

Teaching Resources on the Sustainable Management of Critical Raw Materials

Trainer's Manual for Criticality

March 2020

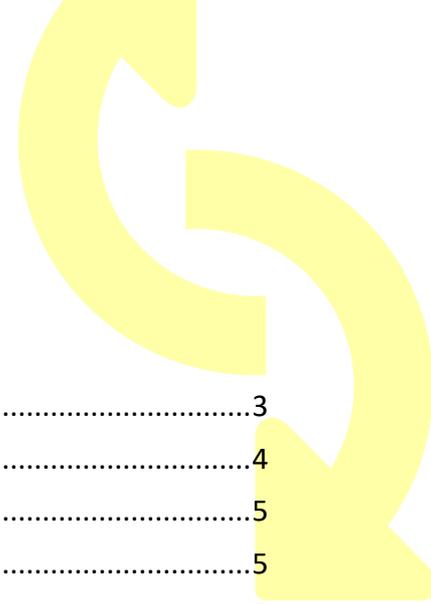


Table of Contents

1	Context and Introduction to Training.....	3
1.1	Training Materials List.....	4
1.2	Suggested timetable	5
1.3	Key Messages.....	5
1.4	Learning Objectives.....	5
1.5	Additional Reading.....	5
2	Slides and Notes	6
3	Exercises	16
4	Acknowledgements and Authors	17
5	Citation	17
6	Disclaimer.....	18



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.

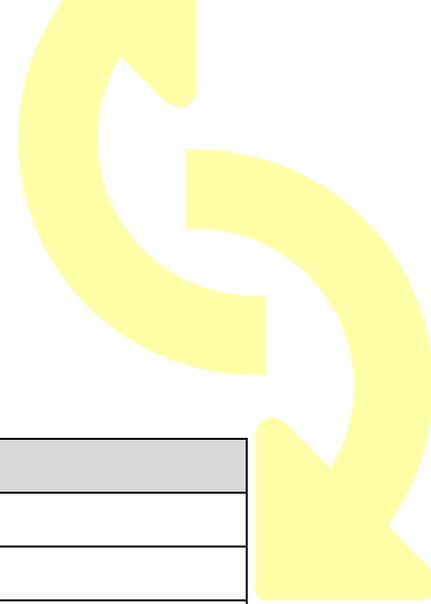
The collection of training manuals presents the key messages related with the sustainable management of critical raw materials in three major sections:

- 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".

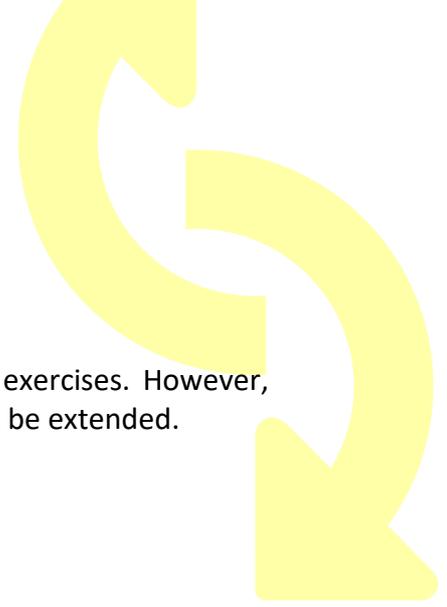
- Learning targets that will be reached after having taught the courses
- Presentations on the specific topics including also notes on how to present the slides and key messages.
- Group work exercises including the task or question to work on, if applicable further reading on the methodology and the 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

The agenda contains a recommended timing for the lecture and exercises. However, depending on the pre-existing knowledge or group size the time can be extended.

Lecture: 1 hour

Exercise: 2 hours

1.3 Key Messages

Sustainability and business interests are more and more intertwined as environmental issues such as natural degradation, climate change or materials depletion cannot be ignored when making business decision because of the costs (e.g. via reputational damage) associated with those phenomena and – increasingly also – legislation. In the field of materials, some of these challenges are particularly relevant. Therefore, conducting a more sustainable business is not (just) a burden, but an opportunity for businesses dealing in this area. The aim must be to become less reliant on primary production, reduce the direct environmental and social damage of mining, and distribute the production of metals more evenly. The approach to the economy including these and other measures is called the “Circular Economy”. Strategies to attain a Circular Economy include everything which leads to more value being retained in the economy. From the lengthening of product life cycles and recycling materials at the end of use to devising new business schemes which rely more on service than on providing a product, therefore restricting materials usage and waste.

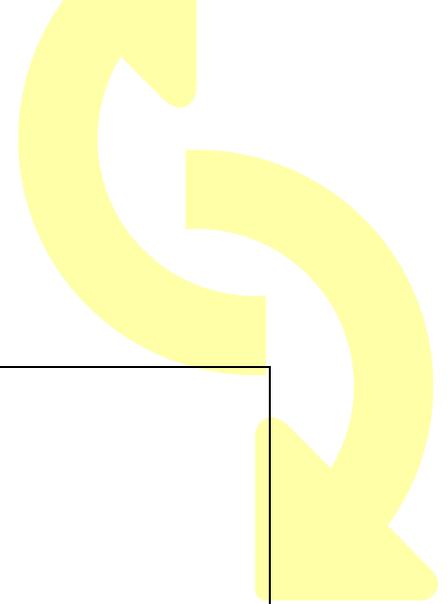
1.4 Learning Objectives

- You can explain how sustainability can be of strategic significance to companies
- You can identify different circular business models
- You can discuss the relevance of circular business models for critical raw materials
- You can select applicable circular business models for products containing a critical raw material

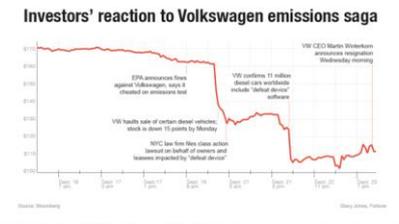
1.5 Additional Reading

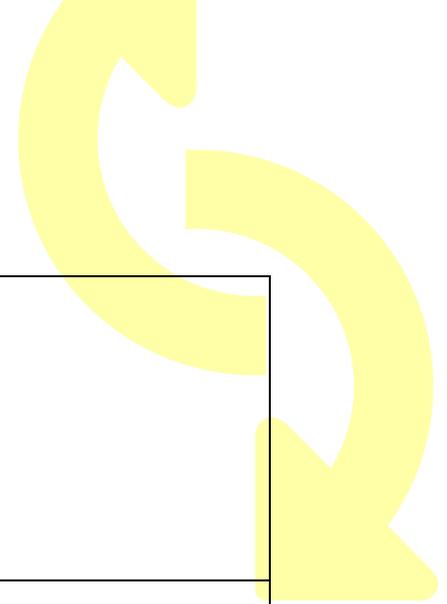
Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, 33(5), 308-320. doi:10.1080/21681015.2016.1172124

Sustainable finance lab, & the circle economy. (2018). *The Circular Phone. Legal, operational and financial solutions to unlock the potential of the ‘Fairphone-as-a-Service’ model*. Retrieved from <https://www.circle-economy.com/new-report-the-circular-phone/>



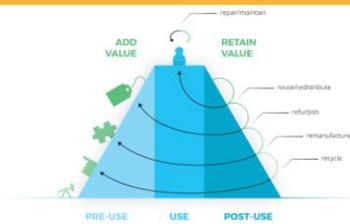
<p style="text-align: right;">SusMat Crit</p> <p>CIRCULAR BUSINESS MODELS</p> <hr/> <p>RUUD BALKENENDE & SONJA VAN DAM [DELFT UNIVERSITY OF TECHNOLOGY]</p> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	
<p>Learning objectives</p> <ul style="list-style-type: none"> You can explain how sustainability can be of strategic significance to companies You can identify different circular business models You can discuss the relevance of circular business models to critical raw materials You can select applicable circular business models for products containing a critical raw material to aid in their recovery <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> © Ruud Balkenende & Sonja van Dam, 2019 2</p>	
<p>Topics</p> <ul style="list-style-type: none"> Explain the relevance of sustainability for business strategies Explain business drivers to engage with sustainability circular economy principles: butterfly diagram, retaining value, slowing, closing & narrowing loops. Explaining potential circular business models and their applicability to critical raw materials <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> © Ruud Balkenende & Sonja van Dam, 2019 3</p>	
<p>Why do companies see sustainability as strategic?</p> <div style="border: 1px solid gray; padding: 10px; margin: 10px 0;"> <p>How can a business survive against its competition <u>over a long period of time?</u></p> <div style="background-color: #0070C0; color: white; padding: 5px; text-align: center; margin: 10px 0;"> <p>SUSTAINABLE COMPETITIVE ADVANTAGE:</p> </div> <p>Maintain and improve competitive position in the market. Maintain profits that exceed the industry average.</p> </div> <p style="font-size: 2em; margin-left: 20px;">?</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> © Ruud Balkenende & Sonja van Dam, 2019 4</p>	<p>What are direct business incentives?</p> <ul style="list-style-type: none"> Escalating concern of public and governments <ul style="list-style-type: none"> Climate change Pollution, food safety Depletion Environmental issues hit companies Increasing environmental pressure due to globalization Externalities (CO₂, H₂O) get important to investors Critical resources (geopolitical dimension)
<p>How are business strategy and sustainability linked?</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid #0070C0; padding: 10px; background-color: #D9E1F2; text-align: center;"> <p>Company focus Competitive</p> <p>Sustainable competitive advantage</p> <p>The ability of a business to survive against its competition over a long period of time.</p> <p>Strengths and weaknesses Opportunities and threats</p> </div> <div style="border: 1px solid #0070C0; padding: 10px; background-color: #D9E1F2; text-align: center;"> <p>Societal focus Collaborative</p> <p>Sustainability</p> <p>Environmental, ethical and social implications of products.</p> <p>Material chemistry, disassembly, recyclability... Fair trade, social responsibility...</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> © Ruud Balkenende & Sonja van Dam, 2019 5</p>	<p>Why is sustainability then strategic for companies?</p>

<p>Why do companies see sustainability as strategic?</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>© Roud Balkemende & Sonja van Dam, 2019</small></p>	<p>What are direct business incentives?</p> <ul style="list-style-type: none"> Escalating concern of public and governments <ul style="list-style-type: none"> Climate change Pollution, food safety Depletion Environmental issues hit companies Increasing environmental pressure due to globalization Externalities (CO₂, H₂O) get important to investors Critical resources (geopolitical dimension)
<p>Why do companies see sustainability as strategic?</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>© Roud Balkemende & Sonja van Dam, 2019</small></p>	<p>What are direct business incentives?</p> <ul style="list-style-type: none"> Escalating concern of public and governments <ul style="list-style-type: none"> Climate change Pollution, food safety Depletion Environmental issues hit companies Increasing environmental pressure due to globalization Externalities (CO₂, H₂O) get important to investors Critical resources (geopolitical dimension)
<p>Why do companies see sustainability as strategic?</p>  <p><small>http://stop-mad-mining.org/downloads/</small></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>© Roud Balkemende & Sonja van Dam, 2019</small></p>	<p>What are direct business incentives?</p> <ul style="list-style-type: none"> Escalating concern of public and governments <ul style="list-style-type: none"> Climate change Pollution, food safety Depletion Environmental issues hit companies Increasing environmental pressure due to globalization Externalities (CO₂, H₂O) get important to investors Critical resources (geopolitical dimension)
<p>Why do companies see sustainability as strategic?</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>© Roud Balkemende & Sonja van Dam, 2019</small></p>	<p>35 B\$ loss</p> <ul style="list-style-type: none"> Escalating concern of public and governments <ul style="list-style-type: none"> Climate change Pollution, food safety Depletion Environmental issues hit companies Increasing environmental pressure due to globalization Externalities (CO₂, H₂O) get important to investors Critical resources (geopolitical dimension)



<h3>Business drivers</h3> <ul style="list-style-type: none"> • Comply to legislation • Set (internal) sustainability targets • Risk management • Improve image • Explore new markets • Lower costs • Increase quality • Stimulate creativity • ... <p><small>© RawMaterials Academy, 2019</small></p>	
<h3>Sustainability: a business megatrend</h3> <ul style="list-style-type: none"> • Escalating concern of public and governments <ul style="list-style-type: none"> • Climate change • Pollution, food safety • Depletion • Environmental issues hit companies • Increasing environmental pressure due to globalization • Externalities (CO₂, H₂O) becoming important to investors • Critical resources (geopolitical dimension) <p>→ Inescapable strategic implications</p> <p><small>© RawMaterials Academy, 2019</small></p>	
<h3>Sustainability: opportunity and challenge</h3> <p>Sustainable metals management</p> <ul style="list-style-type: none"> • Recycling essential for sustainable production: <ul style="list-style-type: none"> • Complementing primary supply of metals • Geographic diversification (urban mines vs mining virgin materials) • Ecological benefits compared to virgin materials: less energy-, water- & land use • However: recycling rates not high enough for electronic products <ul style="list-style-type: none"> • Deficits in collection of e-waste • Low recycling quality • Poor monitoring of material flows <p><small>© RawMaterials Academy, 2019</small></p>	<p>For example Globally around 30 000 tonnes per annum of Cobalt are used for portable Batteries (e.g. in electronics, power tools, ...) with very low recycling rates → The amount of Cobalt would be sufficient for 3-4 Million EVs. (source: Umicore). State of the art concentration processes available but these are often not used.</p> <p>Recycling/reprocessing e-waste requires sophisticated processes & large investments - only becomes cost efficient when there is an economy of scale.</p>
<h3>The circular Economy</h3> <p><small>© RawMaterials Academy, 2019</small></p>	<p>What is the circular economy? An industrial system that is restorative by design and where products and materials retain value through the slowing closing and narrowing of resource flows. This can for example be done through maintenance, repair, reuse, remanufacturing and lastly recycling. The smallest loops are the most preferable because the most value is retained, as will be explained in the next slides,</p>
<h3>'Classic' business model</h3> <p><small>© RawMaterials Academy, 2019</small></p>	<p>In a classic business model value is added through the remanufacturing process, which is then destroyed in the post-use phase.</p>

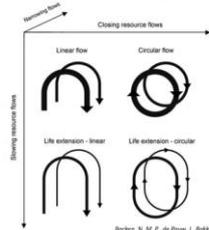
Circular business models



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. © Rood Ballenende & Sonja van Dam, 2019 15

With circular business model this value is retained through e.g. repair, reuse remanufacturing and recycling, where (nearly) all value is retained through repairs but a significant amount of value is lost through recycling because the product is reduced to its raw materials.

Slowing, closing, narrowing flows



Bocken, N. M. P., de Pauw, I., Baller, C., & van der Grinten, B. (2018) *J. of Ind. and Prod. Engineering*, 18(5). 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. © Rood Ballenende & Sonja van Dam, 2019 16

From article 'Product design and business model strategies for a circular economy' (Bocken et al.,):

- (1) Slowing resource loops: Through the design of long-life goods and product-life extension (i.e. service loops to extend a product's life, for instance through repair, remanufacturing), the utilization period of products is extended and/or intensified, resulting in a slowdown of the flow of resources.
- (2) Closing resource loops: Through recycling, the loop between post-use and production is closed, resulting in a circular flow of resources. These two approaches are distinct from a third approach toward reducing resource flows:
- (3) Resource efficiency or narrowing resource flows, aimed at using fewer resources per product.

Design strategies to slow loops

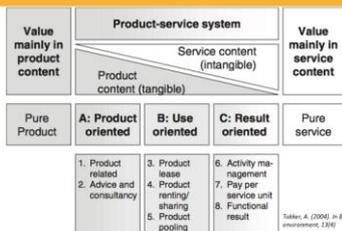
Designing long-life products

- Design for attachment and trust
- Design for reliability and durability
- Design for product-life extension
- Design for ease of maintenance and repair
- Design for upgradability and adaptability
- Design for standardization and compatibility
- Design for dis- and reassembly

Design strategies to close loops

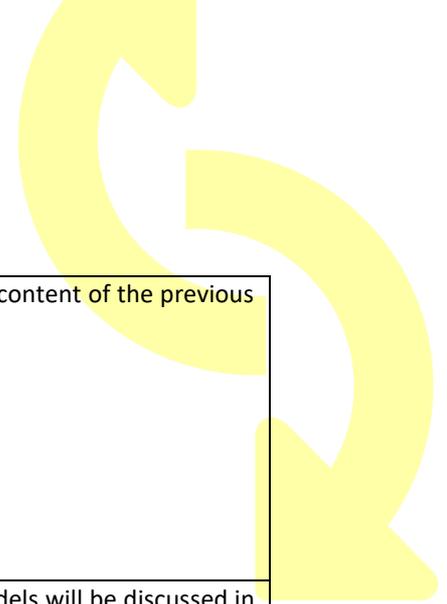
- Design for a technological cycle
- Design for a biological cycle
- Design for dis- and reassembly

Note: Design for dis- and reassembly fit both strategies for closing and slowing loops.



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. © Rood Ballenende & Sonja van Dam, 2019

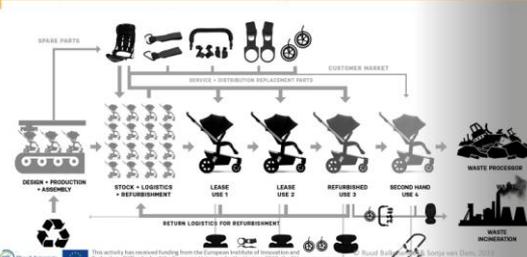
A key element in the development of circular business models is product-service systems because they can aid in the slowing, closing and narrowing of resource flows.



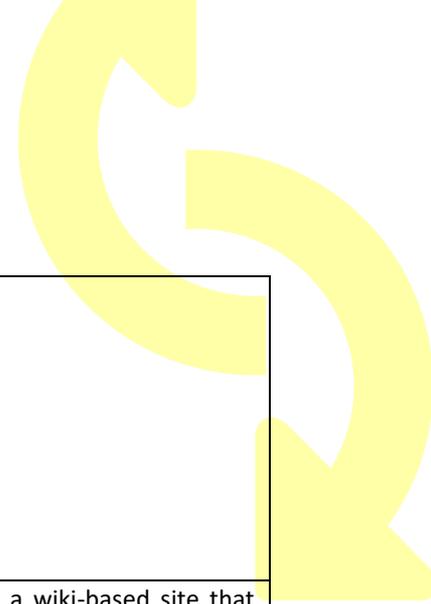
	<p>Narrowing in on the value content of the previous figure</p>
<p>Business models for a circular economy</p> <ul style="list-style-type: none"> • Classic long life model • Extending product value • Access model • Performance model • Gap exploiters 	<p>The following business models will be discussed in the next slides.</p>
<p>Classic long life model</p> <ul style="list-style-type: none"> • Primary revenue stream from sales of high-grade products with long useful life <p>→ product-oriented</p>	<p>The primary revenue stream for companies using a classic long life business model is from the sales of high-grade products with long useful life. Within the PSS framework/graph on pg 17/18 this model is product orientated and generally may contribute to slowing resource flows.</p>
<p>Classic long life model</p>	<p>Miele is a well-known brand that works with this classic long life business model by offering high-quality washing machines that are made to last.</p>
<p>Classic long life – What happens at end of life?</p>	<p>However, what happens to the critical raw materials in products at the end of life? How much of these materials are actually recovered?</p>

<p>Classic long life model</p> <ul style="list-style-type: none"> Which strategies could be applied in this model to recover products/parts containing critical raw materials? <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. © Ruud Balkenende & Sonja van Dam, 2019 23</small></p>	<p>Ask students to consider this question. Think of examples beforehand of potential strategies, e.g. agreements between manufacturers and recyclers to separate certain parts (to be remanufactured) or alloys (to keep pure and reuse directly for new parts), or use cashbacks (see example fairphone next page)</p>
<p>Fairphone</p> <p>Get cash back on your Fairphone 3 Recycle your previous phone with us</p> <p>When buying a new phone, more than 75% of people forget their previous phones in drawers and closets, never to be used again.*</p> <p>Lower your carbon footprint and reduce e-waste! We will give your phone a new life or recover the valuable materials inside for recycling.</p> <p>€30 for any other phone €40 for Fairphone 1 or 2</p> <p>https://www.fairphone.com/en/donut/</p> <p>A fairer phone With every phone we make, we're getting closer to a fairer and more sustainable electronics industry. From responsible material sourcing to supporting local workers, we think of our models, parts and software ecosystems for the entire industry.</p> <p>A fairer future It's not just us who will change the world. Patch one puzzle piece and the planet fits. We care about human rights and worker well-being. We consider the climate and our planet's delicate ecosystem. We care about designing longer-lasting products that are easier to repair. We care about reducing waste and making the most of what we already have.</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. © Ruud Balkenende & Sonja van Dam, 2019 24</small></p>	<p>Ethical branding Modular design Long-lasting phone</p>
<p>Extending product value</p> <ul style="list-style-type: none"> Exploiting residual value of products → product-oriented <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. © Ruud Balkenende & Sonja van Dam, 2019 25</small></p>	<p>With extending product value, the primary revenue streams for companies come from both the sales of high-grade products as well as exploiting the residual value the product, e.g. through in house remanufacturing and sales of remanufactured parts. Within the PSS framework/graph on pg 17/18 this model is product orientated and may (mostly) contribute to closing and narrowing of resource flows.</p>
<p>Caterpillar: remanufacturing</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. © Ruud Balkenende & Sonja van Dam, 2019</small></p>	<p>Caterpillar is and example of a company what remanufactures their own machinery and has direct profits from this, see next slide.</p>
<p>Caterpillar: remanufacturing</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. © Ruud Balkenende & Sonja van Dam, 2019</small></p>	<p>From https://www.caterpillar.com/en/company/brands/cat-reman.html Cat equipment and Cat Reman go hand-in-hand from the time you purchase your product through maintenance, repair, rebuild and overhaul.</p> <p>When you return your used Cat component to your dealer, Cat Reman salvages, reengineers and remanufactures it using state-of-the-art processes and technologies to recapture and renew its built-in quality and performance. Our broad portfolio of replacement parts, available from your Cat dealer, provide same-as-when-new performance and durability at a price</p>

	<p>that is an average of 40% less than an equivalent new part.</p> <p>Cat Reman parts are the dealer and customer choice for consistently high-quality, affordable, readily available replacement parts.</p> <p>WHY CAT REMAN</p> <p>We help you cut costs without cutting corners. Unlike regional competitors, Cat Reman parts are made from genuine Cat materials and are backed by the same warranty as new Cat parts. We offer more than 7600 Cat Reman products, all available off-the-shelf from your Cat dealer.</p>
<p>Extending product value</p> <ul style="list-style-type: none"> Which strategies could be applied in this model to recover/reuse products/parts containing critical raw materials? 	<p>Ask students to consider this question. Think of examples beforehand of potential strategies, e.g. design parts containing critical materials to be usable across product generations.</p>
<p>Access model</p> <ul style="list-style-type: none"> Primary revenue stream from payments for product access. <p>→ Use oriented</p>	<p>The primary revenue stream for companies using an access model is from payments by customers for product access. Within the PSS framework/graph on pg 17/18 this model is use orientated and may contribute to slowing loops (can be worthwhile for companies to invest in long-lasting products, use phase may be intensified through shared use) or closing loops (product ownership remains with company, which may make it easier to close the loop).</p>
<p>Sharing platforms - Greenwheels</p> 	<p>With Greenwheels, ownership remain with Greenwheels.</p>
<p>Sharing platforms - Snapp car</p> 	<p>Snappcar is an online sharing platform but cars are privately owned. Product use can be intensified but doesn't necessarily contribute to an extended lifetime.</p>

<p>Access model</p> <ul style="list-style-type: none"> Which strategies could be applied in this model to recover/reuse products/parts containing critical raw materials? 	<p>Ask students to consider this question. Think of examples beforehand of potential strategies, e.g. case bugaboo (next page)</p>
<p>lease, refurbish, reuse - Bugaboo</p> 	<p>Slowing and Closing loops Strollers have high secondhand value. By leasing, refurbishment and sales on secondhand market, this allows the manufacturer to tap into that value.</p>
<p>modular design - Bugaboo</p> 	<p>Modular design</p>
<p>Performance model</p> <ul style="list-style-type: none"> Primary revenue stream from payments for performance. <p>→ Result oriented</p>	<p>The primary revenue stream for companies using an access model is from payments by customers for performance. Within the PSS framework/graph on pg 17/18 this model is result orientated and may contribute to slowing loops (can be worthwhile for companies to invest in long-lasting products or intensified use phase) or closing loops (product ownership remains with company, which may make it easier to close the loop).</p>
<p>Laundry service</p> 	<p>A laundry service is a performance model: you pay for the performance of a clean laundry rather than the washing machine itself or access to a washing machine (e.g. pay per use).</p>

<p>Taxis</p>  <p><small>https://shuba.com/photos/taxi-should-also-3504032/</small> © Roud Balkenende & Sonja van Dam, 2019.</p>	<p>Likewise, a taxi service is also a performance model. You pay for the ride rather than the use of the car.</p>
<p>Performance model</p> <ul style="list-style-type: none"> Which strategies could be applied in this model to recover/reuse products/parts containing critical raw materials? <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> © Roud Balkenende & Sonja van Dam, 2019 38</p>	<p>Ask students to consider this question. Think of examples beforehand of potential strategies, e.g. within light as a service (next slide) Philips maintains ownership and designed the lamp so that the LED strip can specifically be replaced making it easier to recover the CRM.</p>
<p>light as a service - Philips</p>  <p>Customer "I'm not interested in the product, just the performance. I want to buy light, and nothing else." © Roud Balkenende & Sonja van Dam, 2019.</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>Light as a service - Philips</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> © Sonja van Dam, 2019</p>	<p>Closing loops, narrowing loops. Ownership remain with Philips. Incentive to adapt design to be able to quickly replace essential lighting part Means that LEDs that contains critical raw materials are collected separately with the potential for e.g. remanufacturing or extraction of CRM through recycling Also in their interest to prolong lifetime of product because of service design.</p>
<p>Gap exploiters</p> <ul style="list-style-type: none"> Exploit leftover value Make society more circular.... <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> © Roud Balkenende & Sonja van Dam, 2019 41</p>	<p>The primary revenue stream for gap exploiters is in filling a customer need that is not met by OEMS by exploit the leftover value of products.</p>



<p>Leapp – gap exploiter</p>  <p><small>The 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>Leapp refurbishes Apples</p>
<p>iFixit – gap exploiter</p>  <p><small>The 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>From the website: iFixit is a wiki-based site that teaches people how to fix almost anything. Anyone can create a repair manual for a device, and anyone can also edit the existing set of manuals to improve them. Our site empowers individuals to share their technical knowledge with the rest of the world.</p>
<p>Gap exploiters</p> <ul style="list-style-type: none"> Which strategies could be applied in this model to recover products/parts containing critical raw materials? <p><small>The 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>Ask students to consider this question. Think of examples beforehand of potential strategies, e.g. Cooperation with OEM to send broken parts back to them?</p>
<p>Choice circular business model</p> <p>Useful questions:</p> <ul style="list-style-type: none"> How could the product potentially be offered (selling, leasing, pay per use)? Do (critical) materials dissipate from the product during its lifetime? How long is the product used and reasons for disuse? How long do users need the function the product provides? Can the product be used again after its first use cycle? Is there is still market potential for the product after a first use cycle? Are parts of the product (containing CRM) still useful after a first use cycle and where can these parts be used in? <p>→ Can the answer to these questions be altered? To what effect? → Are loops for products/parts containing CRM closed, slowed or narrowed through this approach? http://rescomd58.eurostep.com/idealco/pathfinder/</p> <p><small>The 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>Useful questions when considering which business models and design strategy to apply to a product containing critical raw materials (CRM). Important to not take the outcome as a given but consider how you could change the outcome of the question.</p>
<p>References</p> <ul style="list-style-type: none"> Bocken, N. M. P., de Pauw, J., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. <i>Journal of Industrial and Production Engineering</i>, 33(5), 308-320. doi:10.1080/21681015.2016.1172124 Sustainable finance lab, & the circle economy. (2018). <i>The Circular Phone. Legal, operational and financial solutions to unlock the potential of the 'Fairphone-as-a-Service' model</i>. Retrieved from https://www.circle-economy.com/new-report-the-circular-phone/. <p><small>The 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>Reading materials for students.</p>



3 Exercises

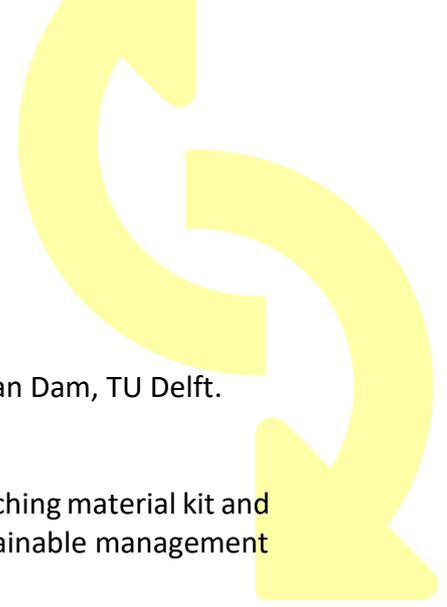
develop a circular business model for a product containing critical raw materials with the intent to increase the recovery of CRM.

Consider the following questions when developing the model:

- How could the product potentially be offered (selling, leasing, pay per use)?
- Do (critical) materials dissipate from the product during its lifetime?
- How long is the product used and reasons for disuse?
- How long do users need the function the product provides?
- Can the product be used again after it's first use cycle?
- Is there is still market potential for the product after a first use cycle?
- Are parts of the product (containing CRM) still useful after a first use cycle and where can these parts be used in?

→ **Can the answer to these questions be altered? To what effect?**

→ **Are loops for products/parts containing CRM closed, slowed or narrowed through this approach?**



4 Acknowledgements and Authors

This teaching material was prepared by Ruud Balkenende & Sonja van Dam, TU Delft.

The following authors have contributed to prepare the complete teaching material kit and intend to provide an overview of major topics surrounding the sustainable management of critical raw materials:

Ruud Balkenende, TU Delft
Stefano Cucurachi, Uni Leiden
Andrea Gassmann, Fraunhofer IWKS
James Goddin, Granta Design
Dominique Guyonnet, BRGM
Heinrich Hofmann, EPFL
Alessandra Hool, ESM Foundation
Amund Loevik, Empa
David Peck, TU Delft
Armin Reller, ESM Foundation
Antti Roine, Outotec
Dieuwertje Schrijvers, University of Bordeaux
Guido Sonnemann, University of Bordeaux
Layla van Ellen, TU Delft
Tatiana Vakhitova, Granta Design
Ester van der Voet, Uni Leiden
Patrick Wäger, Empa
Jan-Henk Welink, TU Delft
Steven Young, University of Waterloo

Besides, many others invested their time and expertise to discuss and review this teaching material. Many thanks to: Conny Bakker

5 Citation

Please cite the SusCritMat teaching material as follows when using them for your curriculum:

SusCritMat – Sustainable Management of Critical Raw Materials, funded by EIT RawMaterials, April 2017 – March 2020.

6 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/>.