

# WHAT DO WE REALLY KNOW ABOUT CRITICAL RAW MATERIAL IMPACT?

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Life Cycle Management

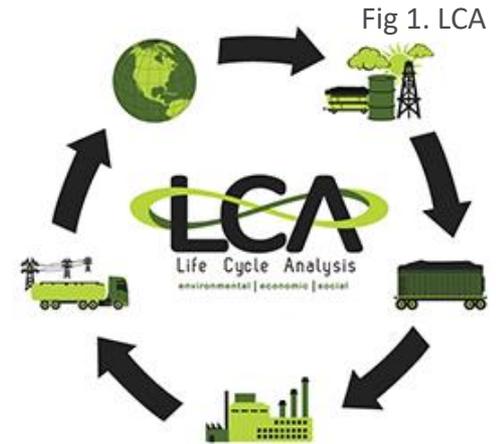
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- 1. Motivation**
- 2. Critical Materials in the European Union**
- 3. Integrating Criticality in Life Cycle Assessments**
- 4. Case Study: Data Center Components**
- 5. Discussion**

- 1. Motivation**
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- With the launch of the Sustainable Development Goals (SDGs, 2016), **raw materials** and their related mining effort have gained interest.
- New Criticality Methodologies and indicators have been released  
*(Most of them focus on the economic pillar of sustainability).*
- Therefore:
  - ➔ Requirement to address criticality in sustainability analysis.
- Lack of a **proper indicator** available that covers this issue.
- Life Cycle Assessment (LCA) is a suitable and the standard method to assess **sustainable life cycles** (EC 2010).
- The **impact of criticality** in Life Cycle Impact Assessment is required.



Source: netl.doe.gov

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- Those raw materials that are most **important economically** and have a **high supply risk** (European Commission 2020b).
  - **Economic Importance:** allocation of raw materials to end-uses based on industrial applications.
  - **Supply Risk:** Country-level concentration of global production of primary raw materials and sourcing to the EU.
- Examples: Sb, Be, Co, REE, Nb, Sc, W, Li.

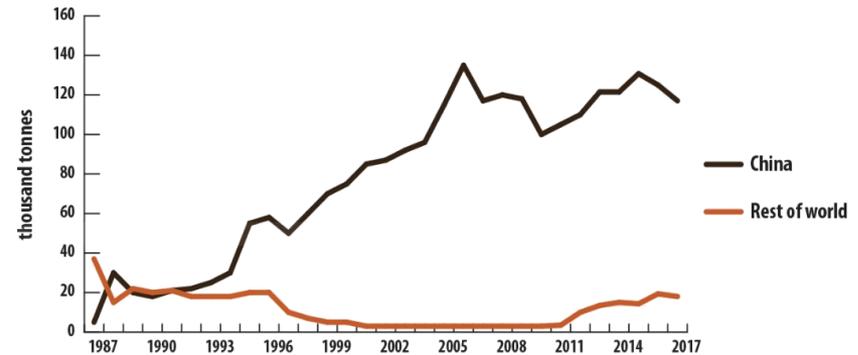
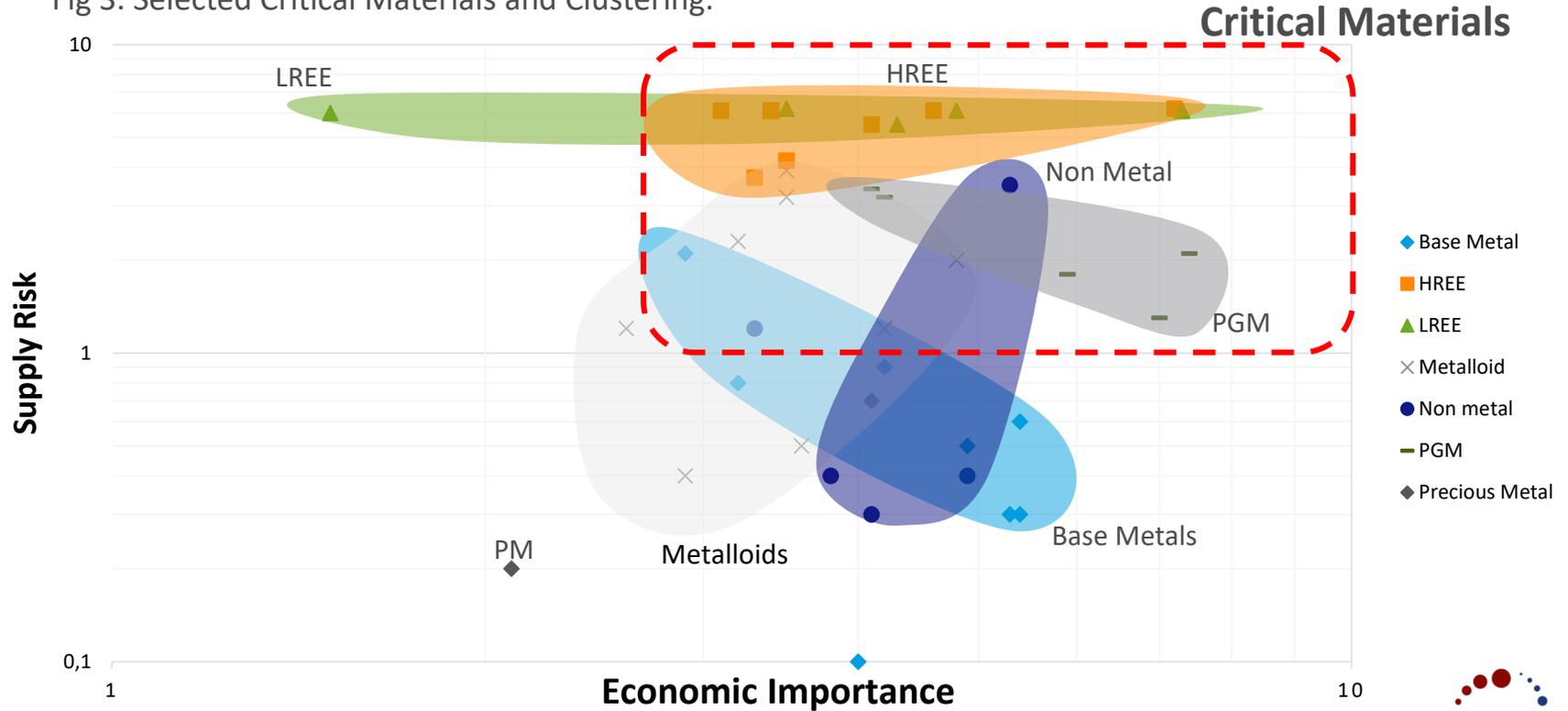


Fig 2. Production of Rare Earth Element Oxides

Source: institut-seltene-erden.de

Fig 3. Selected Critical Materials and Clustering.



Source: Data from EC 2020b

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# Proposal of a Criticality Indicator Set

Existing Work

Author	Approach	Supply Aspects	Economic Aspects	LCA
Gemechu et al. 2016	Geopolitical Approach in LCA	(✓) Geopolitical	(✗)	Risk assessment
Schneider et al. 2011	AADP	(✓) Depletion Potential and Urban mines	(✗)	Methods Incorporated
Valero et al. 2018	Exergy Flow Analysis	(✓) Raw Demand, Mineral Exergy	(✗)	Exergy methods
Cimprich et al. 2019	ESSENZ	(✓) Resource supply risk assessment	(✗)	Risk assessment
Van Oers et al. 2016	ADP	(✓) Depletion Potential	(✗)	Methods Incorporated (CLM)
Schneider et al. 2011	AADP	(✓) Depletion Potential and Urban mines	(✗)	For some materials
Penaherrera et al.	CW-ADP	(✓) EU, ADP	(✓) EU, Recovery	<b>New method</b>

# Proposal of a Criticality Indicator Set

## Existing Work

- Use of **Abiotic Depletion Potential** to quantify depletion rate.
- Combination of **ADP** with **Supply Risk** and **Economic Importance** to assess criticality of material resource depletion.
- High degree of abstraction in term of economic values
- Normalization of values.



Fig 4. Formation of indicators.

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# Proposal of a Criticality Indicator Set

## Proposed Indicators

### Data for Development of Characterization Factors

- Criticality database: Criticality Assessment Report (EC 2020b)  
**Economic Importance (EI) and Supply Risk (SR)**
- Abiotic Depletion Potential: CLM Method (Van Oers et al. 2016)

### Data for Development of LCA Models

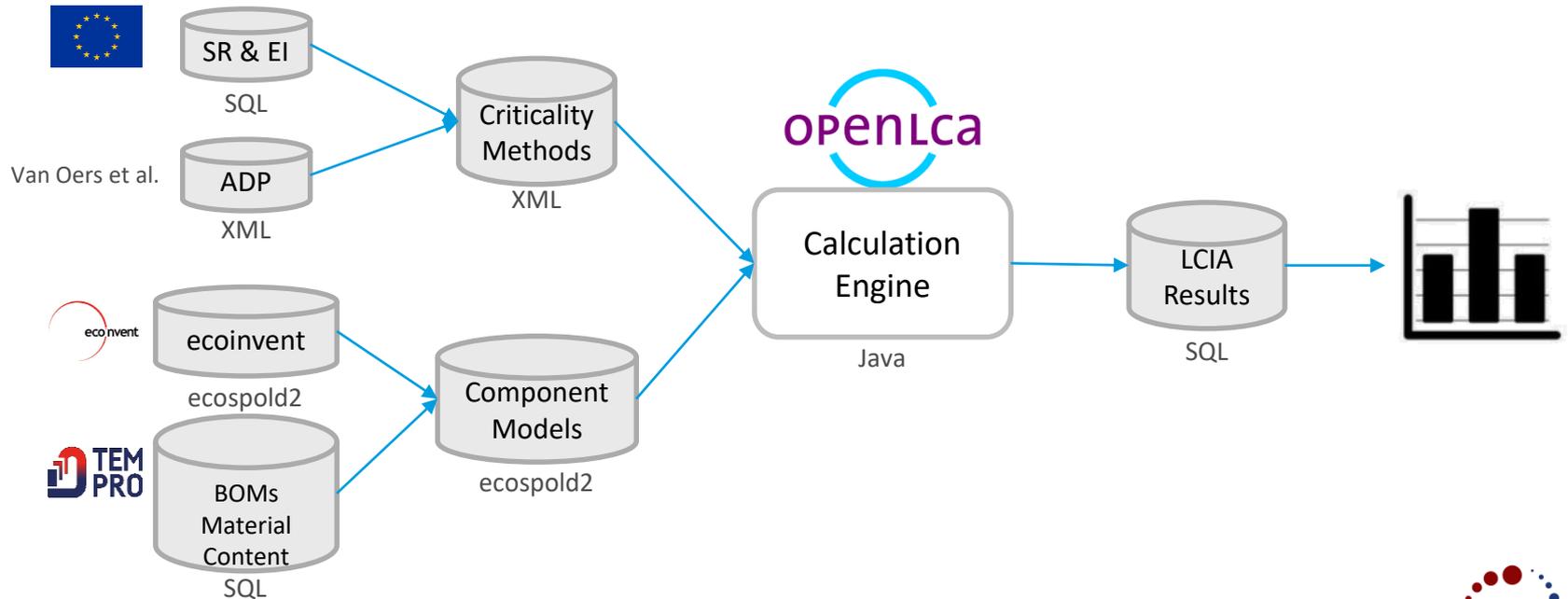
- ecoinvent 3.4 database
- BOM and LCIA databases from TEMPRO Project:  
PDU (Power Distribution Unit)  
Dell Server 1U (2008)  
Blade Server 1U (2011)

### Software:

- Java Applications for database connections and automation of calculations (Penaherrera et al. 2021).
- openLCA (Java) calculation engine for LCIA.

# Proposal of a Criticality Indicator Set

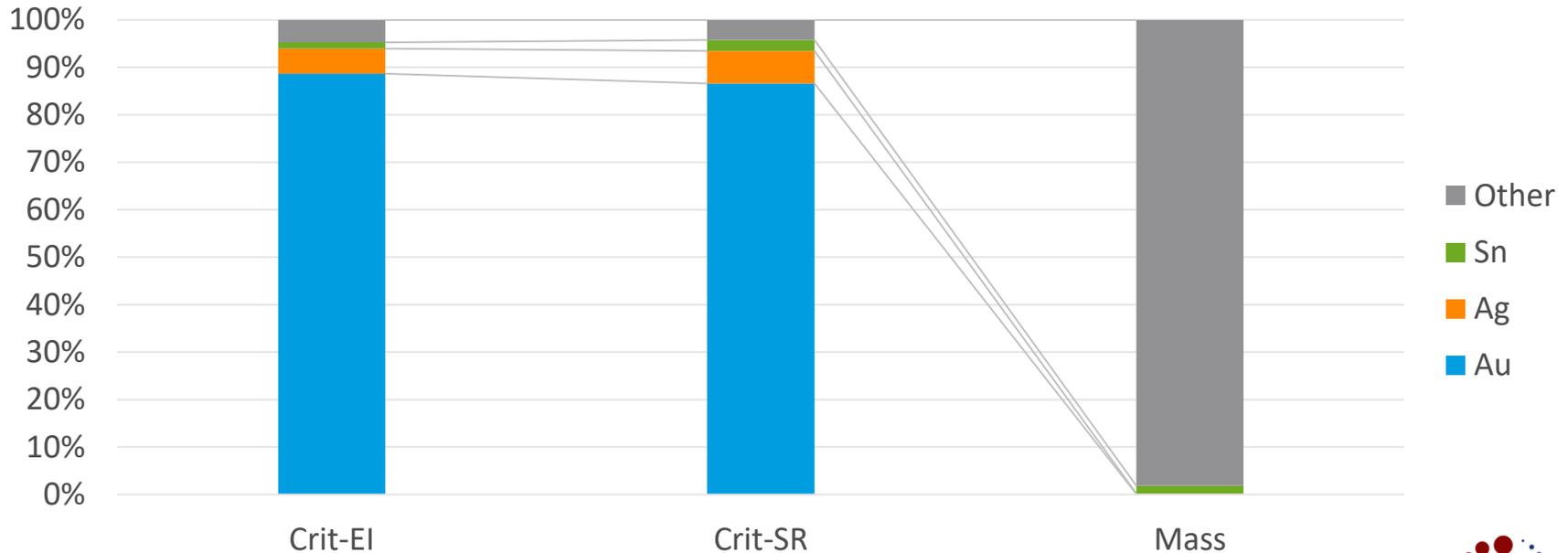
## Data flows



# Proposal of a Criticality Indicator Set

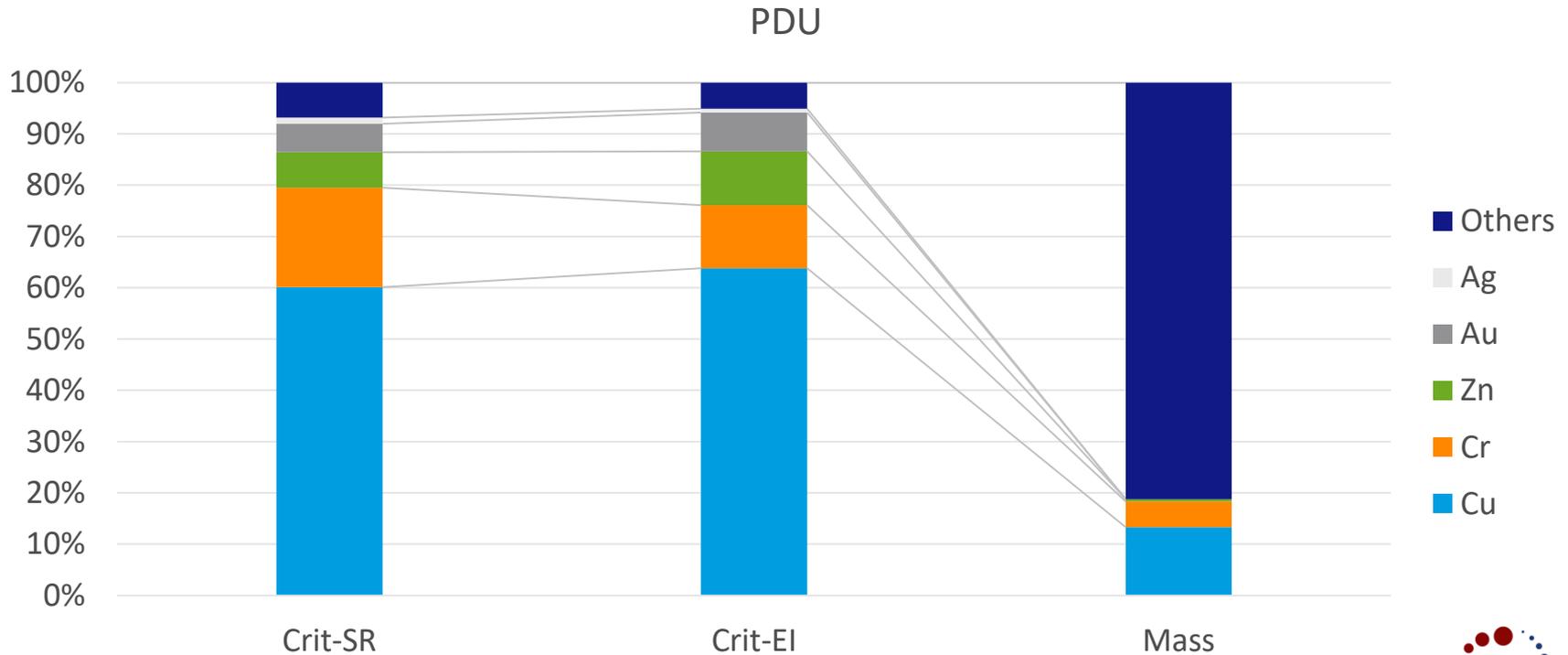
## Proposed Indicators

4408 Blade Server Dell



# Proposal of a Criticality Indicator Set

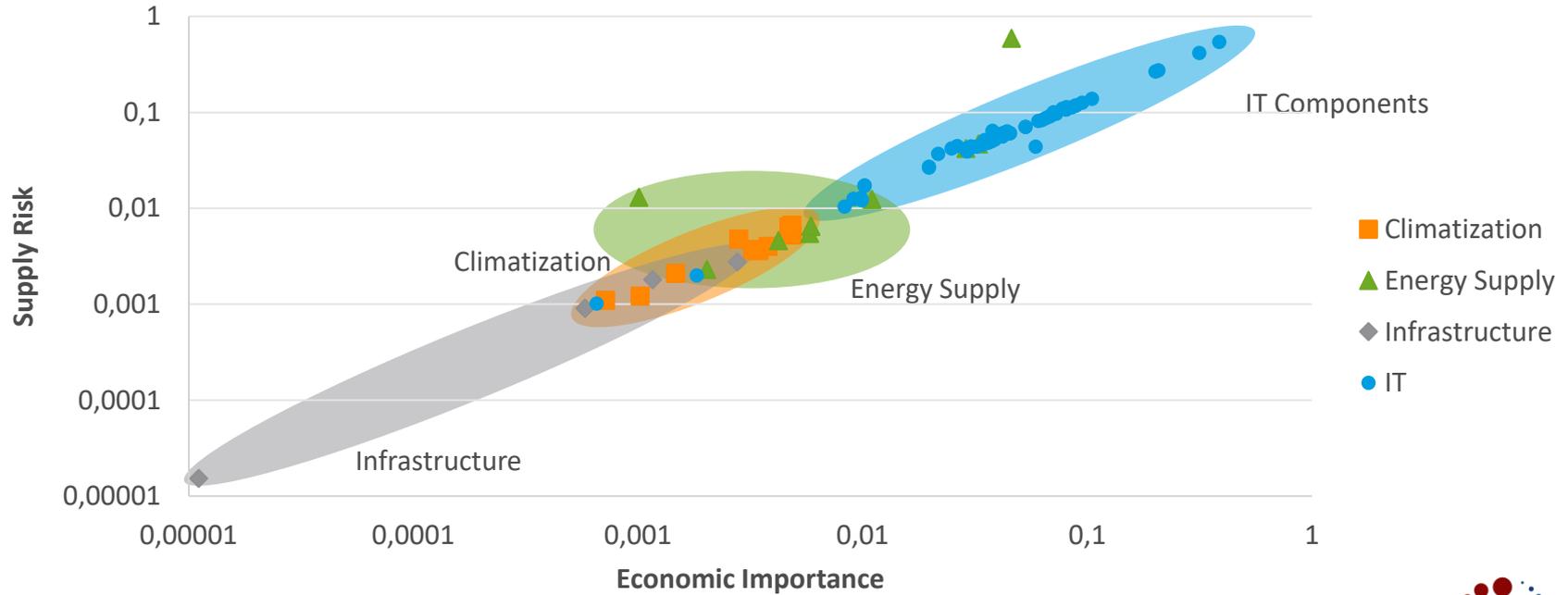
## Proposed Indicators



# Proposal of a Criticality Indicator Set

Proposed Indicators

Criticality of Data Center Devices (normalized to unit of mass)



# Discussion and Conclusion

What do we really know about Critical Raw Material Impact?

- **Advantages:**

- Our approach includes Criticality of Materials as per the EU definition
- Applicable to different technology components (e.g., wind energy and PV)
- Provides extra weighting to materials relevant to the EU economy.
- Indicators provide extra incentive for recovery of materials when considering circular economy.

- **Disadvantages:**

- Factors depend on multiple sources of information.
- Factors are relative and change constantly with time.
- For assessing recovery potentials, better information on concentration is required and we need to cooperate with the other experts



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## Book on Critical Materials

Including a chapter on our approach presented here

Check online:

<https://www.sciencedirect.com/book/9780128195345/the-material-basis-of-energy-transitions>

The Material Basis of Energy Transitions explores the intersection between critical raw material provision and the energy system on a socio-technical approach.



# The Material Basis of Energy Transitions

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