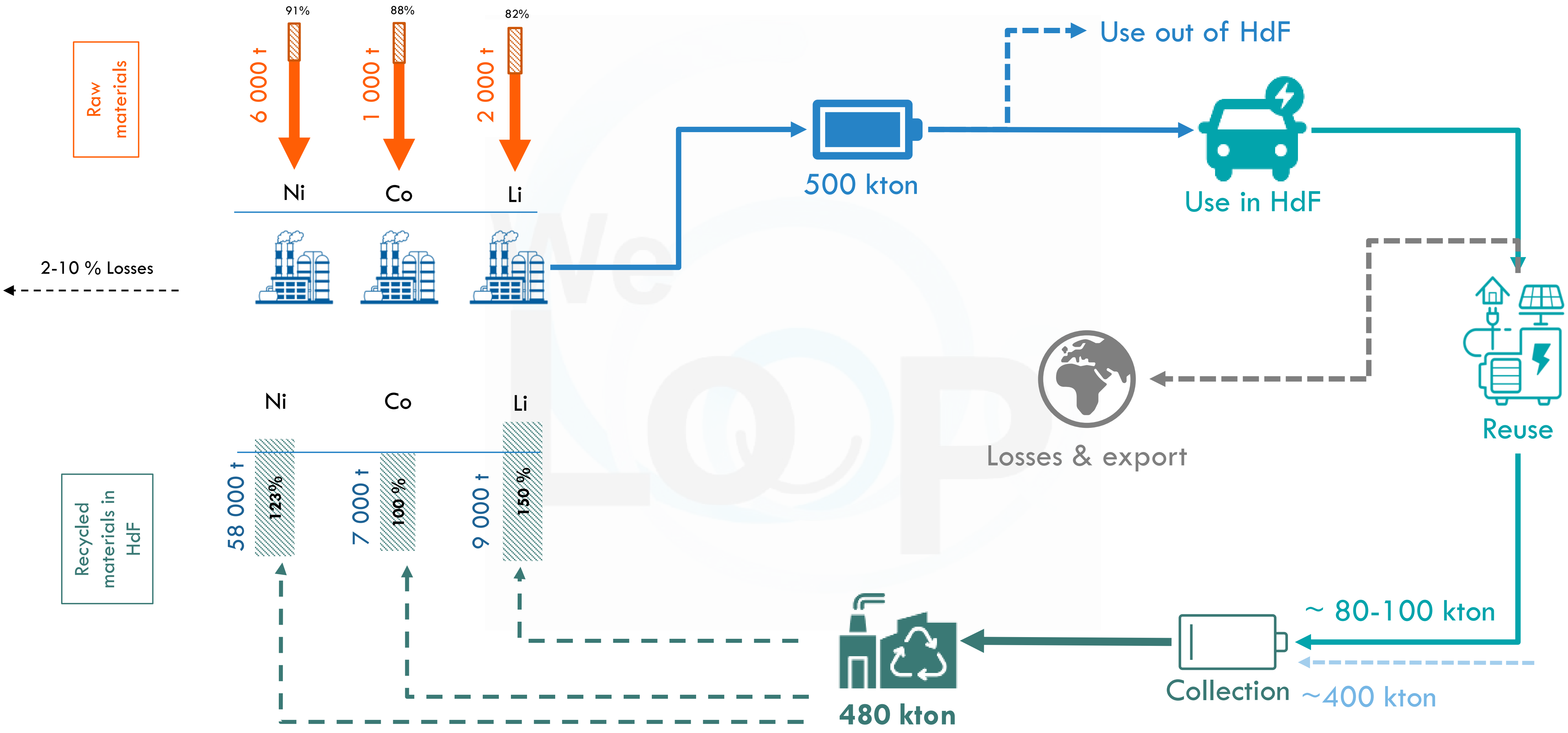
Envision AESC — **24** GWh

Annual production in HdF in 2030+ **106** GWh **500 000** tons

Reduction in **production scraps**

- **30%** high scenario
- **5%** low scenario

LIFE CYCLE OF BATTERIES IN HdF



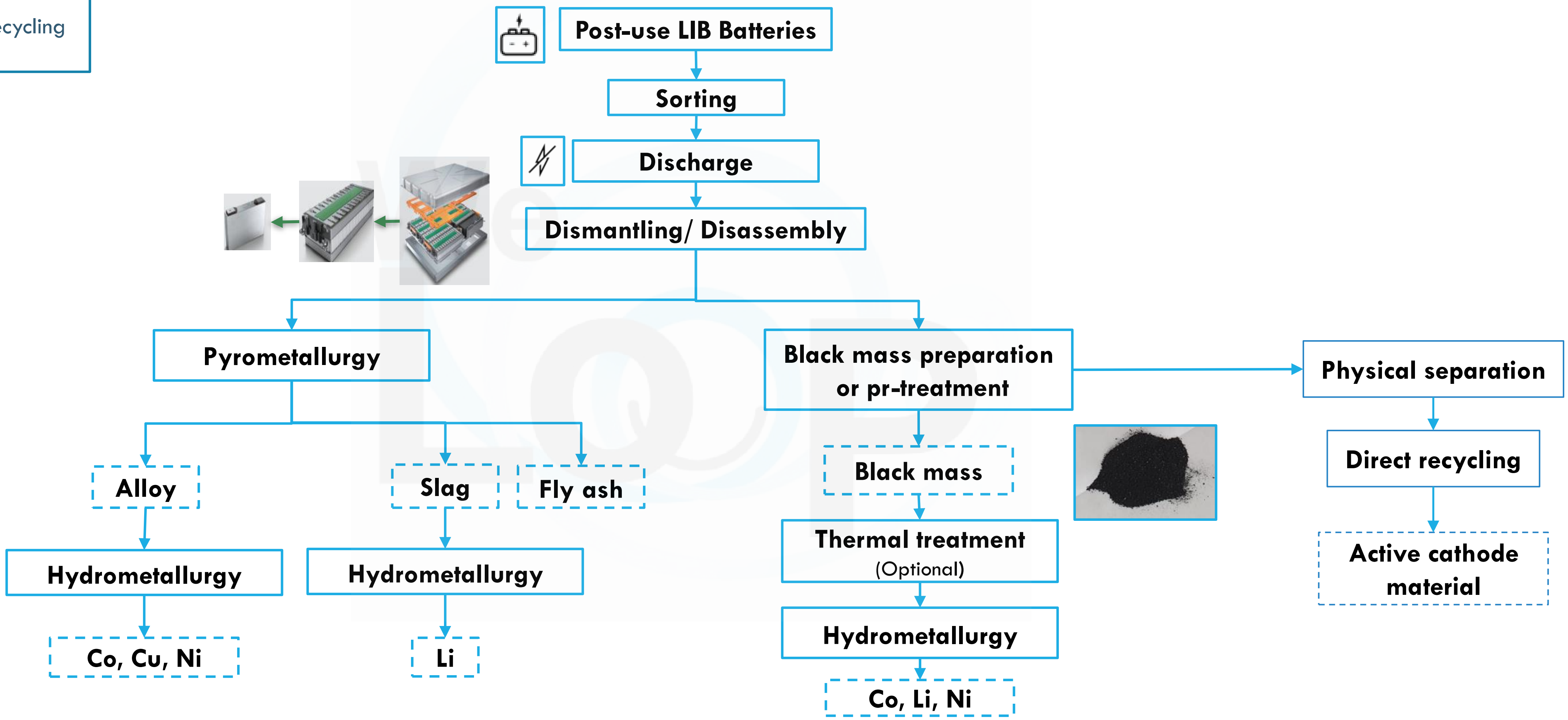
NEEDS IN BETTERY DEPOSITE

	Ni	Co	Li
Recovered quantity (tons) for a factory of a capacity of 100kton	12 000	1 400	1 700
Recovered quantity (tons) for a factory of a capacity of 200kton	24 000	3 000	3 400
Goals for a stable market (tons)	**24 500**	**3 000**	**3 000**

480 000 tons = **2 600 000** Electric cars = **97%** of cars sold in France every year

POSSIBLE WAYS OF RECYCLING LIB

Recycling

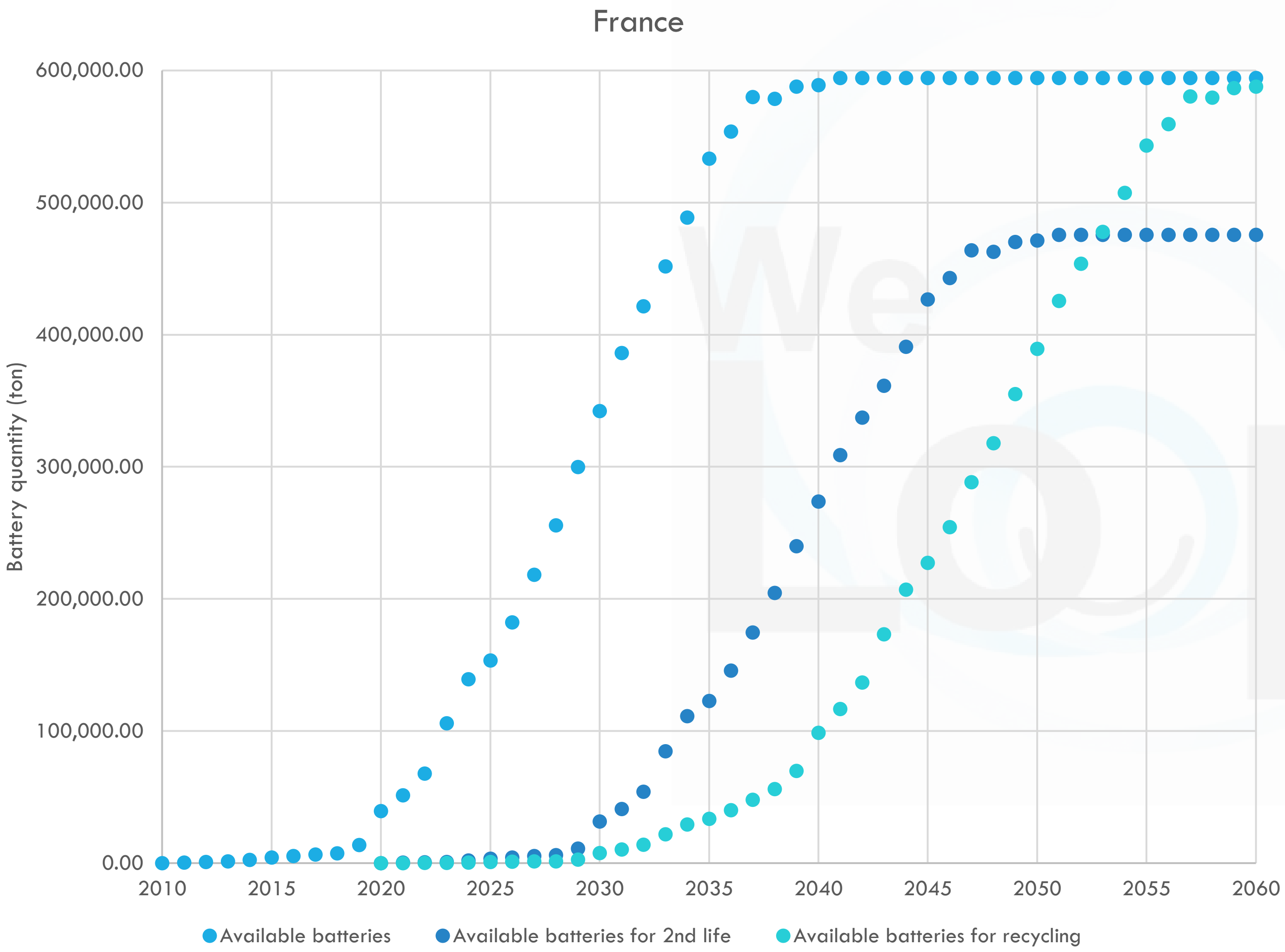


COMPARISON OF RECYCLING PROCESSES

	PYROMETALLURGICAL	HYDROMETALLURGY	DIRECT RECYCLING
👍	- Simple process to extract high value metals (e.g. Co & Ni) - Flexible and easy process - Long term profitability - Optimal technological preparation. - Low safety risk	- High recovery efficiency - High quality outputs - Moderate energy consumption - No gas emissions - Recovery of all cathode metals from LIBs	- Reducing energy consumption and greenhouse gas emissions - Process low-value lithium battery chemicals (e.g. LFP). - Fewer processing steps result in economic benefits
👎	- Very high CO2 emissions - Limited number of recovered materials - High investment and operating costs - No recovery of electrolyte and plastic fractions and lithium - Need for co-containing battery chemistries - Generation of gaseous pollutants (these toxic gases must be captured and treated)	- Use of harmful solvents - Generation of wastewater - Complexity of the process - Need for pre-treatment - Very resource-intensive - Incomplete recycling of binder/electrolyte	- Has not yet proven its industrial feasibility. - Has not yet proven full restoration of cathode capacity. - Designed for specific batteries; therefore, it is sensitive to market variations and the introduction of battery chemistries. - Active material recovery out of step with market technology

RECYCLING AND REUSE (challenges)

Temporal gaps of flows



- We have a long way to go to reach a market stability!
- Technology differences between input and output (+20 to +30 years)!
- Input materials exceed the available material from recycling in any case!
- We need to deal with export and losses + energy consumption at EoL

Yet recycling is inevitable to cope with the impacts of criticality !

MERCI !

n.adibi@weloop.org

WeLOOP
254 Rue du Bourg, 59130 Lambersart
09 81 85 76 82

11th edition of Life Cycle Management International Conference

LCM 2023

September 6-7-8, 2023

Lille, France

Call for abstracts for #LCM2023 is now open!
The deadline to submit your session is February 17st 2023.
Call for Abstracts - LCM 2023