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Integrating Anthropogenic Resources into UNFC-2009: Update on Case Studies

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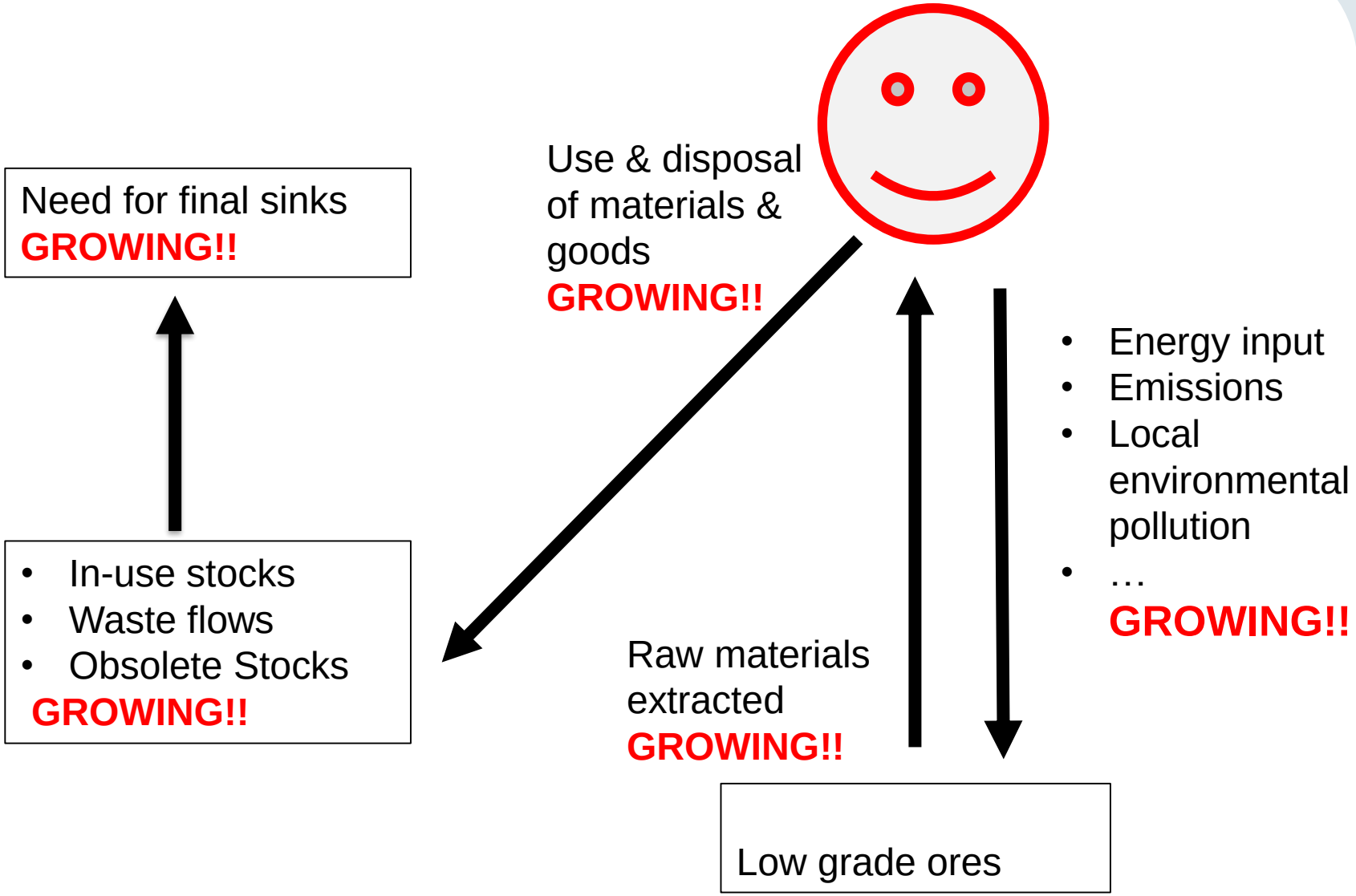
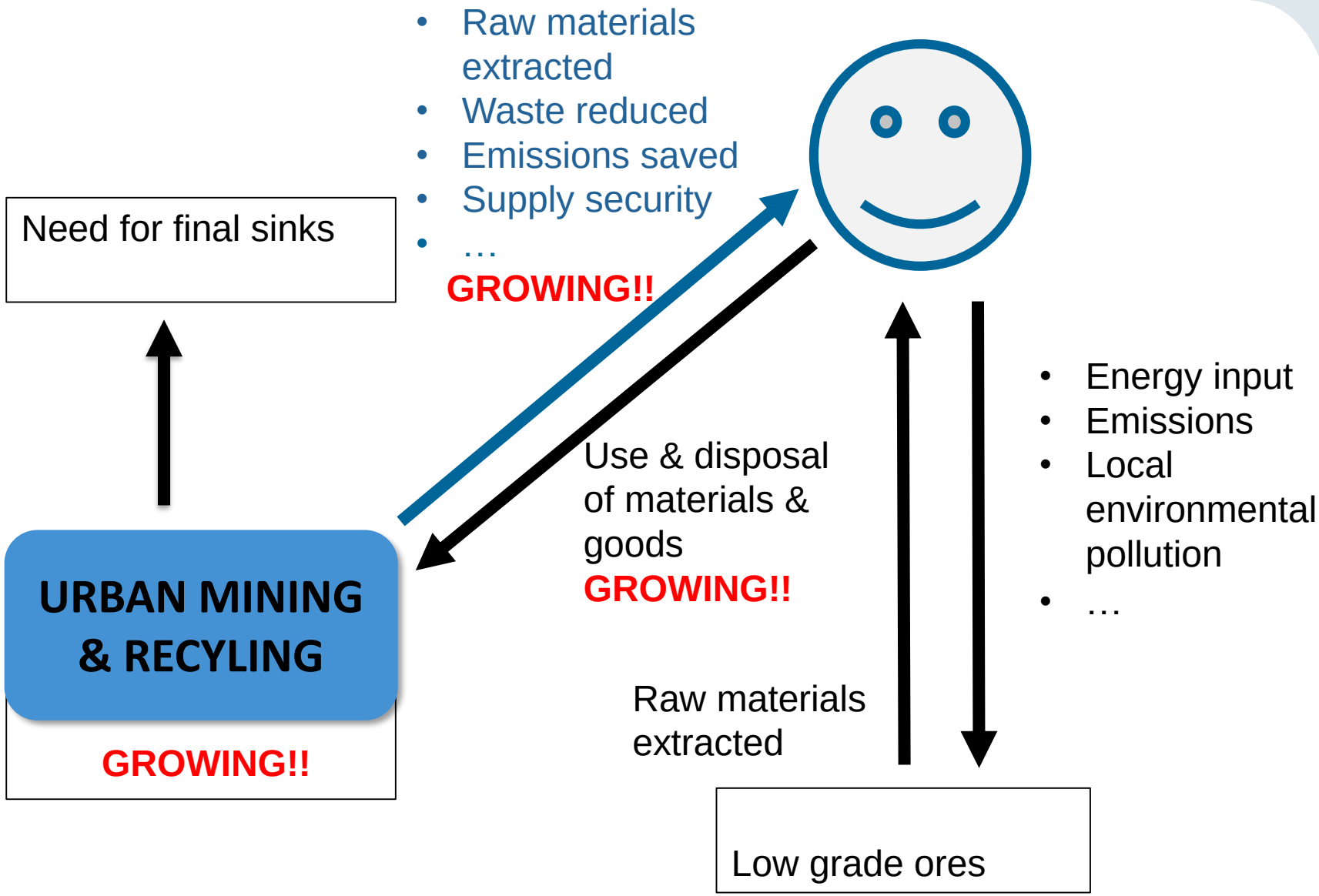
Content

1. The Bigger Picture



The Bigger Picture 2



2. Goal & Motivation

Goal: Fit anthropogenic resources into UNFC-2009

Why?

- **Holistic view** of resource availability
- Information for decisions makers in **waste management**
- Feedback for **design for recycling**

➡ **Systematic & transparent** method necessary

3. Application of a Primary Resource Classification Framework to Anthropogenic Resources

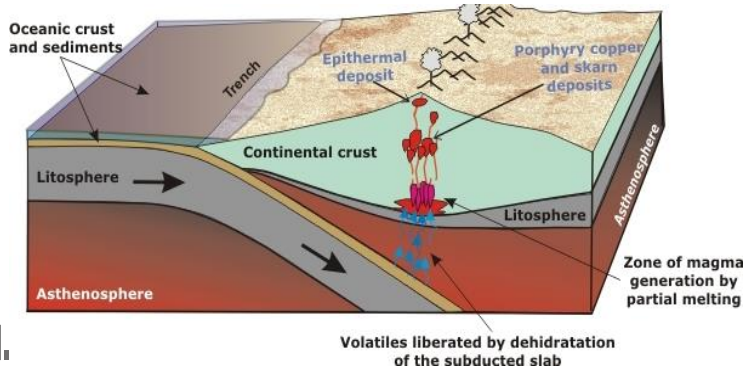
Geogenic vs. Anthropogenic Resources

Geogenic Resources

Human Activity

Anthropogenic resources

Geological Activity



(1) Human influence
(2) Diverse & scattered sources
(3) Many diverse recoverable fractions
(4) Time of genesis shorter
(5) High uncertainties
(6) Anticipating future obsolete stocks & waste flows by investigating in-use stocks
(7) Often positive externalities

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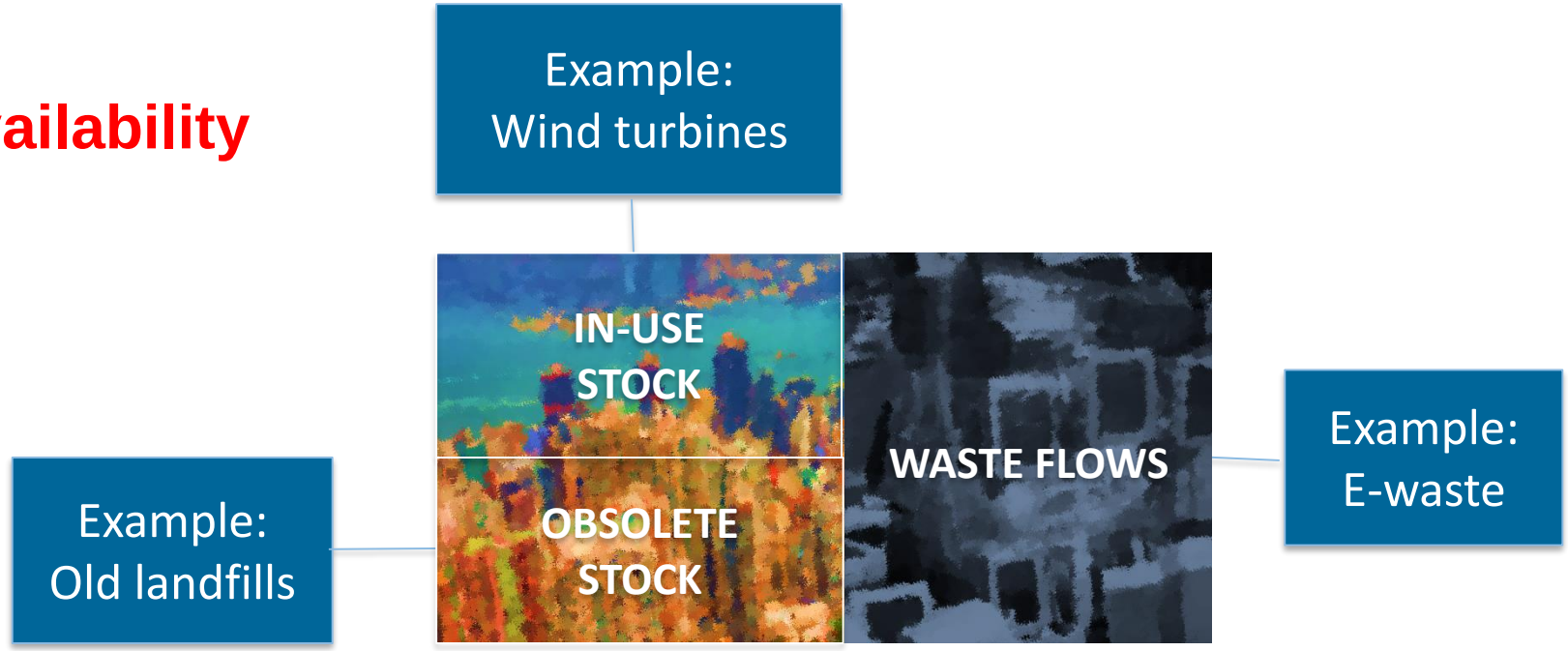
Heterogeneity of Anthropogenic Resources

- **Availability**



- **"Push" vs. "Pull" situation:**
  - "Pull": Landfill can be mined for resource recovery
  - "Push": Due to immanent pollution threat some landfills must be mined, e-waste flows must be treated in any case (EU law)

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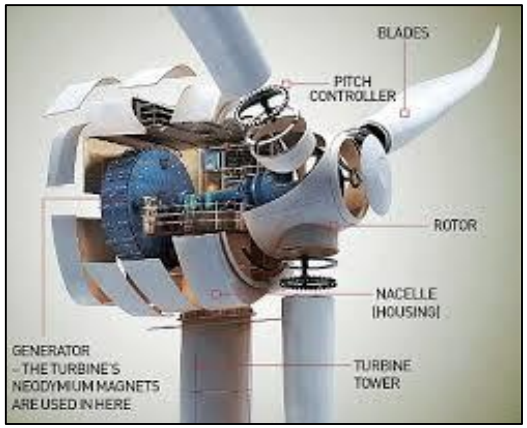
4. Three show cases



In-Use Stock: NdFeB magnets in wind turbines

Waste Flow: Obsolete PCs

Obsolete Stock: Old landfill

Case Studies: Results

	Old landfill		Obsolete PCs (EU)		Permanent magnets in wind turbines	
	Present	Potential future	Scenario 1 (High income & collection rate)	Scenario 2 (Low income & collection rate)	Scenario 1 (Re-use)	Scenario 2 (Hydromet. extraction)
NPV total	**-277 Mio.**	**46 Mio.**	**96,000**	**34,000**	**6 Mio.**	**5 Mio.**
NPV in € / t excavated waste materials / t collected PCs / t magnetic scrap	**-17**	**2.9**	**120**	**340**	**37,500**	**31,800**

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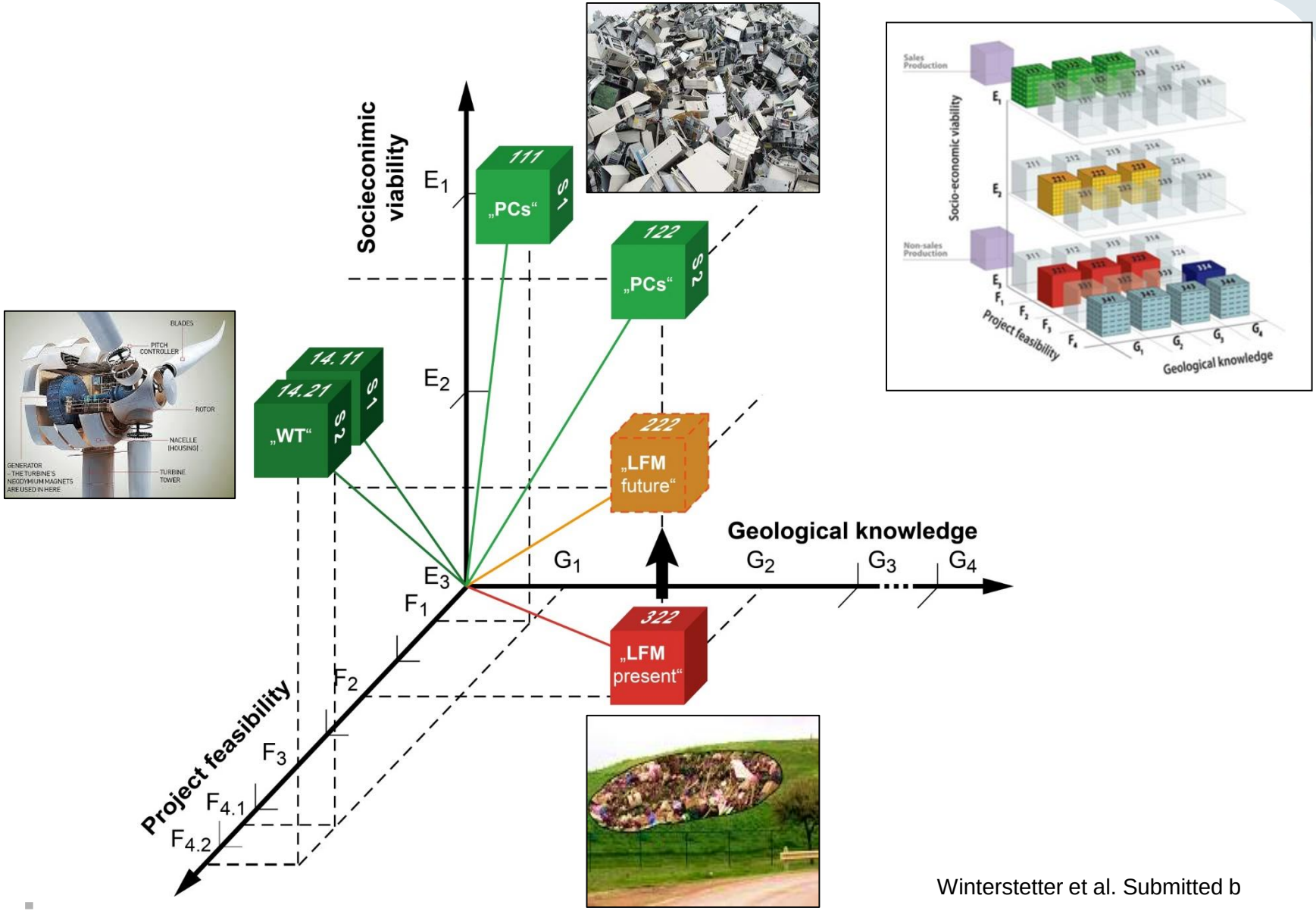
Classification under UNFC-2009



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5. Conclusion & Outlook

- Classification of different types of anthropogenic resources under UNFC-2009 possible
- Operative evaluation procedure & guidelines developed
- Criteria in line with the classes of UNFC-2009 defined, e.g. in-use stock = F4

Challenges:

- How to deal with the inclusion (monetization) of non-monetary effects: E-axis?
- System boundaries of “project” for dynamic waste flows?

Common platform for evaluating

a) Different types of anthopogenic resources

b) Geogenic & anthropogenic resources

Thank you for your attention! ☺

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Literature

- UN Economic Commission for Europe (UNECE), (2010). United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009. ECE ENERGY SERIES No.39. United Nations: New York, 2010.
- Winterstetter, A., Laner, D., Rechberger, H., Fellner, J., 2015. Framework for the evaluation of anthropogenic resources: A landfill mining case study–Resource or reserve? Resources, Conservation and Recycling 96, 19-30.
- Winterstetter, A., Laner, D., Rechberger, H., Fellner, J., Submitted a. Integrating anthropogenic material stocks and flows into a modern resource classification framework: Challenges and potentials. Submitted to Journal of Cleaner Production.
- Winterstetter, A., Laner, D., Rechberger, H., Fellner, J., Submitted b. Evaluation and classification of different types of anthropogenic resources: The case of old landfills, obsolete computers and in-use wind turbines. Submitted to Journal of Cleaner Production.

	Obsolete Stocks (Old Landfill)	Waste Flows (Obsolete PCs)	In-Use Stock (NdFeB Magnets)
E1	Project yields positive NPV		
		KMF: Labor costs, avoided disposal costs, secondary raw material prices	KMF: *Secondary raw material prices, REE separation costs in hydrometallurgical scenario*
E2	Project yields negative NPV, but due to future expected changes in key modifying factors (KMF), cut-off values might be reached		
	KMF: Treatment costs, secondary raw material prices, gate fees for energy recovery		
E3	Project yields negative NPV or evaluation is at too early stage to determine economic viability		
F1	Feasibility of extraction by a defined development project or mining operation has been confirmed • Existing legal framework • Existing societal, institutional & organizational structure • Mature technologies applied • Project status: Ongoing activities		
		<u>*Scenario 1*</u> *Existing infrastructure & public awareness for PC collection via EPR (in line with WEEE directive).*	-
F2	Feasibility of extraction by a defined development project or mining operation is subject to further evaluation, at least one of the F1 criteria is not fulfilled		
	• *No legal framework for landfill mining* • *Positive public perception* • *Mainly design & planning activities ongoing* • *Operations only on a pilot scale.*	<u>Scenario 2</u> • *Weakly enforced laws* • *Poor collection infrastructure* • *Low awareness about source separation* • *Application of established recycling methods* • *Interference with informal recycling sector (high uncertainties about collection rates).*	-
F3	• Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data. • Extraction, processing & valorization technologies exist and are planned to be applied, but the project is not sufficiently advanced to determine the quantity & quality of potentially recoverable material, F1 criteria are widely not fulfilled		-

F4	In situ (in-place) quantities that will not be extracted by any currently defined development project or mining operation.
	• F1 criteria are not fulfilled, also not (yet) existing technologies
	• F4.1 – F4.3 describe the current state of technological development:
	  ○ F4.1: Technology under development, but no type-specific applications (yet)
	  ○ F4.2: Technology is researched, but pilot studies are not yet available
	  ○ F4.3: Technology for recovery is not currently under research or development

	• *In-use stocks are classified as F4 as they are currently not available for mining.* • *No legal framework for treating obsolete wind turbines* *<u>Scenario 1 (re-use)</u>* *F4.1: Existing research project on the re-use of NdFeB-magnets from hybrid cars & e-vehicles* *<u>Scenario 2 (hydrometallurgy)</u>* *F 4.2: Technology currently being researched (e.g. Ellis et al., 1994; Itakura et al., 2006; Itoh et al., 2009),but no successful pilot studies have yet been completed / no published data*

G1	The stock's / flow's volume, composition & the applied technologies' recovery efficiencies can be estimated with a high level of confidence to assess the share of potentially extractable & usable materials* Alternative: P90 => Low estimate**		
		Scenario 1 • *Volume & composition of PC waste flow is well known* • *Recovery efficiencies are well known*	• *Detailed exploration studies on magnets in wind turbines* • *Knowledge about extractable material content* • *Minor uncertainties about recovery efficiencies*
G2	The stock's / flow's volume, composition & the applied technologies' recovery efficiencies can be estimated with a medium level of confidence to assess the share of potentially extractable & usable materials* Alternative: P50 => G1+G2 = Best estimate**		
	• *Medium level of confidence about quantity & composition of landfilled material (based on sample excavations & the landfill's logbook data).* • *Recovery efficiencies sufficiently known*	*Scenario 2* • *Volume & composition of waste flow is well known, however significant uncertainties about collection rate due to informal sector* • *Recovery efficiencies can be estimated with sufficient detail*	
G3	The stock's / flow's volume, composition & the applied technologies' recovery efficiencies can be estimated with a low level of confidence to assess the share of potentially extractable & usable materials* Alternative: P10 => G1+G2+G3 = High estimate**		
G4	Quantities estimated during the exploration phase, subject to a substantial range of uncertainty & major risk that no mining operation will be implemented to extract these quantities		

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Phases & UNFC axes	Goal	Influencing factors	
1.Prospection G Axis	Selection of a deposit to be mined (preconditions) First estimates on resource potential	Availability	• In-use stock • Obsolete stock • Waste flows
		Mining / handling condition	• Push • Pull
		System Variables	• Type • Location • Volume • Composition • Legal, institutional, organizational & societal structures • Different options for technologies & project set-upsfor extraction & processing with specific efficiencies & maturity • Project status
2. Exploration G Axis F-Axis	Knowledge on the deposit's share of extractable & potentially usable materials Technical feasibility & Project status		
3.Evaluation E-Axis	Socioeconomic viability of extraction & utilization	Modifying factors	• Prices for secondary products • Costs • Avoided costs • Indirect financial effects & monetized external effects
4. Classification	Combination of all criteria & classification under UNFC-2009		

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Anthropogenic Resources

Investigated Scenarios