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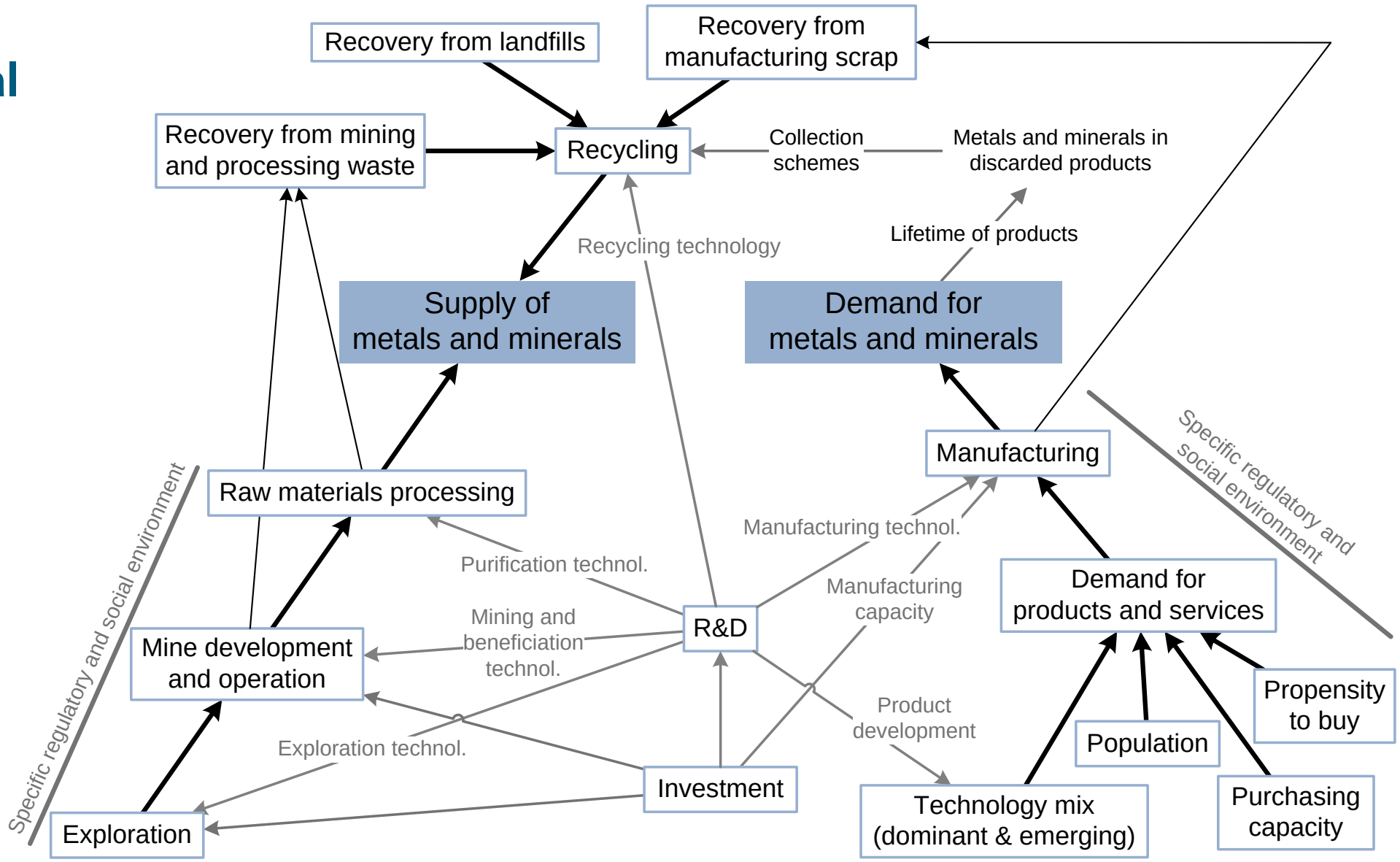
SCRREEN2 Symposium | 30 March 2023 | Ljubljana

Luis Tercero Espinoza

Raw materials for a multitransition: Digital, electric & low-carbon

A simple view of raw material markets



Modified after Tercero Espinoza, L. ; Wittmer, D. : On the influence of technological change and substitution on the demand for non-energy raw materials. In: Wittmer, D.; Sievers, H. (Hrsg.): MInerals 4EU Thematic Report V

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Learning from the past

Ex-post view of changing primary supply

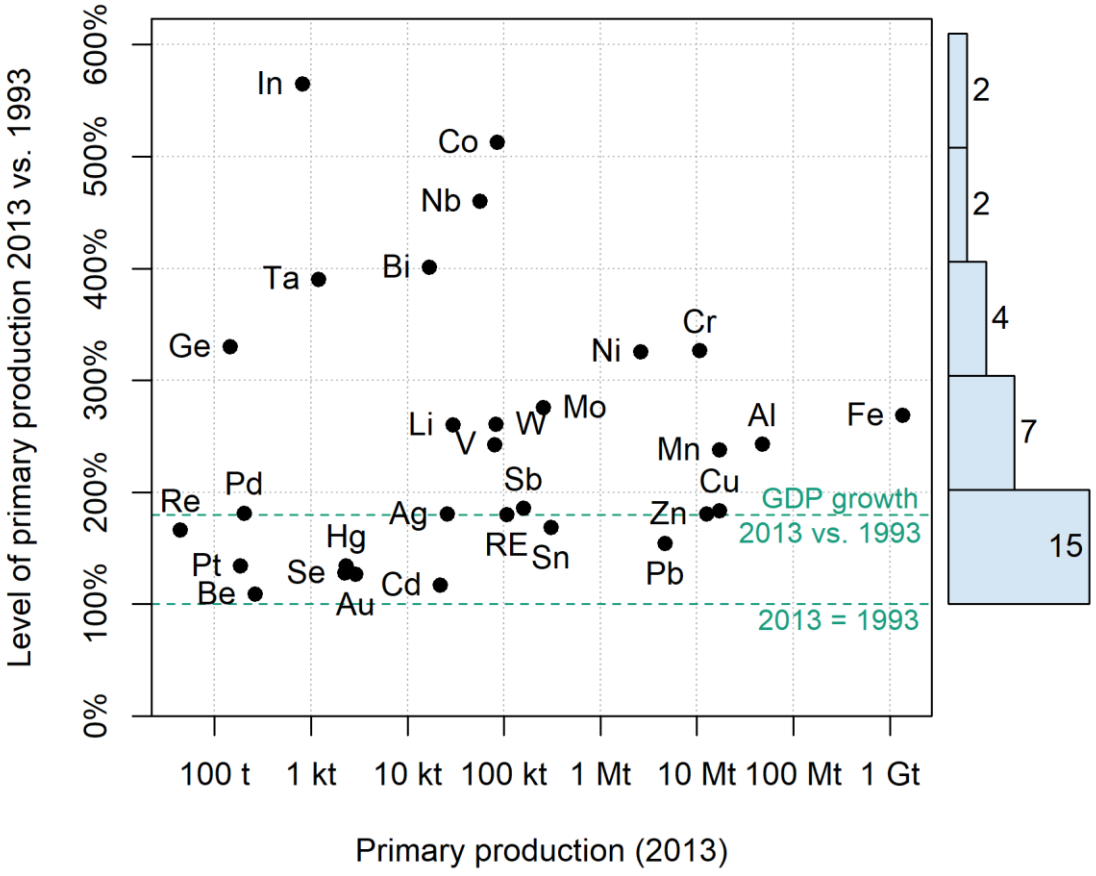
Proxy for demand (excludes secondary supply!)

Readily available from different sources

- Data in the graph: USGS Mineral Commodity Summaries and Minerals Yearbook

In short:

- Primary production of many raw materials grew the same or slower than GDP
- Some grow faster than GDP and some exceptionally fast
  - What's behind the exceptional cases?



Langkau und Tercero Espinoza (2018): *Sustainable Materials and Technologies* 16, 54-59

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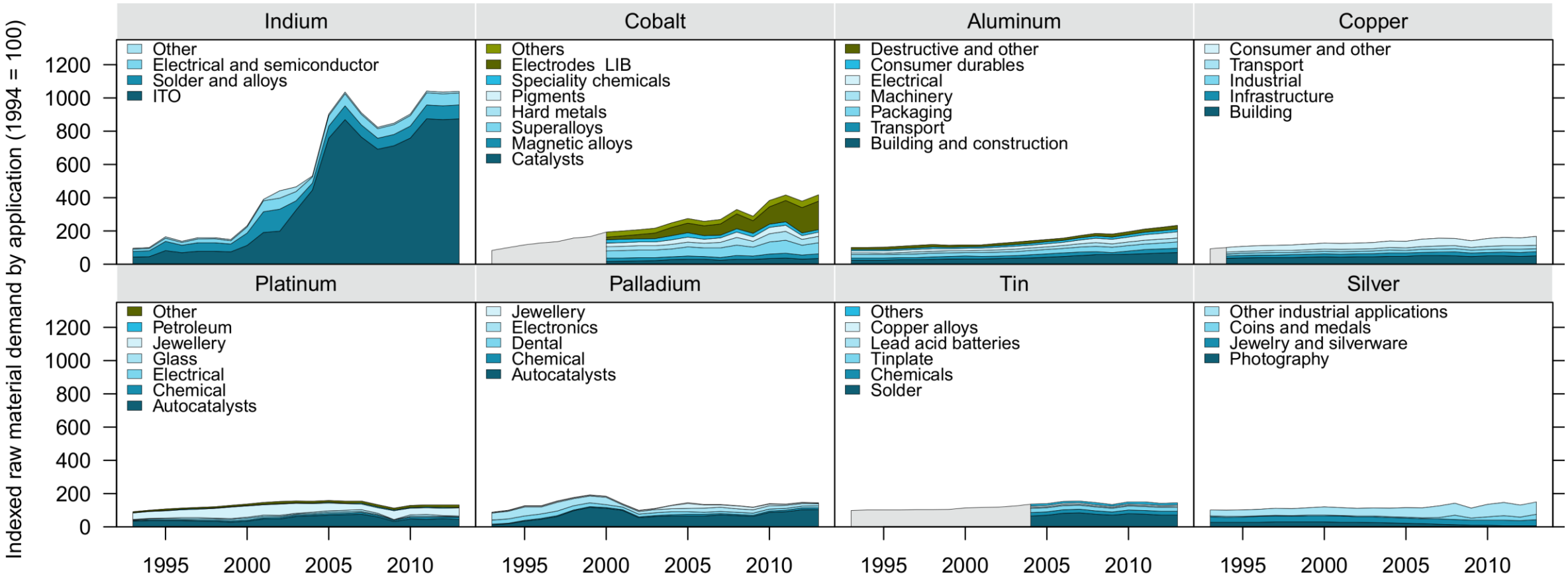
Learning from the past

Technological change drives exceptional demand



Langkau und Tercero Espinoza (2018): *Sustainable Materials and Technologies* 16, 54-59

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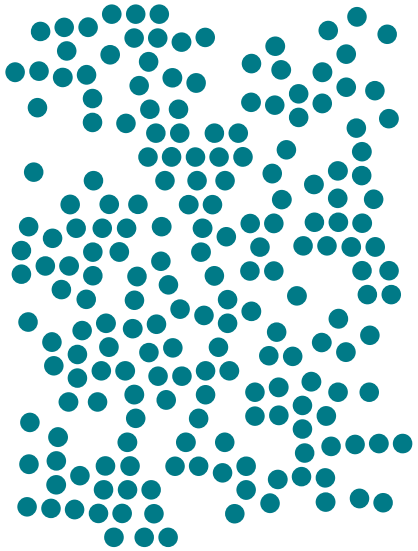
A look into the future: Broad technology view

Selecting and filtering technologies with potentially significant future demand

Collection of candidate technologies



Examine technologies

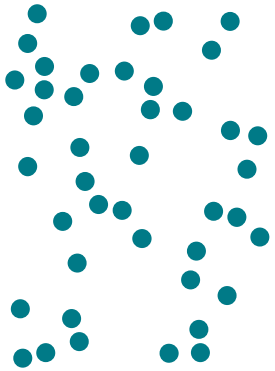
Rapid assessment

Market potential

Raw material requirements

If both „high“

Selected technologies



Marscheider-Weidemann et al (2021): Raw materials for emerging technologies 2021. DERA Rohstoffinformationen 50. Berlin

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A look into the future: Broad technology view

Groupig technologies into clusters

Selected 33 technologies and organized them into five clusters

- Mobility & Aerospace
- Digitization & Industry 4.0
- Energy Technologies and Decarbonization
- Recycling & Water Management
- Power & Data Networks

Clusters include not only „future technologies“ but also those essential to the functioning of one or more clusters, e.g., power grid

Marscheider-Weidemann et al (2021): Raw materials for emerging technologies 2021. DERA Rohstoffinformationen 50. Berlin

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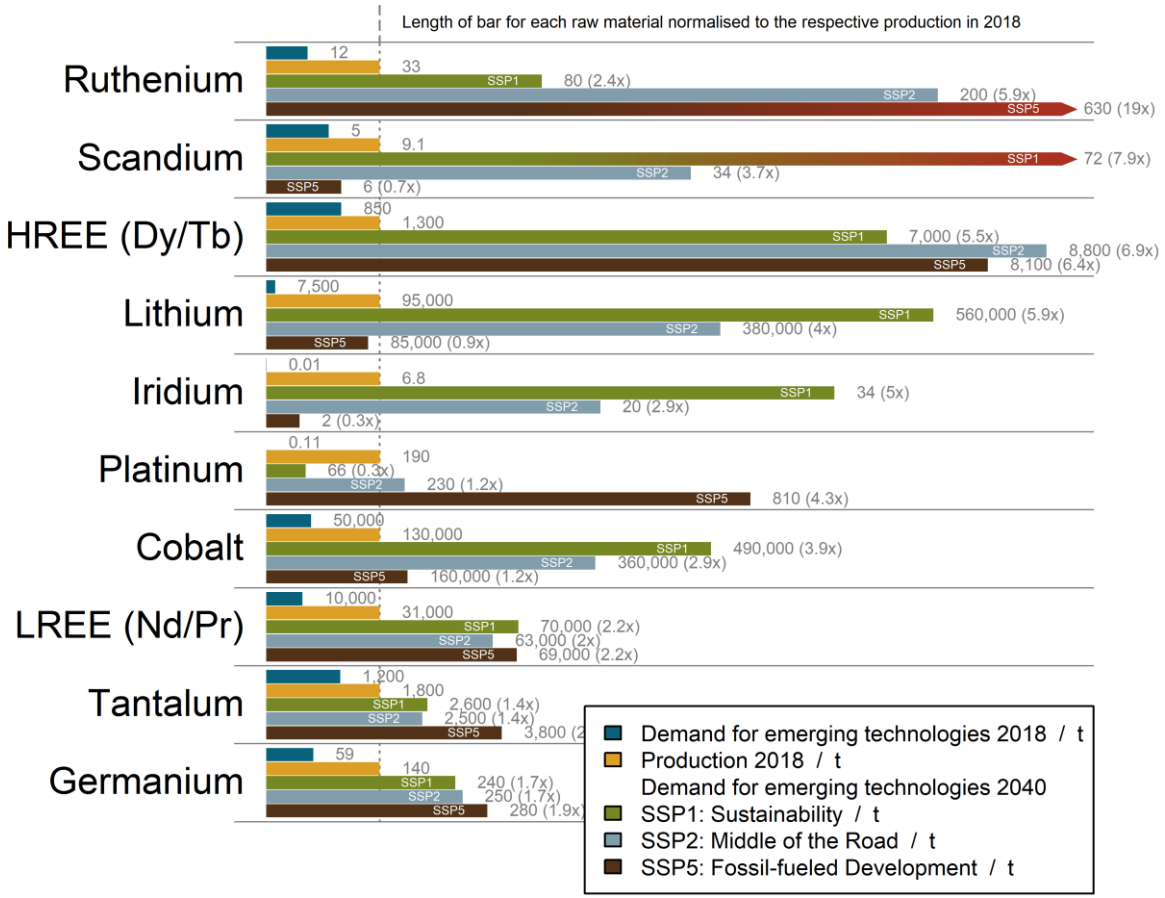
A look into the future: Broad technology view

Raw materials with largest potential increase in demand

E-mobility, energy transition and digitalization are associated with the largest expected increases in raw material needs

- E-Mobility: Li, Co, Ni, graphite for LIB as well as light and heavy REE for electric motors
- Energy transition: mainly scandium for electrolyzers and stationary fuel cells, Ir for electrolyzers, light REE for wind power and V for stationary storage
- Digitalization: Ru for data centers, lights REE for HDD in data centers as well as magnets in electronics

Raw Material demand differs greatly between scenarios



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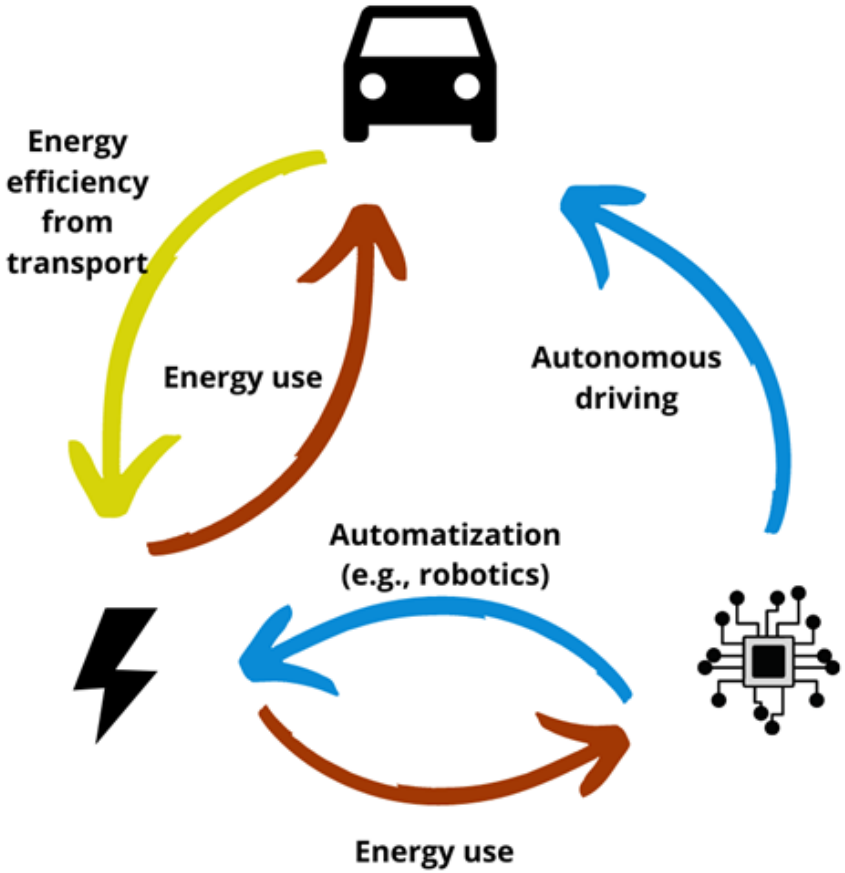
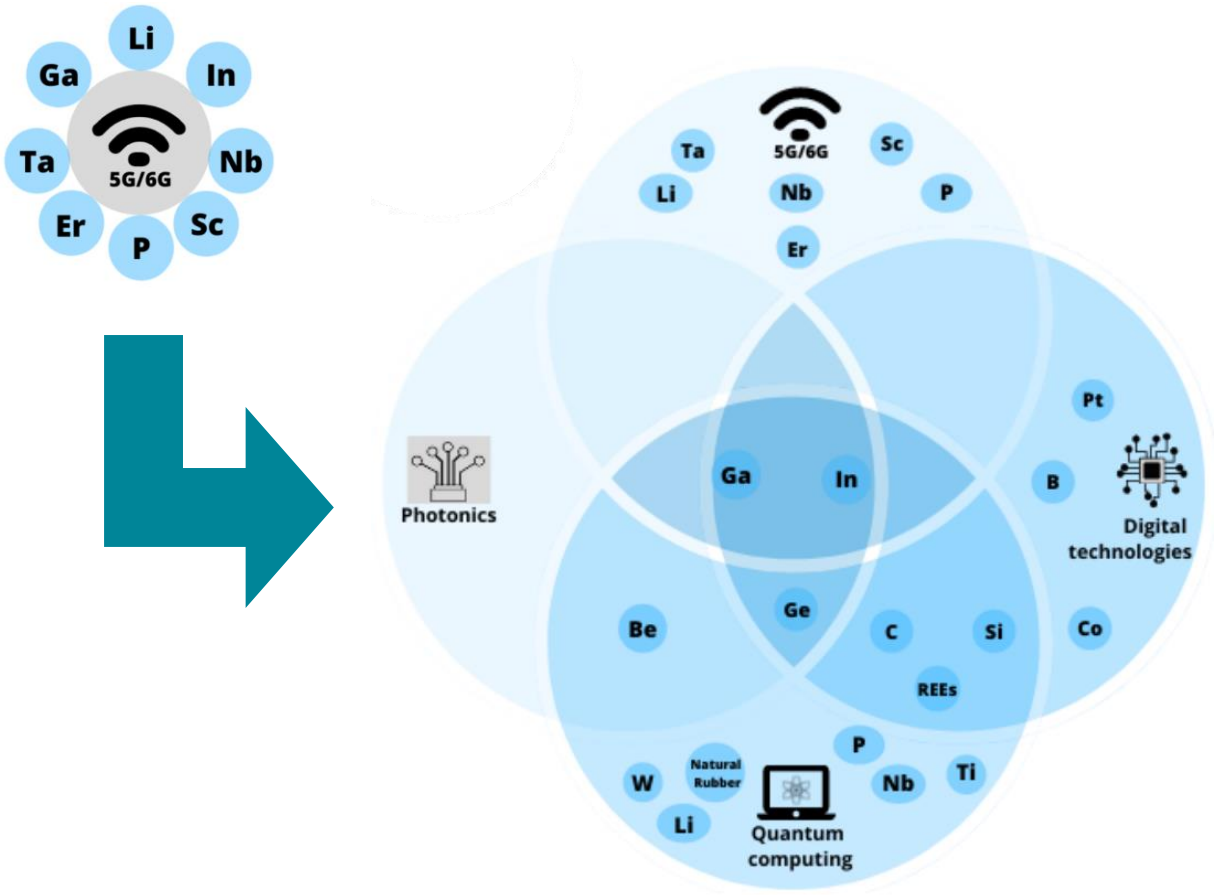
A look into the future: Broad technology view

Tracing interconnections between sectors





Aguilar-Hernández et al. (2022): A review of future Critical Raw Material demand in 11 key technologies for transport, energy, electronics and tececommunication sectors.. Deliverable 7.2 of SCRREEN2 available online at https://scrreen.eu/

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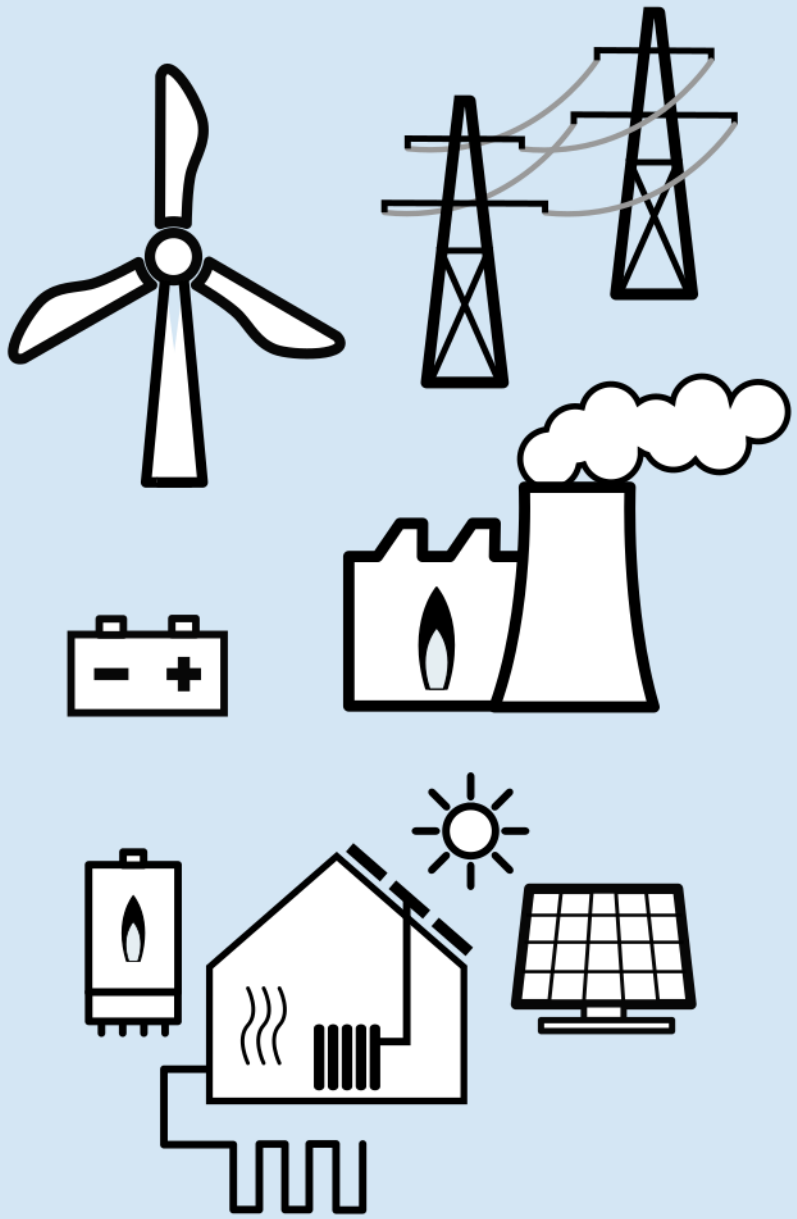
A look into the future: Focus on low-carbon energy

Illuminate the raw material dimension of the energy transition

Energy systems modelling

- Generally based on total cost of ownership (TCO) under certain restrictions, including
  - Solar and wind potentials
  - CO_2 targets
- Assume facilities can be built/sourced as needed
  - Sufficient manufacturing capacities to produce them are in place
  - Availability of raw materials is given and affects neither timeline nor pricing

Need for a complementary tool to evaluate – at the system level – the raw materials dimension of the energy transition



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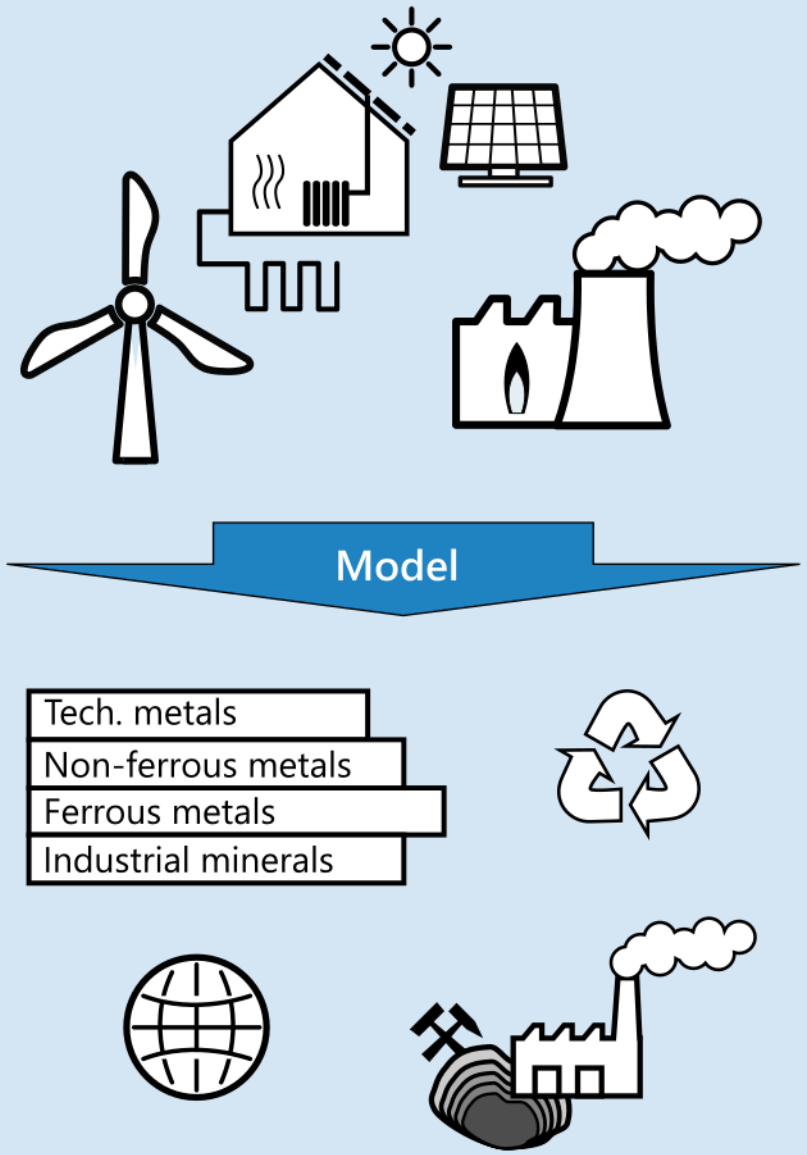
A look into the future: Focus on low-carbon energy

A tool to expose the raw material needs of the energy transition

Translate quantitative energy scenarios into raw material requirements to answer questions

- How much of what raw materials do energy scenarios require for their realization?
- How are these materials distributed among the different technologies?
- What environmental impacts are caused by these raw material requirements?
  - Quantify trade-offs between CO_2 savings in Germany vs. CO_2 emissions for technologies
- How fast does the stock-in-use grow and how much is in it at any given time?
- When can we expect what quantities of which raw materials in decommissioned installations?
  - What would be reasonable amounts to expect as secondary material?



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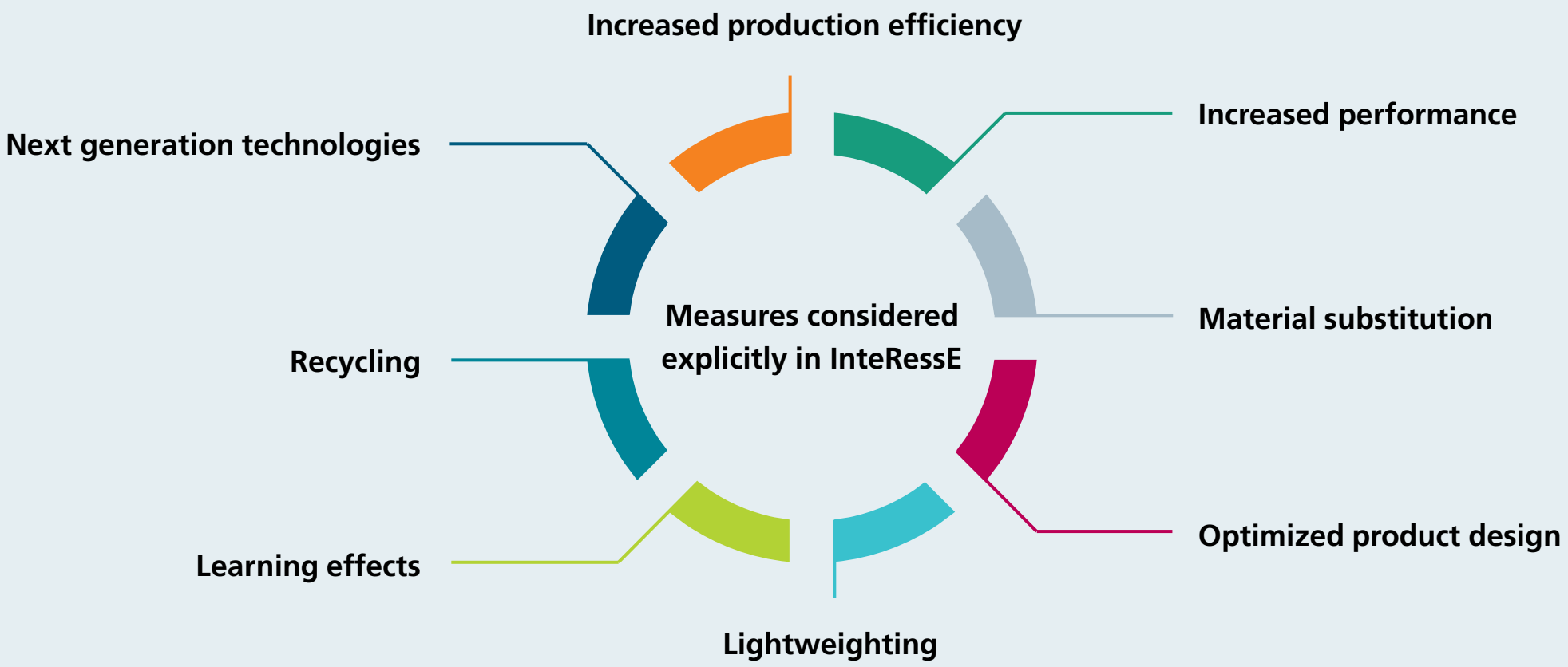
A look into the future: Focus on low-carbon energy

Explicit consideration of technological change



Gervais et al.: Material requirements for the energy transition – Energy technology profiles and environmental impacts (2022)

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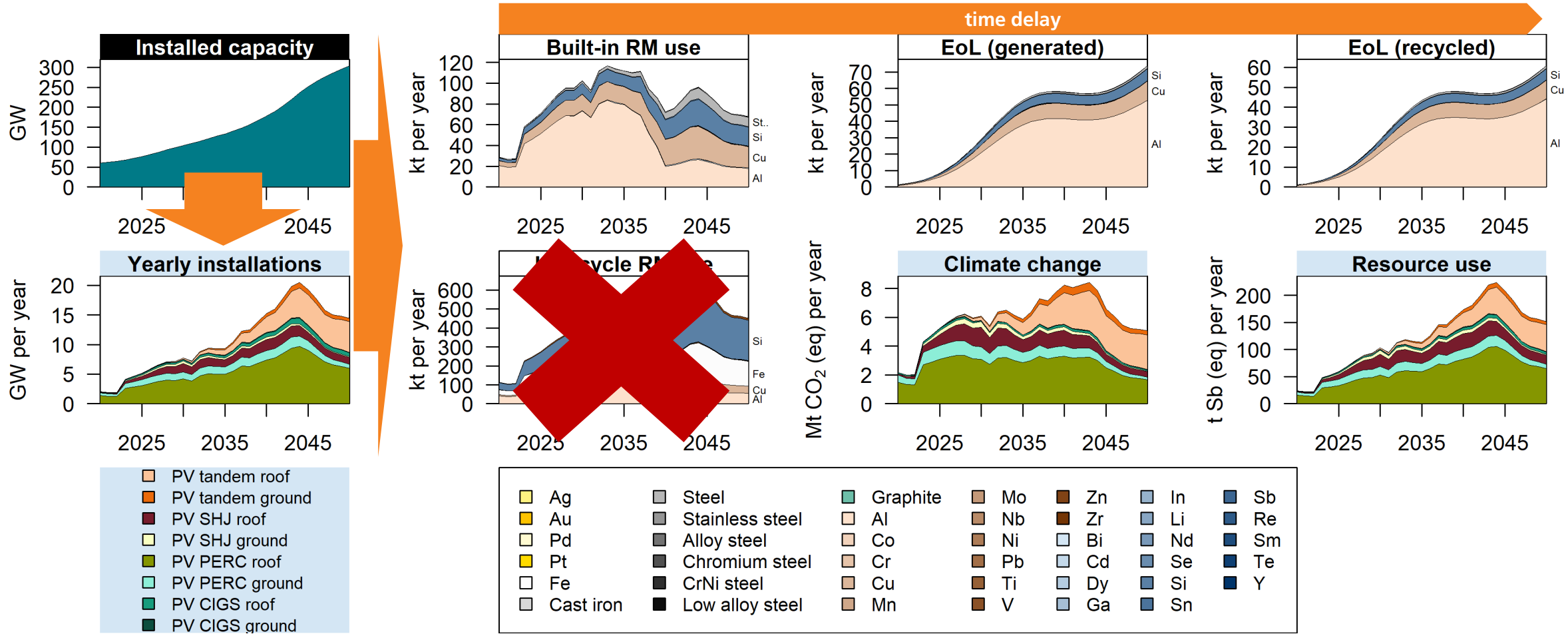
A look into the future: Focus on low-carbon energy

From cumulative scenarios to recycling and environmental impacts



InteRessE project results awaiting publication

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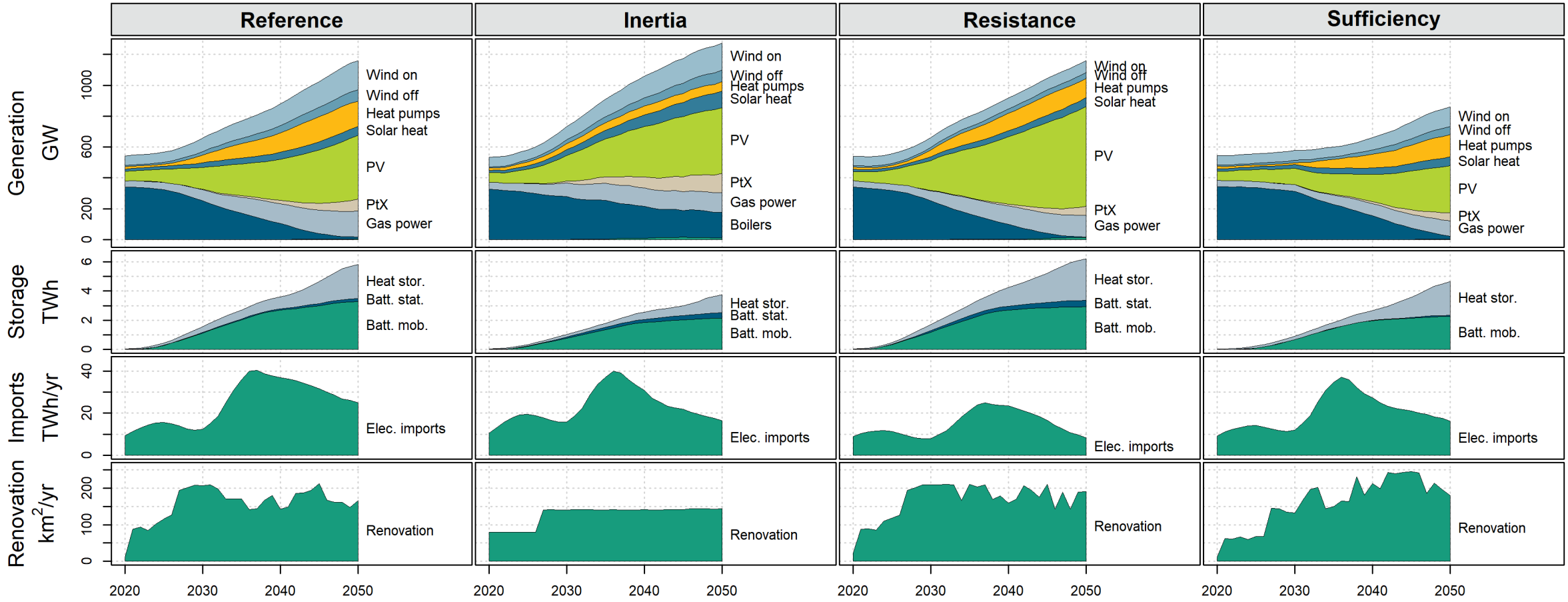
Focus on low-carbon energy in Germany

Different pathways towards the same goal



Fraunhofer ISE (2020): Wege zu einem klimaneutralen Energiesystem. Die deutsche Energiewende im Kontext gesellschaftlicher Verhaltensweisen. Siehe auch: https://blog.innovation4e.de/

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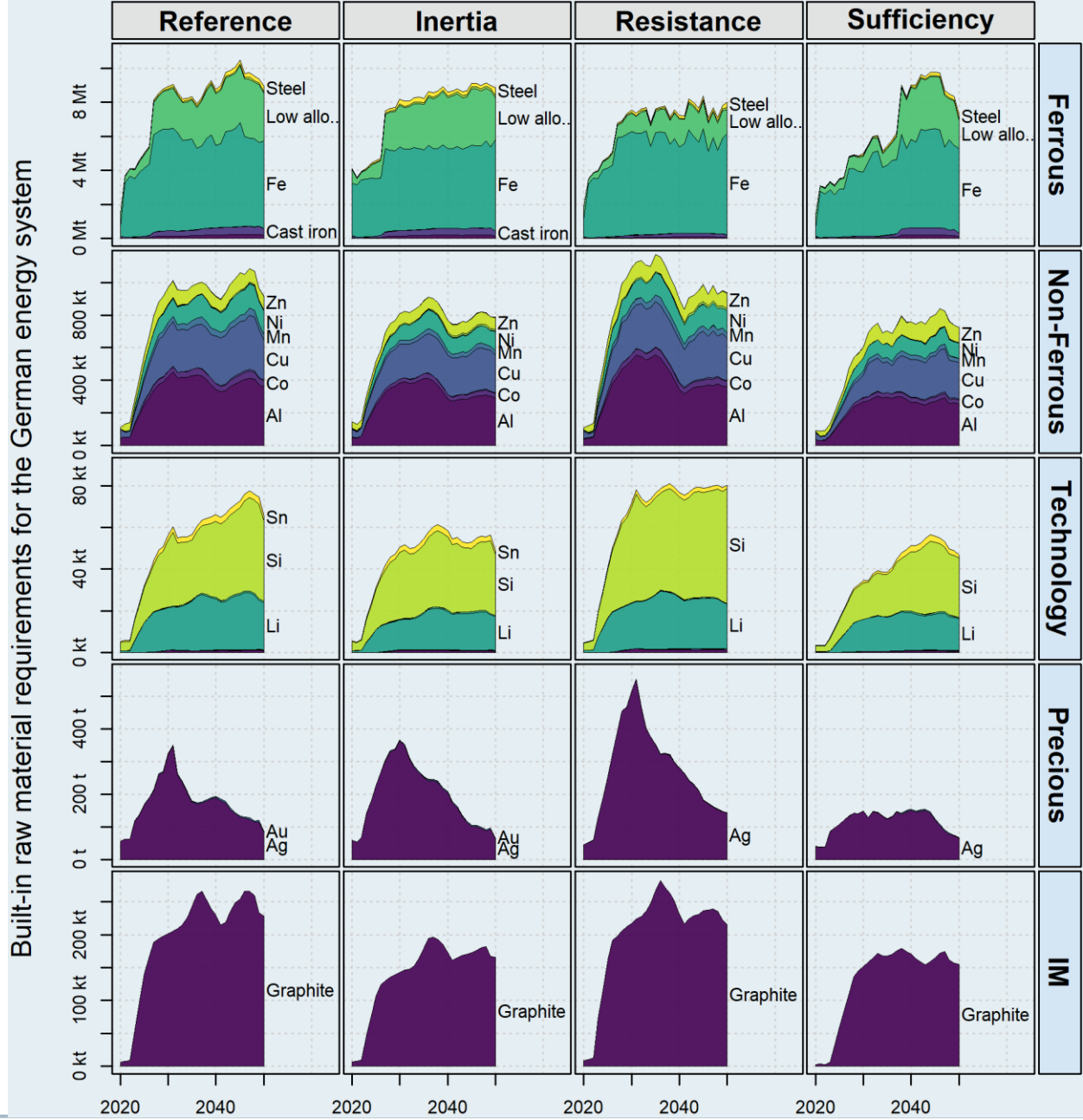
Focus on low-carbon energy in DE

Aggregated raw material demand per scenario

Exploration of scenario implications for raw materials

- Reveals dynamics of raw materials use (which? when? how much?)
- Reveals trade-offs between different raw materials as a result of different market penetration of technologies in different scenarios



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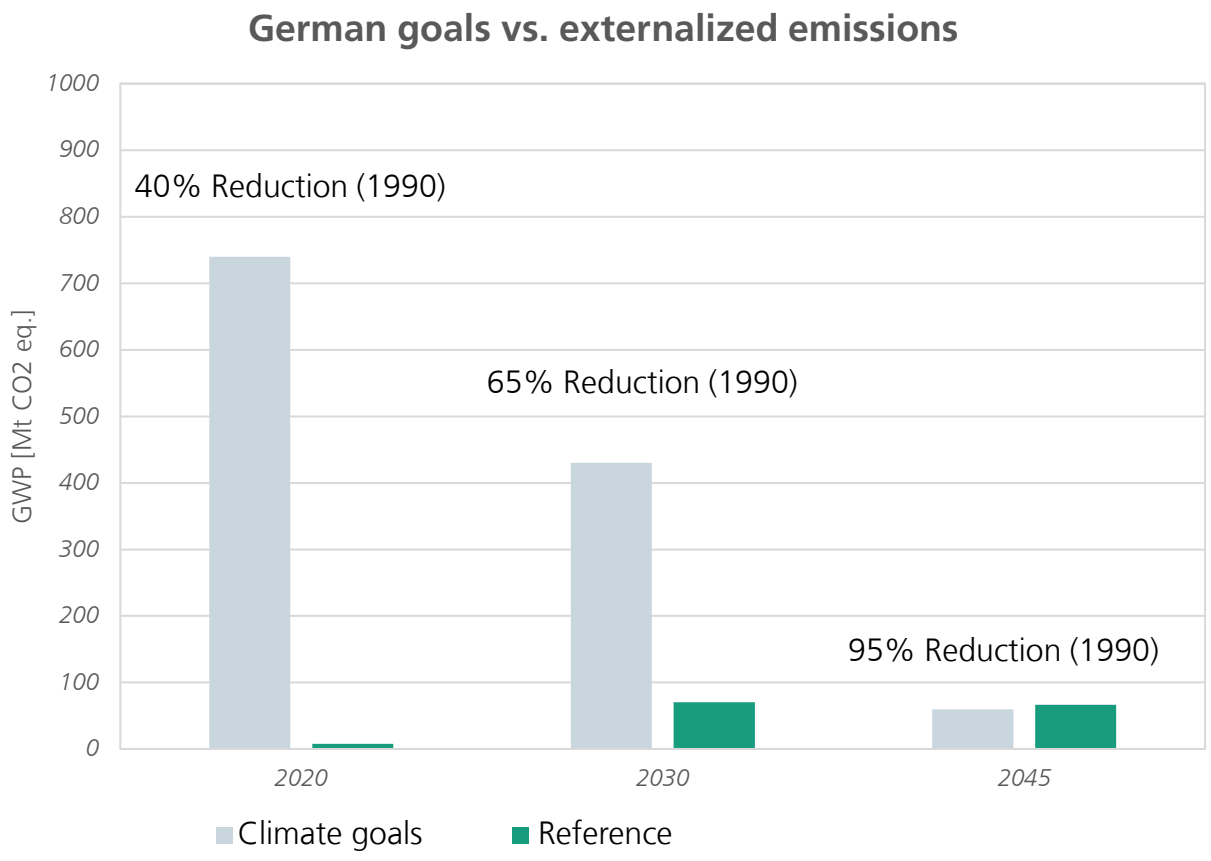
Focus on low-carbon energy in Germany

German climate goals and shift in emissions towards extraction and production countries



InteRessE project results awaiting publication

Goal: Drastic reduction of emissions in Germany until 2045

- Building up a new stock of climate friendly energy technologies
- High material demand during build up phase
- Most necessary raw materials and technologies are produced outside Germany

Emissions are shifted!

- The projected emissions for providing raw materials and technologies for the German energy system in 2045 are higher than what goals allow the entire German economy to emit.

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Sourcing raw materials for the EU

An overview of European potential Critical Raw Material sources

Class (based on principle geological process governing mineral deposit formation)*	Mineral deposit type*	PGE	V	Ti	Co[1]	Sc[2]	REE[3]	Hf[4]	Nb and Ta[5]	P[6]	phosphate rock	Be	Li[7]	Si	Fluor-spar	Sr	Baryte	W	Sb[8]	In[9]	Ga[9]	Ge[9]	Bi[10]	Mg	Borate	Bauxite	Coking coal	natural graphite
Mafic to ultramafic magmatism	PGE deposits in layered mafic-ultramafic intrusions	X	X[11]		X																							
	Cu-Ni deposits in ultramafic lavas (komatiites)	X			X																							
	Nickel and titanium deposits in mafic-ultramafic intrusions	X	X	X	X	X																						
Evolved magmatism	Iron-oxide apatite deposits[12]						X[12]			X[12]	X[12]																	
	Carbonatites and peralkaline granitoids[13]					X	X	X	X	X[13]	X[13]				X	X												
	(alkaline) granitoid intrusions						X	X	X	X	X	X			X													
	Felsic pegmatites[14]						X		X			X	X	X														
Hydrothermal fluid flow with linkages to magmatism	Granite-related vein deposits (including Greisen)					X			X				X	X	X		X	X										
	IOCG deposits		X[11]		X[22]		X																X					
	Epithermal base metal deposits																X		X	X	X	X	X					
	Skarn																	X		X	X	X	X					
	VMS deposits				X[15]												X		X	X	X	X	X					
	SEDEX (clastic-hosted) Pb-Zn deposits																X			X	X	X	X					

Eilu et al. (2023): Critical Raw Materials in Europe. Geological perspectives on domestic European supply options. Deliverable 7.1 of SCRREEN2 available online at https://scrreen.eu

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