

# MOOC Teacher Manual

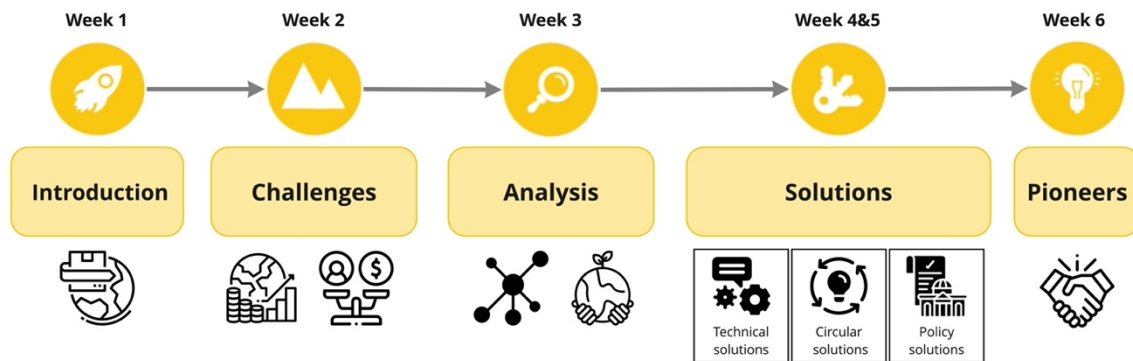
## Content

1. Introduction	3
2. Course structure	4
3.1 How each module is structured	5
3. How to use the MOOC in a blended learning environment	6
4. Annex	7
4.1 Module structure	

## 1. Introduction

Due to the modular structure of the course, the MOOC is designed in a way that it can be fully or partially integrated into University courses on Circular Economy, Critical Raw Materials, sustainability, and related topics.

## 2. Course structure



The MOOC is structured into 5 modules. Each module covers different aspects of the critical raw materials and can be individually gone through as well. In module 4, three tracks allow to put a focus on one area of the topic, looking at solution approaches from different perspectives.

Below is an overview of the content that will be covered per module, and approximately how long it will take to complete each module.

**Module 1 - Introduction:** Relevance of critical raw materials in our society  
 What is the definition of a critical raw material? What role do these materials play in our transition to a more sustainable future? Will we run out of critical raw materials soon?  
*Estimated study load: 4-5 hours*

**Module 2 - Challenges:** The issues with critical raw materials and their opportunities  
 What are the challenges related to critical raw materials that have to be overcome or managed?  
*Estimated study load: 6-7 hours*

**Module 3 - Analysis:** Tools for evaluating raw material challenges  
 What are the tools needed to analyze material systems and dynamics? What impact on the environment and society do these resources have?  
*Estimated study load: 6-7 hours*

**Module 4 - Solutions:** Approaches and strategies for tackling the challenges  
 How can we overcome the challenges we are facing with critical raw materials? Learn the tools to tackle them from different perspectives:

- Technical solutions
- Circular solutions
- Policy solutions

### 3. Estimated study load (per track): 8-9 hours

#### **Module 5 - Pioneers:** Good practice examples

What are example companies in this field and what do they differently? Hear from example businesses how they tackle some of the most pressing material challenges.

*Estimated study load: 2-3 hours*

#### 2.1 How each module is structured

In each module, there are a variety of readings, video and audio lectures, and interviews on the different topics. There can also be found a formative assignment for the learner to check if they have understood the concepts that were explained. These assignments include tasks such as technical calculations, writings, forum discussions, questions, etc. At the end of each module, participants are asked to complete a formative quiz which tests their knowledge on the topics that were covered.

At the beginning of every module there will be a feedback video in which the main course instructor looks back on the previous module with another instructor and summarizes the highlights of the last module.

## 4. How to use the MOOC in a blended learning environment

In order to use the MOOC in a blended learning environment, individual modules can be used for the course, covering the desired topics.

It is proposed to let the students study the teaching materials in the form of videos or readings individually before a physical class. The exercises can either also be done individually and afterwards discussed or presented in class, done in class together, or as a group work individually or at home.

In order to find the right content that fits into your course, instructors should look at the module structure in the table attached in the annex.

Here, the whole course is laid-out according to what is covered in each module. For each of them, you find the following information:

- Learning objectives (The learner will be able to...)
- Main contents
- Instructor
- Teaching material
- Available exercise
- Suggestion for an exercise format, distinguishing in-class and individual work

The time estimates for the exercises are based on an individual performance of the exercise on the level of an average MOOC learner. This can of course be widely varied, depending on factors such as the preexisting knowledge of learners, targeted depth of understanding, and available time.

## 5. Annex

### 5.1 Module Structure

Module	Main learning outcome (the learner will be able to ...)	Main contents	Video instructor	Material for individual study	Available exercise	Recommended exercise format	
<b>1. Intro</b>							
<b>Introduction</b>	Critical raw materials for emerging technologies	<b>Describe</b> the importance of CRMs for a sustainable future	Relevance of CRMs for clean technologies; Global trends in CRM use; Finiteness of elements	Alessandra Hool, ESM Foundation	3x 4 mins videos (60 mins workload)	Drag and drop exercise (workload 5min)	Exercise to be done individually; discuss possible questions in class
	Introduction video by EIT RM	<b>Describe</b> the role of the EIT RM in responding to the critical raw materials challenges	the role of critical raw materials for Europe; examples of critical raw materials that are important for Europe	Patrick Nadoll, EIT Raw Materials	2x 3 mins videos (30min workload)	Forum discussion (15min workload)	Discussion in class – possibly use existing forum entries as starting points
	Will we run out of resources?	<b>Determine</b> whether geological scarcity is a key challenge to accessing CRM resources	Resources, reserves and geological distribution of example CRMs; Description of other key challenges that may limit resource availability	Eimar Deady, British Geological Survey	2 x 2-3min video (25min workload)	Simulation of evolution of reserves (10 min workload)	Look at simulation/ explanation individually, discuss the changes in class
	Criticality concepts	<b>Define</b> criticality according to perspectives of different countries and stakeholders	Main problem of criticality is access; introduction of economic, geopolitical, environmental and social constraints; qualitative and perspective-dependent nature of criticality assessments; need for thorough and stakeholder-specific analysis	Dominique Gyuonnet, French Geological Survey	3x 3mins videos (40min workload)	HH index calculation exercise (30 mins workload)	Calculation individually; discuss results in class

	Summary of the "Introduction" modules					Quiz on topics above (6 questions, 15 mins workload)	Go to quiz together in class, recap context of the question
<b>Introduction: Total time required (minutes)</b>							<b>240</b>
<b>Challenges</b>	<b>2. Resource Challenges</b>						
	Resources for a growing world population	<b>Relate</b> the impact of population growth and an emerging middle class with resource use	Growing world population and middle class, growing material use and its footprint, need for decoupling	René Kléijn University of Leiden	4min video (20 mins workload)	Future demand calculation exercise (30min workload)	Calculation individually; discussion in class
	Resource efficiency	<b>Recall</b> methods to improve resource efficiency	Consumption patterns; Interrelation of consumption and production; Decoupling	Unversity of Bordeaux University of Leiden	3x 5mins films (75 min workload)	Dropdown with keywords and concepts (30 mins workload)	Perform exercise together in class
	Geopolitical issues	<b>Recognize</b> the complexity of competition for resources in a globalized world	Protectionist measures, China-US trade war, other examples of trade wars, areas of disagreement and conflict (deep sea etc.)	Roland Dannreuther, University of Westminster	3x 4 mins videos (60 mins workload)	Guided forum discussion (30 mins workload)	Discussion in class – possibly use existing forum entries as starting points
	<b>2. Economic Challenges</b>						
Rare metals economics	<b>Recognize</b> economic mechanisms that affect CRMs	Co- and byproduction; Price elasticities of demand	David Peck, TU Delft	1x 9min videos (45 min workload)	Forum discussion (10 min workload)	Discussion in class – possibly use existing forum entries as starting points	



	Commodity markets	<b>Describe</b> the volatility of CRM markets	Price volatilities of CRMs; Contracting types and economic risk mitigation strategies; why some minor metals are not exchanged on official markets	Yves Jégourel, University of Bordeaux	3x 4mins videos (60 mins workload)	Price development exercise (20 mins workload)	Exercise to be done individually; discussion in class
	Summary of the "Challenges" modules					Quiz on topics above (5 questions, 15 mins workload)	Go to quiz together in class, recap context of the question
	<b>Challenges: Total time required (minutes)</b>						
<b>Analysis</b>	<b>3. Resource Dynamics</b>						
	Data availability in primary supply	<b>Recognise</b> the importance of data and that lacking data impedes raw material assessment	Present data availability of primary resources, their gaps and importance in criticality assessments	Evi Petravatzi, British Geological Survey	2x 4mins films (40 min workload)	Drop down exercise with example data gaps and consequences (10min workload)	Perform exercise together in class
	Potentials of secondary supply	<b>Identify</b> the extent to which secondary supply can cover current raw material needs	Availability of secondary sources, their potential to cover demand; stock dynamics; delays between inflow and outflow; impossibility of secondary supply to meet demand in a situation of stock build-up	Ester van der Voet, University of Leiden	2x 3-5min films (60 min workload)	Poll on future secondary supply with paper reading (10min workload)	Perform poll in class and discuss results
	Supply and demand scenarios	<b>Create</b> raw material supply and demand scenarios	Driving forces for stock growth; Product vs material level; Demand vs supply; Different supply routes; Possibilities to decouple demand from stock growth; Storylines for the future; SSP scenarios vs black swan scenarios; Metal requirement for a renewable energy system	Ester van der Voet, University of Leiden	2x 3-5min films (60 min workload)	Fill in sentences to make logical narrative, 3 questions (10mins workload)	Fill in sentences together in class and discuss

4. Social and Environmental Impacts/Factors						
Climate	<b>Interrelate</b> the mechanisms that influence the climate impacts of materials; Interrelate the complexities of the energy-materials nexus	Energy requirement of metal production; Ore grade decline; Mining/refining technology; Energy-materials nexus	Ester van der Voet, University of Leiden	2x 4mins videos (40 mins workload)	Rank energy use of various metal productions (10min workload)	Perform ranking together in class and discuss
Intro to environmental factors	<b>Exemplify</b> different types of environmental impacts on different levels of the value chain	Impacts related to mining and production processes; Impacts related to electricity/fuel use; LCIA impact categories; Land/biodiversity vs Climate change/air pollution vs Toxicity related impacts	Dieuwertje Schrijvers, WeLOOP	- 4mins video (20 mins workload) - Reading (20min workload)	Pair environmental impacts with image (10mins workload)	Exercise to be done individually; discussion in class
LCA	<b>Understand</b> and <b>reproduce</b> the basic principles and value of LCA to assess environmental impacts of CRM	cradle-to-grave, cradle-to-gate, grave-to-gate; life cycle inventory and life cycle impact assessment; comprehensive environmental assessment	Stefano Cucurachi, University of Leiden	- 2x 3-4mins videos (35 mins workload) - Reading (10 mins workload)	LCA drawing (30 mins workload)	Exercise to be done individually; go through a more complex example in class

		Social factors	<b>Identify</b> relevant social factors in mining countries. Recall the social impact evaluation tools SLCA (and the Social Impact Audit Tool.)	Social circumstances in mining countries; evaluating social impact, using the Social LCA framework; example using Social Impact Audit tool	Tatiana Vakhitova, Ansys	- 1x 6mins videos (30 min workload)	Forum exercise (30 mins workload)	Discussion in class – possibly use existing forum entries as starting points	
		Summary of the “Analysis” modules					Quiz on topics above (9 questions, 30 mins workload)	Go to quiz together in class, recap context of the question	
	<b>Week 3: Time required (minutes)</b>								<b>380</b>
Solutions (Lead Bordeaux)	Track 1	<b>5. Technical Solutions</b>							
		Exploration	<b>Determine</b> the role of exploration to identify CRM resources	Dynamics of reserves, scarcity, and economics; Basic steps of exploration; Requirements to open a mine (ore grade, policy); Overview of key players and initiatives (geographically, which materials are targeted); space and deep sea mining	Paul Lusty, British Geological Survey	- 3x 4mins films (60 mins workload) - Reading 30mins		Discuss reading in class	
		Substitution	<b>Classify</b> different types of substitution	Introduction that many CRMs cannot be easily substituted on a material level (examples of typical substitutes, and which CRMs do not have such substitutes); Alternative substitutions and examples (material-level, product-level, technology-level, system-level); Potential drawbacks of substitution (shifting environmental impacts, substitutes are also critical, costs)	Oliver Gutfleisch, Guest from TU Darmstadt	3x 4-8mins videos (85 mins workload)	Technical exercise (40 mins workload)	Exercise to be done individually; discussion in class	

		Summary of Technical Solutions Part I				Quiz on topics above (10 questions, 30 mins workload)	Go to quiz together in class, recap context of the question
<b>Technical solutions part I: Time required (minutes)</b>							<b>210</b>
	Characterizing the urban mine	<b>Evaluate</b> the potential of urban mining by using the database urbanmingplatform.eu in order to clarify basics of CRM stocks and flows in the EU		Patrick Wäger, Charles Marmy, Empa	3x 3-7mins videos (65 mins workload)	Stock and flow exercise (40 mins workload)	Perform exercise together in class
	Process-model based LCA; whole value chain of metals	<b>Identify</b> the thermodynamic limitations of recycling and relate analytical tools to evaluate the recyclability of products	Limitations and opportunities of CE strategies for CRMs; exergy-based dissipation, introduction of simulation software / MACHINES AND INTERFACE	Outotec	4x 5mins videos (100 mins workload)	Wheels of metals exercise (15 mins workload)	Discuss wheel of metals together in class
	Sustainability assessment	<b>Identify</b> tools to evaluate the sustainability of products and processes	Ashby 5-step methodology, stakeholder mapping, trade-offs	Granta Ansys	2x 4mins videos (40 mins workload)	Drop-down exercise on stakeholders (20min workload)	Exercise to be done individually; discussion in class
	Summary of Technical Solutions Part I					Quiz on topics above (10 questions, 30 mins workload)	Go to quiz together in class, recap context of the question
<b>Technical solutions part I: Time required (minutes)</b>							<b>225</b>
Track II	<b>6. Circular Solutions</b>						

		Circular economy and circularity indicators	<b>Differentiate</b> between CE concepts and available indicators	Overview of circularity strategies (recycling, reuse, remanufacturing, refurbishing, etc); Key/secondary purposes: reduce waste and reduce primary resources, reduce environmental impacts, local sourcing, increase profits, generate jobs; circularity indicators of Ellen Macarthur Foundation	David Peck, TU Delft	1x 6mins videos (30 mins workload)	Essay on indicators (30 mins workload)	Essay to be written individually; presentation of topics in class	
		Circular business models	<b>Clarify</b> the different types of business models to improve circularity in organisations	Product service systems/leasing/sharing with examples; Benefits for CRM (material comes back to producer); Other benefits (producer becomes responsible for end-of-life, increased performance (no planned obsolescence), decreased environmental impacts	TU Delft	Reading text (20 mins workload)	Short essay on existing example (30 mins workload)	Essay to be written individually; presentation of topics in class	
		Economic aspects of recycling	<b>Describe</b> economic drivers and policies supporting recycling	Basic understanding of recycling infrastructure/network; Factors that make a material interesting for recycling (quantity, dispersion of products, technology, price); Examples of materials that are easy/not easy to recycle, and why; What economic circumstances would favor recycling rates of CRMs; What role could policymakers play here	Christian Hagelüken, Guest from Umicore	3x 6mins videos (90 mins workload)	Introduction quiz (10mins workload)	Go to quiz together in class, possibly in the form of a poll	
		Summary of Circular Solutions part I					Quiz on topics above (10 questions, 30 mins workload)	Go to quiz together in class, recap context of the question	
		<b>Week 4: Time required (minutes)</b>							<b>220</b>

		Design for recycling	<b>Recall</b> ways to facilitate recycling on a technical level	Use of simulation software; thermodynamical limitations of recycling; Optimisation strategies (costs vs CRM yield) / WHEELS OF METALS	Markus Reuter, SMS Group	3x 7-8mins videos (100mins workload)	Wheel of metals exercise (15mins workload)	Perform exercise together in class and discuss wheel of metals
		Circular product design	<b>Characterize</b> the strategies to help make products more circular	Repairability; Modular design; Actors involved to enable circularity	Ruud Balkenende, TU Delft	3x 3mins videos(40 mins workload)	Repairability exercise (50 mins workload)	Case to be written individually; presentation of topics in class
		Summary of Circular Solutions part II					Quiz on topics above (10 questions, 30 mins workload)	Go to quiz together in class, recap context of the question
	<b>Circular solutions part II: Time required (minutes)</b>							
Track III	<b>7. Policy Solutions</b>							
	How to mitigate supply risks	<b>Categorize</b> different supply risk mitigation strategies	Strategies to mitigate supply risk (exploration of primary sources, access to raw materials in foreign countries, substitution, circular economy strategies), barriers of mitigation (technological, social/environmental, economic); Collaboration of policymakers, industry, researchers	Dieuwertje Schrijvers, WeLoop, Alessandra Hool, ESM	2x 3-4mins videos (30 mins workload)	Dropdown menu of strategies and type of solution (20 mins workload)	Perform exercise together in class	

		Responsible mining	<b>Identify</b> solutions to environmental and social risks of mining activities	Basic functioning of mining activities; Main ecological problems/examples of disasters; Overview of good practices	Dominique Guyonnet, French Geological Survey	3x 3-4mins videos (40 mins workload)	Scenarios exercise (30 mins workload)	Develop a scenario as a group work and present in class		
		International trade and diplomacy	<b>Describe</b> basic trade agreements and their relevance for CRMs	Introduction on the relevance of a steady supply of materials for a national economy; Examples of trade agreements in general; Examples of disruption of trade agreements and their consequences; Can materials become less critical via trade agreements?	Constanze Veeh, EU Commission	3x 4-6mins videos (75 mins workload)	Forum discussion	Discussion in class – possibly use existing forum entries as starting points		
		Summary of policy solutions part I					Quiz on topics above (10 questions, 30 mins workload)	Go to quiz together in class, recap context of the question		
		<b>Policy solutions part I: Time required (minutes)</b>								<b>210</b>
		Certification	<b>Recognise</b> how certification can help to improve social conditions in mining regions	Why companies are interested in certification (regulation, demand of customers), How a certification program works; Certification of conflict minerals; Relevance of certification for CRMs	Steven Young, University of Waterloo	3x 3-5mins videos (60 mins workload)	Drag and drop exercise on benefits (20 mins workload)	Exercise to be done individually; discussion in class		

	Critical raw materials and sustainable development	<b>Relate</b> SDGs to CRM challenges (about the the need for managing resources comprehensively)	Introduction of sustainable development goals; Need for raw materials for attaining the SDGs; How resource management can benefit the SDGs (creation of jobs, lower env. Impacts, better social circumstances, stronger supply chains supporting long-term investments in the region, etc)	Julian Hilton, Guest from UN	3x 3-5mins videos (65 mins workload)	Forum discussion (30min)	Discussion in class – possibly use existing forum entries as starting points	
	Summary of policy solutions part I					Quiz on topics above (10 questions, 30 mins workload)	Go to quiz together in class, recap context of the question	
	<b>Policy solutions part II: Time required (minutes)</b>							<b>210</b>
<b>Pioneers</b>	<b>8. Good Practice Examples</b>							
	Good practice examples	<b>Reflect</b> on examples of business cases for a more sustainable management of critical raw materials	Intodroduction of start-ups and projects working in the field, ways to tackle the problems with concrete initiatives	Circularize	7mins video (35 mins workload)		Discuss business case in class	
				Minespider	5mins video (25 min workload)		Discuss business case in class	
				Hitachi	Reading (30 mins workload)		Discuss business case in class	
				KPN	4mins video (20 min workload)		Discuss business case in class	
				Fairphone	9mins video (45 min workload)		Discuss business case in class	
<b>Pioneers: Time required (minutes)</b>							<b>155</b>	