

Teaching Resources on the Sustainable Management of Critical Raw Materials

Trainer's Manual for Sustainability Assessment

March 2020

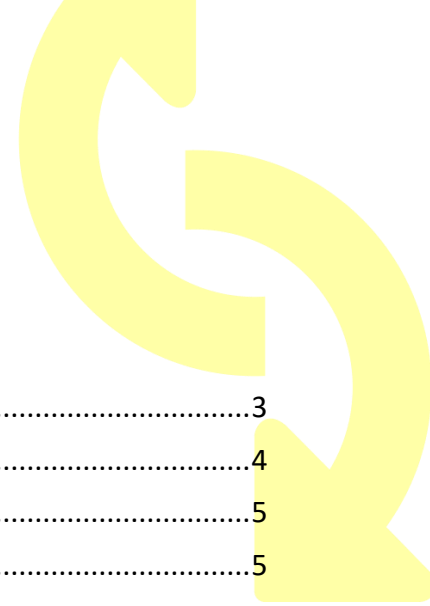
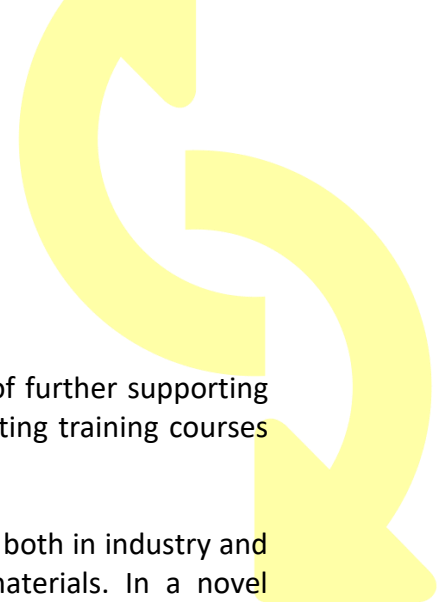


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1 Context and Introduction to Training

This booklet is supplementing the teaching materials and the set of further supporting booklets that have been developed to support teachers in conducting training courses related to the sustainable management of critical raw materials.

SusCritMat aims to educate people from Master's student level up, both in industry and academia about important aspects of sustainable critical raw materials. In a novel concept, it introduces courses on these complex and interdisciplinary topics in a modular structure, adaptable to a variety of different formats and accessible to both students and managers in industry. These courses will develop new skills, which will help participants to better understand the impact and role of critical raw materials in the whole value chain; enabling them to identify and mitigate risks. Understanding the bigger picture and the interconnected nature of global business and society is increasingly necessary to and valued by industry.

SusCritMat is an EU-funded project that brings together the technical and pedagogical expertise of leading educational institutions and business partners. It uses and creates teaching materials which can be combined into different course formats.

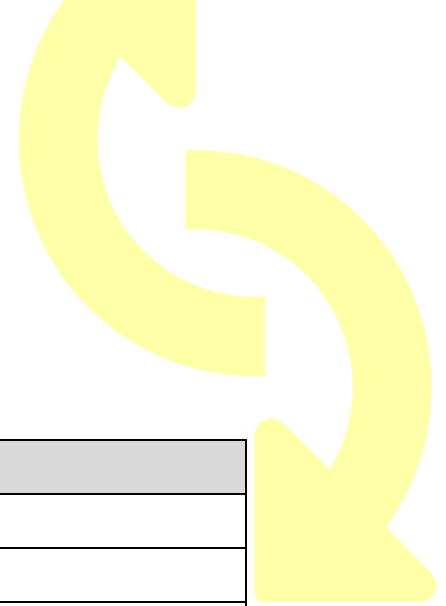
The collection of training manuals presents the key messages related with the sustainable management of critical raw materials in three major sections:

- Introduction to criticality
- Analysis of criticality
- Solutions for sustainable management

In particular, the solutions part will be in the focus. The intention is to underline the possibilities that are available to approach and implement a circular economy for critical raw materials and the products bearing these. Doing so the concrete actions, i.e. the things that can be done, are highlighted, instead of only mentioning all sorts of associated problems or barriers in the context of CRMs.

The overall goal of the SusCritMat project is to qualify lecturers to teach the topics themselves. Therefore, the teaching resources do not only provide an introduction and improved insight into selected thematic issues, but also deliver a set of teaching materials "ready-to-use".

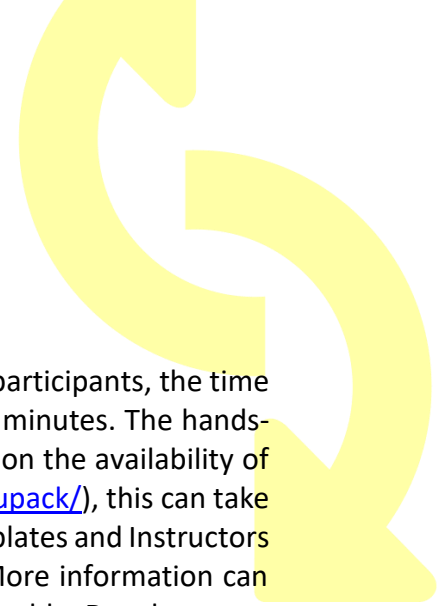
- Learning targets that will be reached after having taught the courses
- Presentations on the specific topics including also notes on how to present the slides and key messages.
- Group work exercises including the task or question to work on, if applicable further reading on the methodology and the solutions in case of tasks requiring calculations.
- Assessment questions and the correct answers for each specific topic.
- Additional reading for each topic.



1.1 Training Materials List

The *SusCritMat* project developed the following teaching materials:

Basics
Critical Resources for Emerging Technologies
Criticality
Supply Chain Resilience
Supply Risk Factors
Circularity
Circular Economy
Characterizing the Urban Mine
Circular Business Models
Waste Management and Recycling Potential
Closing Loops on Product Level
Governance
Geopolitical Aspects
Metals & CRM Scenarios
Restricted Substances Legislation
Impact on Society and the Environment
Sustainability Assessment
Responsible Mining
Responsible Sourcing / Certification
Environmental Aspects
Sustainable Materials Usage
CRM and Sustainable Development
Tools
MFA - Material Flow Management
Good Use of Data
LCA – Life Cycle Assessment
Process Models based on LCA



1.2 Suggested timetable

Depending on the level of pre-existing knowledge and a number of participants, the time can be amended. The current lecture slides can be presented in 15 minutes. The hands-on work can extend this to a workshop of 2,5 - 3 hours. Depending on the availability of CES EduPack software (<https://grantadesign.com/education/ces-edupack/>), this can take anything – between 15 minutes to an hour. Two separate files – Templates and Instructors experiences – should be useful to run this in a workshop format. More information can be found in Teaching Package: Active-learning ToolKit - Sustainable Development, <https://grantadesign.com/education/teachingresources/package/>

1.3 Key Messages

Sustainable development is understood as one that provides needed products or services in ways that minimizes the drain on resources, is legal, economically viable and acceptable to all stakeholders.

The mission of the proposed 5-step methodology is to provide framework and toolkit for critical, independent discussion of a proposed Sustainable Development proposal.

Challenges for electric cars, which experience an exponential growth include:

- Most battery types contain toxic elements, such as Lead, Cadmium and some contain critical elements: Lithium, Cobalt.
- Most electric motors contain magnets, which have rare earth elements: Neodymium, Samarium.

Visualization tools in GRANTA's EduPack allow us to have a quick overview of material properties to select the best alternative, for example, showing that the Li-ion battery is a very competitive battery alternative based on its overall performance.

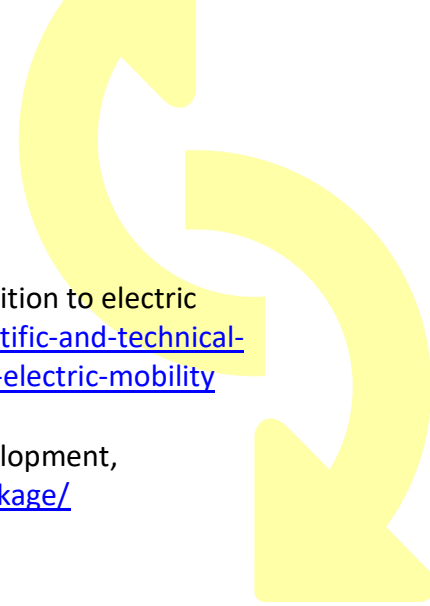
1.4 Learning Objectives

This session will provide learners:

- Systemic approach to complex sustainability challenges
- Introduction to topic of e-mobility from materials' perspective

1.5 Additional Reading

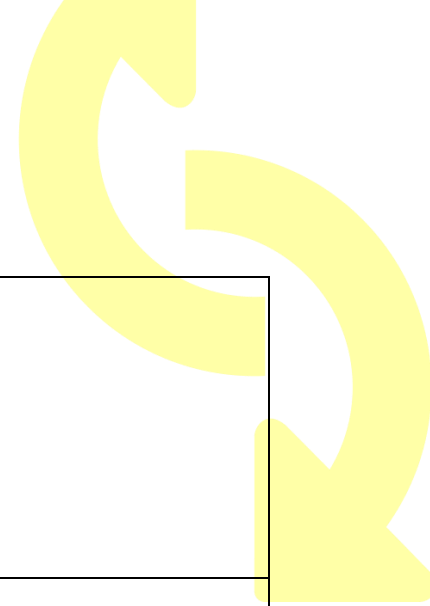
- White paper "Electric Cars: Sustainability and Eco Design", <https://grantadesign.com/education/teachingresources/>



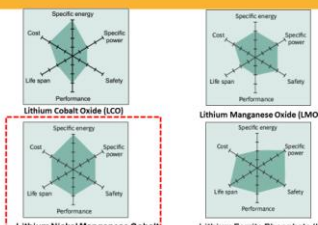
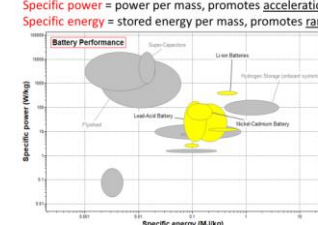


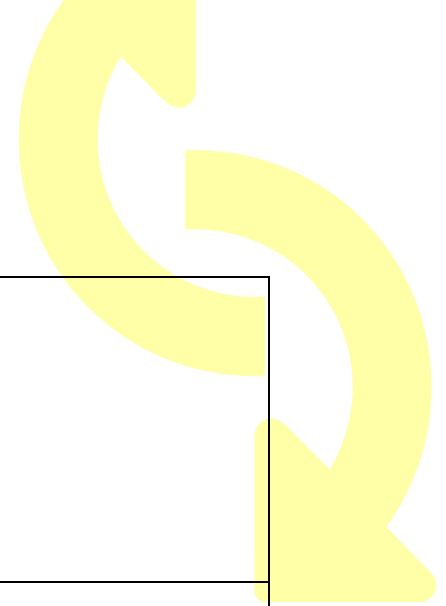
- EU publication “Cobalt: demand-supply balances in the transition to electric mobility”, <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/cobalt-demand-supply-balances-transition-electric-mobility>
- Teaching Package: Active-learning ToolKit - Sustainable Development, <https://grantadesign.com/education/teachingresources/package/>

2 Slides and Notes


<p style="text-align: right;">SusMat Crit</p> <p>SUSTAINABILITY ASSESSMENT</p> <hr/> <p>DR TATIANA VAKHITOVA (PRESENTER) AND PROF MIKE ASHBY ANSYS GRANTA AT ANSYS INC. / UNIVERSITY OF CAMBRIDGE</p> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p style="text-align: right;"><small>© Vakhitova, Ashby, 2020</small></p>	
<p>5-step Methodology: Mission</p> <p style="text-align: center;">Mission Provide framework and toolkit for critical, independent discussion of a proposed Sustainable Development proposal</p> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p style="text-align: right;"><small>© Vakhitova, Ashby, 2020</small></p>	
<p>The three essential Capitals</p> <div style="text-align: center;"> <p><i>Natural capital</i> <i>Manufactured capital</i> <i>Human and Social capital</i></p> </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p style="text-align: right;"><small>© Vakhitova, Ashby, 2020</small></p>	
<p>What are we trying to achieve?</p> <p style="text-align: center;">What is a “Sustainable” Development? One that provides needed products or services in ways that minimize the drain on resources, is legal, economically viable and acceptable to all stakeholders.</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 5px; text-align: center;">  <p>“Half of all new cars must be electric by 2030 to meet EU emission targets” – <i>The Times</i>, 26 November (2015)</p> </div> <div style="text-align: center;">  <p>Articulation icon</p> </div> </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p style="text-align: right;"><small>© Vakhitova, Ashby, 2020</small></p>	



<h3>Defining Articulation</h3>  <p>Any articulation has an</p> <ul style="list-style-type: none"> Objective Size scale Time scale <div style="border: 1px solid black; padding: 5px;"> <p>"Meet EU emission targets" = Objective</p> <p>"Half of all new cars" = Size scale (40 m/year globally, 7 m/year Europe)</p> <p>"By 2030" = Time scale (11 years)</p> </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	
<h3>5-step Methodology</h3> <ol style="list-style-type: none"> 1. What's the proposal? How big? How soon? 2. Who will be affected? What are their concerns? 3. FACTS about the Articulation & Stakeholder concerns? 4. What impact on the 3 Capitals? 5. Reflection: consider alternatives. <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	
<h3>Which facts?</h3>  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	
<h3>Li-ion types of batteries</h3>  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</small></p> <p><small>Source: http://batteryuniversity.com/learn/article/types_of_lithium_ion</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	
<h3>Battery performance</h3> <p>Specific power = power per mass, promotes <u>acceleration</u> Specific energy = stored energy per mass, promotes <u>range</u></p>  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	



<h3>Battery performance</h3> <p>Another important consideration is battery space: Energy density = stored energy per volume, aids design and comfort</p> <p>Electrical performance</p> <p>Lithium is the best but, it's on the US list of critical elements and Lithium batteries usually contain Cobalt, which is a conflict mineral (critical EU & US)</p> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	
<h3>ZOOMing in on Cobalt ...</h3> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	
<h3>Forming a Judgement</h3> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	
<h3>Impact on the Three Capitals</h3> <div style="display: flex; justify-content: space-around;"> <div data-bbox="287 1232 478 1456"> <p>Natural capital</p> <ul style="list-style-type: none"> × Objective not achieved ✓ Possible if grid decarbonized </div> <div data-bbox="494 1254 606 1433"> </div> <div data-bbox="606 1299 766 1388"> <p>Human and Social capital</p> <ul style="list-style-type: none"> × Range anxiety not met ✓ Battery development </div> </div> <div data-bbox="287 1344 446 1456"> <p>Manufactured capital</p> <ul style="list-style-type: none"> × Supply chain for Li & Co in doubt ✓ Expanded production ✓ Social investments opportunities </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	
<h3>Impact on the Three Capitals</h3> <div style="display: flex; justify-content: space-around;"> <div data-bbox="287 1545 478 1769"> <p>Natural capital</p> <ul style="list-style-type: none"> × Objective not achieved ✓ Possible if grid decarbonized </div> <div data-bbox="494 1568 606 1747"> </div> <div data-bbox="606 1612 766 1702"> <p>Human and Social capital</p> <ul style="list-style-type: none"> × Range anxiety not met ✓ Battery development </div> </div> <div data-bbox="287 1635 446 1747"> <p>Manufactured capital</p> <ul style="list-style-type: none"> × Supply chain for Li & Co in doubt ✓ Expanded production ✓ Social investments opportunities </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p> <p><small>© Vakhitova, Ashby, 2020</small></p>	

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3 Exercises

In conjunction to the lecture slides provided and based on templates and material from Workshop, using “Active-Learning Tool Kit – Sustainable Development” available from: <https://grantadesign.com/education/teachingresources/>:

The expected Learning Outcomes of these exercises are the following:

- Expanded understanding of concepts, relating to Sustainable Development
- Ability to tackle open-ended, complex, problems in a limited timeframe
- Ability to summarize and present information clearly and concisely
- Ability to use CES EduPack software at an introductory level.



4 Assessment Questions

Include 10 multiple choice quiz questions and 4 possible answers here.
Mark the correct answer(s) by putting “correct” in brackets behind it.

1 Which are the three capitals that form the basis of the 5-step method

Answer 1: Population, Natural and Planetary

Answer 2: Natural, Manufactured and Human/Social (correct)

Answer 3: Biological, Manufactured and Historical

Answer 4: Monetary, Natural and Legal

2 Which one of the alternatives listed below represents stakeholders for e-cars.

Answer 1: Lobbyists

Answer 2: The public

Answer 3: Both of the above (correct)

Answer 4: None of the above

3 The main information on Critical materials in CES EduPack is found in this data-table:

Answer 1: Process Universe

Answer 2: Nations of the World

Answer 3: Legislation and Regulations

Answer 4: Elements (correct)

4 The Cobalt is currently on very critical materials information section in CES EduPack does NOT contain:

Answer 1: Annual World Production (correct)

Answer 2: Sourcing and geopolitical risk

Answer 3: Price volatility

Answer 4: Abundance risk

5 Yttrium is on list of critical material. Which option is NOT a reason for this:

Answer 1: It fills a strategically important role

Answer 2: It was discovered in Sweden, which still holds the patent (correct)

Answer 3: Its supply chain is uncertain

Answer 4: There is no easy substitute

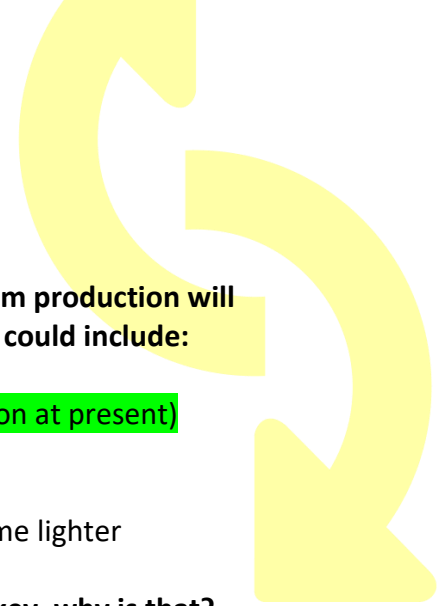
6 Which are the two main areas of sustainability concern discussed in the Case study

Answer 1: Peak oil and pollution

Answer 2: Congestion and greenhouse gas emissions

Answer 3: Fuel efficiency and particle filters

Answer 4: Critical elements in batteries and electric motors (correct)



7 There is a very strong growth in global Lithium demand, so Lithium production will have to rise for e-car production. Actions to deal with the shortfall could include:

Answer 1: Using Lithium based Fuel-cells instead of batteries

Answer 2: Recovery of lithium from end-of-life batteries (not common at present) (correct)

Answer 3: Development of cheaper lead battery systems

Answer 4: Finding ways of modifying the Lithium ions, so they become lighter

8 Li-ion batteries are dominating applications where portability is key, why is that?

Answer 1: Superior mechanical properties and no liquids

Answer 2: High recyclability and robust design

Answer 3: High specific power and specific energy (correct)

Answer 4: Low price and abundant supply

9 Which type of car needs the greatest battery capacity to operate well

Answer 1: Fully electric (correct)

Answer 2: Electric-gasoline hybrid

Answer 3: Plug-in hybrid (electric-gasoline)

Answer 4: Gasoline (combustion engine)

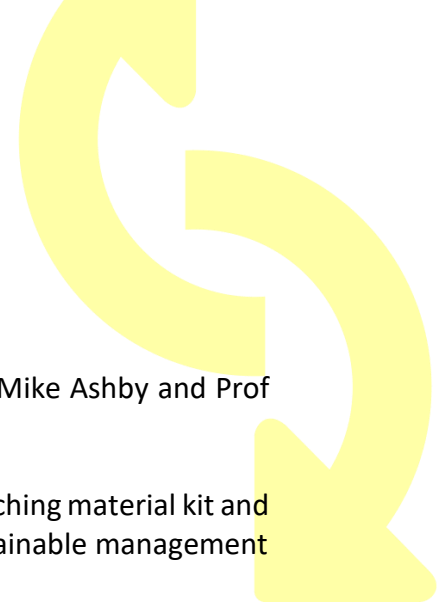
10 Electric car motors need strong magnets to operate. Which materials are used?

Answer 1: Rare metals, like platinum

Answer 2: Rare ceramics, like sand

Answer 3: Rare composites, like boron carbide

Answer 4: Rare earths, like Neodymium (correct)



5 Acknowledgements and Authors

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6 Citation

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7 Disclaimer

The teaching materials within the SusCritMat project have been prepared with great care and experienced several revisions. Nevertheless, the consortium assumes no liability for the topicality, completeness and correctness of the content provided.

In case you have suggestions or other feedback how to improve the materials, we value your opinion: Please contact us via the project webpage <https://suscritmat.eu/contact/>.

