EU-REI
Creating a Resource Efficient India

Resource Efficiency and Circular Economy in the Indian Context

Participants' Handbook

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B-5/1, Safdarjung Enclave
New Delhi 110029
T: +91 11 4949 5353
I: www.giz.de

Responsible:

Dr. Rachna Arora
E: rachna.arora@giz.de

Authors

adelphi
Hannak, Jürgen; Hemkhaus, Morton; Hibler, Sophia; Hack, Jana; Bauer, Tim; Kohler, Franziska

Project consortium lead and review

Gesellschaft für Internationale Zusammenarbeit (GIZ)

Mutz, Dieter; Rachna, Arora; Sinha, Pranav Chandan; Prakash, Reva

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Where to find what

Introduction

Welcome to this handbook on Resource Efficiency and Circular Economy (RE/CE) in the Indian context! If you access this handbook for the first time, please quickly read this section first before proceeding to the various modules.

How to Use this Handbook

This handbook serves as guidance document to the training programme on Circular Economy and Resource Efficiency in the Indian context. This training programme primarily targets central and state government officials from concerned ministries as well as selected representatives from training institutions, administrative training colleges, state authorities (including SPCBs, planning department, industry etc.), urban local bodies, civil society representatives and the private sector (including industrial associations).

Learning objectives

At the end of the training programme, you will be able to:

1. Relate to the objectives, importance and opportunities associated with the concepts of RE and CE in the context of the Indian Sustainable Consumption and Production (SCP) strategy;
2. Identify opportunities and implement activities within their scope of responsibility for RE and CE in relation to the four sectoral strategies; and
3. Apply a range of different tools, standards and indicators which support the decision making process for implementing RE and CE solutions.

Structure of the Handbook

The handbook is divided into two parts. Part 1 consists of the four modules including their submodules, which relate directly to the content of the modular training programme and aims to support participants in better following along or gaining additional knowledge. The numbering corresponds to the modules and sub-modules of the training programme. Each section is structured in form of a short topic-specific fact sheet that briefly describes the key messages of the respective module/sub-module and presents some of the key figures for your further and ready reference. At the end of each chapter, you will find a comprehensive list of links and references in case you are interested to deepen your understanding on specific topics. Part 2 provides handouts, templates and exercise sheets according to the four technical modules as well as the solutions to the respective exercises. In the back of the handbook, you will additionally find a glossary of highlighted terms and abbreviations used in the training toolkit.

PART 1

This part contains the basic modules 2 and 3 as well as the applied and advanced module 4, including seven sub-modules under the latter. Module 2 offers an overview of the core principles of RE and CE including an international as well as national perspective on the topic. Module 3 guides you through some of the sectoral strategies regarding RE/CE in India and beyond. In module 4, you will be introduced to important tools, standards and indicators in the RE/CE context. For each module, you will find an overview of the key topics as well as some learning objectives. This is followed by factsheets relating to the training programmes content. You will find the respective exercises of each module at the end of the factsheet. The sections are summarised again with take-home messages at the end of the factsheets as well as some recap questions you can ask yourself in order to check your own comprehension of the module. Finally, there is a list of references and additional reading material at the end of each module in case you would like to know more about a specific topic.

Basic modules

1	Introductory session
2	Foundations of RE and CE in the International Context
3	Towards RE and CE through Sectoral Strategies in India

Applied and advanced modules

4	Tools, Standards and Indicators for RE and CE	
	4a	Material Flow Analysis
	4b	Life Cycle Assessment
	4c	RE and CE Standards
	4d	RE and CE Indicators
	4e	Public Procurement
	4f	Circular Business Models
	4g	RE and CE Funding

Module 2: Foundations of RE and CE in the International Context

In this module, you will cover following topics:

- Introduction to lifecycle thinking
- Introduction to Resource Efficiency (RE) and Circular Economy (CE)
- Principles of circularity
- Conceptual considerations on RE and CE
- RE and CE in the international context.

At the end of this module, you will be able to:

- summarize the principles of lifecycle thinking;
- differentiate conceptual implications of RE and CE; and
- contextualise RE and CE to international debates.

Lifecycle Stages

Let us start with getting a common understanding about common terminologies, which you will come across in course of this training: **Lifecycle stages and impact categories.**

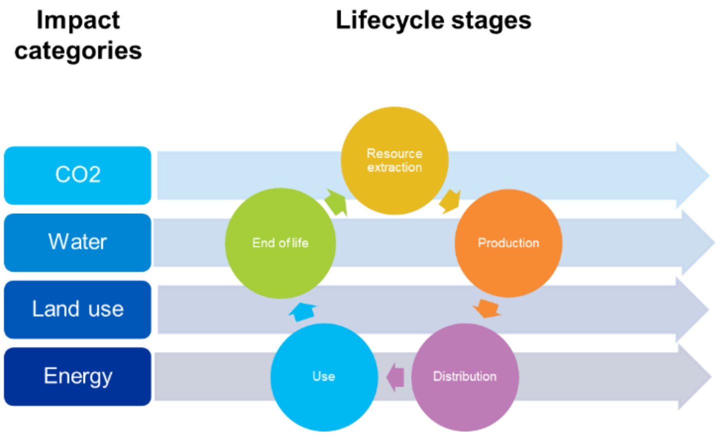


Figure 1: Lifecycle stages

Typically, the different stages of a product lifecycle can be divided into (1) the resource extraction phase, for example the mining or growing of raw materials required for the later production, (2) the production phase as such, (3) the distribution phase which may include the transport from a production site to a point-of-sale and retailing, (4) the use phase by the end-user, for example the buyer of vehicle or read-made garment, and (5) the end of life phase. Typically, the end-of-life phase includes dismantling, recycling, landfilling, conversion into energy (e.g. waste-to-energy) and/or other final disposal measures. At each of these stages, certain impact categories may incur. Commonly, these can include energy use, land use, water use and/or CO2 emissions.

Life-cycle Thinking and its Effects

Thinking in a lifecycle means looking at all stages of a product or service instead of only focusing on one or a few stages only. The application of the lifecycle thinking has several advantages. The thinking can contribute to a reduction in the use of resources that are required for a product. This in turn will contribute to a reduction of its impacts on the environment.

Figure 2: Three pillars of sustainability

By thinking in lifecycles, a product's socio-economic performance can be considered as well as improved. Extended lifecycle thinking may imply that one takes into consideration and analyses the different economic, social and environmental impacts. This thinking is not confined to the impact of the product as such but also takes into account the impacts within an organisation, a factory or from a brands perspective. This offers the potential to improve the product performance by increasing RE and can identify trade-offs (e.g. lower global greenhouse gas (GHG) emissions but higher land use requirements).

Thinking in lifecycles is an essential for the transition to a CE as well as performing Lifecycle Assessments, (LCA) which additionally helps to monitor a products or services sustainability performance. More about LCA will be discussed in module 4.

- Take ten Minutes to collect your own thoughts on RE/CE as part of the **Exercise 2.2**. You will find complementary documents in Part 2 on page 62.

Resource Efficiency

RE at its core is a simple input-output concept. Following this approach means achieving “more with less” by either minimising the required input at constant output or maximising the desired output at constant input. Sometimes referred to as resource productivity, RE can be understood as the ratio between a given result and the natural resources required for it. As such, it is a means to optimisation that concerns three dimensions of sustainability. The economic area can for instance benefit from RE through monetary savings, reduced price volatility and improved competitiveness. From a social perspective RE can help to mitigate displacement (e.g. by reducing land use requirements of deforestation), avoid social and political conflicts and create jobs. On the environmental side, ecological degradation can be mitigated by applying RE, energy can be saved and GHG emissions can be reduced.

Circular Economy

“A circular economy is a regenerative system in which resource input and waste, emission and energy leakages are minimized by reducing, closing and narrowing material and energy loops. This is achieved through long-lasting and environmentally sensitive design, requiring lean maintenance and promoting repair, refurbishing, reuse, remanufacturing and recycling.” [1]

- *RE & CE Status Paper, India*

The definition above taken from the RE & CE Status Paper India by Geissdorfer et al. (2017) is just one of many definitions that aim to describe the key features of CE. What many definitions have in common is a general concern about waste and the overconsumption of finite resources. According to this concept, CE products or services with a closed material cycle are thought from beginning to (new) beginning (from “cradle to cradle”), instead of a linear economy which typically follows a take-make-dispose perspective.

In contrast to CE, a linear economy is characterised by a high requirement for raw materials, a high consumption rate of products and a high generation of waste (by-)products. Whereas a linear system creates waste and contributes to down-cycling, aims for competition, adds value and focuses on standardization, a CE contributes to upcycling and seeks to keep the quality of raw materials as high as possible, aims for collaboration, shared value creation and local production.

As illustrated in Figure 3, products in a CE are either circulated in a biological or technical cycle, depending on their characteristics and components.

[1] Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J., 2017, p.7

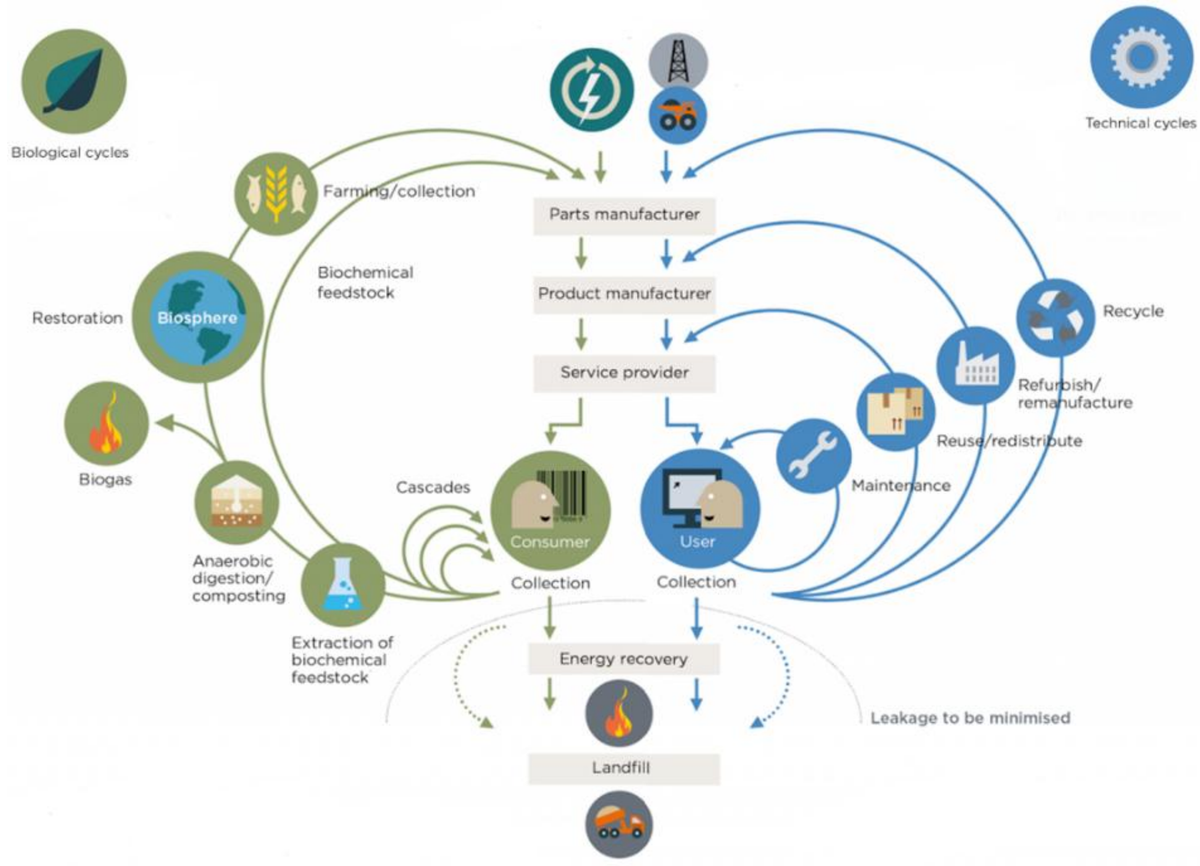


Figure 3: Two cycles in a CE

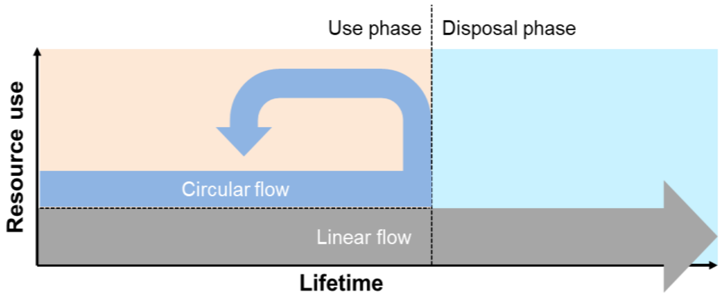
Source: https://www.ellenmacarthurfoundation.org/circular-economy/concept/infographic (adapted)

The foremost rule of the technical cycle is to maintain products and keep them in good condition as long as possible. Maintenance is followed by a hierarchy of actions to be taken by users that want to ensure the circularity of their product: reuse, refurbishment, remanufacturing. If a product loses its purpose for one user, it can still be reintroduced to the market in order to be redistributed to someone who can reuse the product. To keep up the quality, products might need refurbishment at times. Even if the functional quality of product cannot be maintained any longer, its components are still valuable and disassembly can enable the recovery of different usable parts for remanufacturing.

The biological cycle on the other hand begins with cascading, which refers to putting materials or components into different use after the end-of-life phase of a product across different value streams. Biochemical feedstock that cannot be cascaded is returned to the biosphere through biomass conversion, anaerobic digestion or composting. The biosphere finally restores valuable biological components in soil to make them available to plants and other organisms, which then links back to a new product cycle.

The three principles for circularity can be summarized as follows: 1) preserve and enhance natural capital by controlling finite stocks and balancing renewable flows; 2) optimise resource yields by circulating products, components, and materials at their highest utility at all times in both, technical and biological cycles; and 3) foster system effectiveness by revealing and designing out negative externalities.

Strategies in a Circular Economy



Circular strategies focus on the resources in well-defined use scenarios. These strategies aim at keeping resources and products at their highest value for as long as possible by managing resource use per unit of time. The key strategies are closing, slowing and shrinking

Figure 4: Preventing the disposal phase through circular flows

Source: https://discardstudies.com/2017/11/13/moving-the-circular-economy-beyond-alchemy/ (adapted)

loops.

By closing loops, the proportion of material captured before disposal in order to recirculate in technical or biological cycles is increased. For example, in the production of a mobile phone, the content of recycled material is increased. Slowing loops allows extending or intensifying the time materials spend in use before being recycled or disposed. Looking at the example of a mobile phone, loops would be slowed by keeping it is use for longer and thus reducing the overall material demand for mobile phones in the economy. Finally, shrinking loops aims to decrease the overall material use by doing more with less (e.g. increasing durability or resource efficiency in production). In the example case, this means the production of a mobile phone would be optimised to use fewer resources.

Conceptual Considerations on RE and CE

The concept of eco-efficiency and eco-effectiveness play a central role in distinguishing RE and CE. Eco-efficiency describes the relation between input and output (see definition of RE above). For instance, an optimised process leads to reduction in less toxic waste per product. Eco-effectiveness (in a CE) on the other hand describes the degree to which a goal has been achieved. Optimisation leads to the substitution of harmful substances and elimination of toxic waste on a product-level – but at times at the cost of efficiency. Ideally, a balance can be

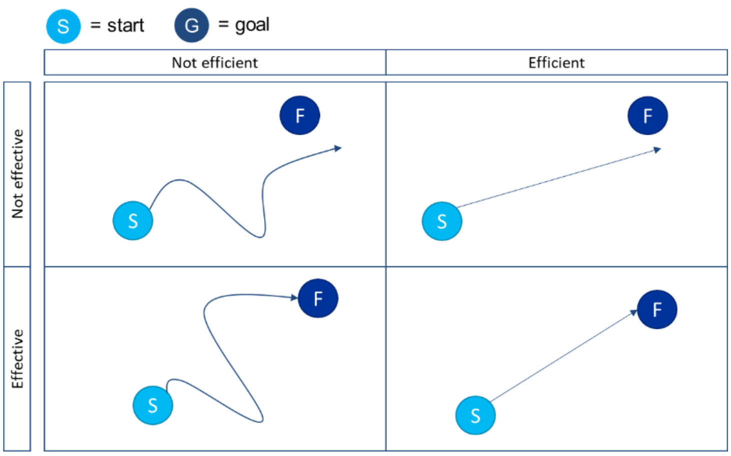


Figure 5: Combinations of Efficiency and Effectiveness

achieved to maximise both eco-efficiency as well as eco-effectiveness but often times we will encounter trade-offs. Yet, applying both RE (which optimizes system components) and CE (which fosters system effectiveness) can provide orientation in finding a balance. Even though the two concepts slightly differ in their goals, they are not opposing concepts but two sides of the same coin to promote optimal use of resources. Not only are the two of them normative concepts that seek to reduce the use of raw inputs by increasing material circulation and minimizing losses, but they also suggest maximising wealth and wellbeing within the limits of the natural environment.

- Take ten minutes to brainstorm about the following questions as part of **Exercise 2.3:**

  - What are the global environmental drivers that necessitate RE and CE?
  - What international/global initiatives are you familiar with?
  - To what extent do they relate to the concept of RE and CE?
  - How do India and other countries contribute to the fulfilment of these initiatives?

RE and CE in the International Context

Through the last decades, RE and CE have become essential parts of global multilateralism. There is also an urgent need for holistic interventions based on RE and CE in order to halt climate change and biodiversity loss. According to the Intergovernmental Panel on Climate Change (IPCC), human activities are estimated to have caused ~1.0°C of global warming above pre-industrial levels until today. Even more concerning, as can be seen in figure 6, is the rapid development of global warming in the foreseeable future which is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.

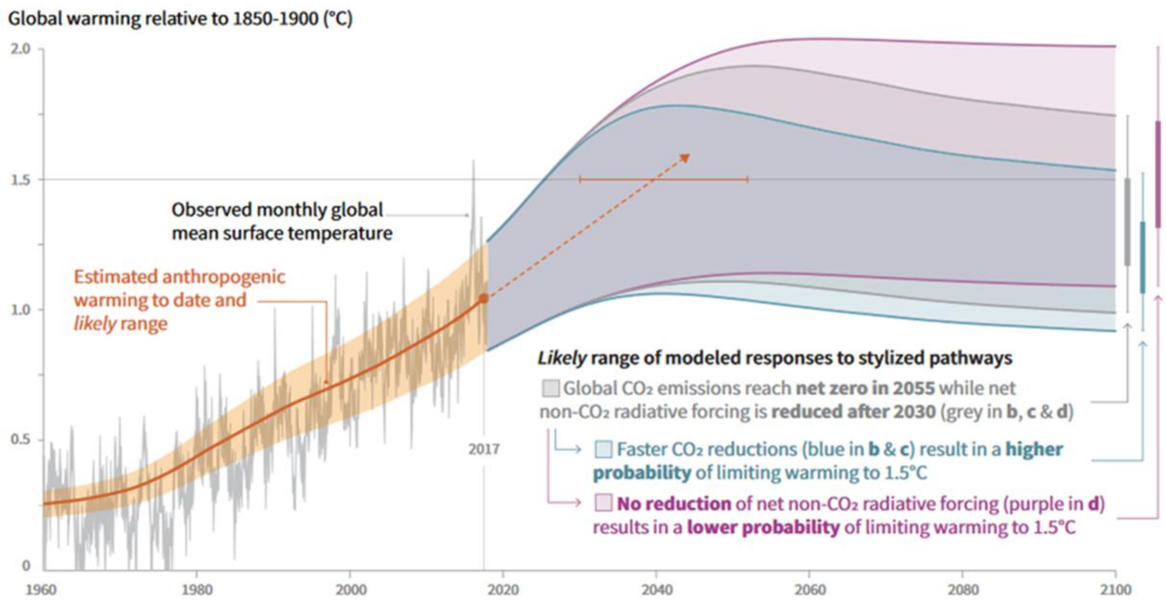


Figure 6: Global Warming developments according to the IPCC

Source: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf

Among the reasons for these developments are the ongoing and increasing rates of resource extraction as well as processing of materials, fuels and food. They contribute to about half of total GHG emissions and more than 90 percent of biodiversity loss and water stress. Global biodiversity and ecosystem functions and services are deteriorating at unprecedented speed and scale. To address these challenges, the international community has launched various initiatives. The central pillars of international collaborative engagement include the Agenda 2030, the Paris Agreement and the G20 Dialogue on Resource Efficiency:

- The G20 Resource Efficiency Dialogue was launched in 2017 during G20 Summit in Hamburg, Germany. It facilitates a dialogue between international organizations as well as with private companies and academia. The latest follow-up during G20 Osaka Summit (2019) calls for developing in a roadmap to “effectively promote, not to prescribe or restrict the future activities of the G20 Resource Efficiency Dialogue”.

- The Paris Agreement was initiated within the United Nations Framework Convention on Climate Change (UNFCCC) and signed by 195 UNFCCC member after a consensus was reached in 2015. According to the agreement, each country must determine, plan and regularly report on its contribution to mitigate global warming through Nationally Determined Contributions (NDCs).
- The Agenda 2030 has led to a collection of 17 global goals designed to be a "blueprint to achieve a better and more sustainable future for all“. Following this agenda, the Sustainable Development Goals (SDGs) were set in 2015 by the United Nations General Assembly and intended to be achieved by the year 2030.

In connection with the global dialogues, many countries have translated these goals and commitments into national policies, while also taking RE and CE into account. For instance, Germany introduced the Closed Substance Cycle Waste Management Act already in 1994, followed by Japan that brought the Basic Act for Establishing a Sound Material-Cycle Society into existence in 2000. China in 2009 for the first time introduced a law focused on CE with their Circular Economy Promotion Law. In 2015, the EU too has brought a Circular Economy Package on its way and currently, India is engaged in several programmes and initiatives for launching similar initiatives such as the National Resource Efficiency Policy.

Take-home messages

- Today‘s economy operates on a take-make-dispose basis, thus creating increasing amounts of waste.
- RE and CE are two sides of the same coin but ultimately seek to achieve the same goal: optimal use of resources.
- Lifecycle thinking is essential to achieve this goal and can identify opportunities and trade-offs in all lifecycle stages.
- RE and CE have become important pillars of multilateralism and contribute to the achievement of the SDG and the Paris Agreement.

Recap questions

- Can you give a brief definition and explanation of RE and CE?
- What is the difference between the concepts of (eco-) efficiency and (eco-) effectiveness and how to they relate to RE and CE respectively?
- What are the global environmental drivers necessitating a shift towards RE and CE?
- Which international collaborations and initiatives address circular economy and resource efficiency?

Useful Links and References: Module 2

- Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm?. *Journal of cleaner production*, *143*, 757-768.
- https://reset.org/knowledge/denken-kreislaeufen-die-circular-economy-als-schluessel-fuer-nachhaltiges-wirtschaften-072
- http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-globl-supply-chains/from-linear-to-circular-accelerating-a-proven-concept/
- https://www.ellenmacarthurfoundation.org/circular-economy/infographic
- https://www.ellenmacarthurfoundation.org/circular-economy/concept
- https://ec.europa.eu/environment/circular-economy/pdf/circular_economy_MoU_EN.pdf
- https://cdn.website-editor.net/1d19b3c8e4ec4cea997a5b973b37c28c/dms3rep/multi/tablet/Africa+Case+Study+Map+10.4.19.jpg
- https://www.resourceefficient.eu/sites/easme/files/Circular%20Policy%20Action%20Brief.pdf
- https://www.youtube.com/watch?v=4wQ2Jm6i9F0
- https://www.youtube.com/watch?v=zCRKvDyyHmI

Module 3: Towards RE and CE through Sectoral Strategies in India

In this module, you will cover following topics:

- Challenges and opportunities in of RE and CE India
- National progress on RE and CE
- Strategies on RE and CE across selected sectors in India.

At the end of this module, you will be able to:

- contextualize challenges and opportunities of RE and CE in India;
- outline the existing policy context along the entire lifecycle;
- capture the key elements of the RE strategy and four sectoral strategy papers; and
- map out the stakeholders involved in the implementation of sectoral strategies at the national level.

RE and CE: Challenges and Opportunities in India

With urbanization and industrialization as main drivers of resource consumption, India's middle-income class is growing steadily. As of 2019, the Indian population consisted of almost 1.4 billion people. According to latest projections, the country could overtake China and become the world's most populous country by 2027. Because rising income and economic growth has fuelled resource consumption, India experienced a six-fold increase in annual material consumption between 1970 and 2015, from 1.8 billion tonnes to 7 billion tonnes. Consequently, India's raw material demand can be expected to increase tenfold by 2050. Without further actions, resource scarcity may create shocks to the Indian economy.

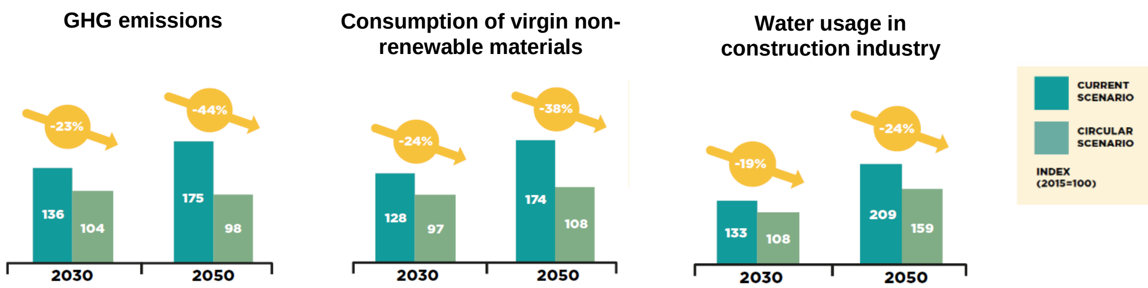


Figure 7: Future Scenarios of the development of three sustainability indicators in India

Source: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Circular-economy-in-India_5-Dec_2016.pdf

Potential impact scenarios with and without a transition to CE are illustrated above. Particularly affected sectors from the transition to CE to mitigate these impacts include: "mobility and vehicle manufacturing", "food and agriculture" and "cities and construction". Some of the environmental and social benefits of the implementing RE and CE India may include a decreased price structure of products and services for India's population while reducing congestion and pollution. Economic benefits on the other hand can include the potential to secure long-term material needs and increase resilience of Indian economy, enable material cost savings of businesses while increasing their profit, making use of digital technology and reinforcing India's position as an innovation hub with an annual value creation potential of ₹ 14 lakh crore (US$ 218 billion) in 2030. As an example, new revenue streams can be achieved for the automotive industry by increasing a cars utility. This can imply using cars more intensively or applying innovative vehicle design, which allows easier maintenance and boosted fuel efficiency.

During the implementation of CE or RE it is important to determine priority materials. According to the EU, critical raw materials are raw materials that are economically and strategically important for the European economy, but have a high risk associated with their supply. These materials are characterized by economic importance, supply chain disruptions, price volatility, and environmental issues.

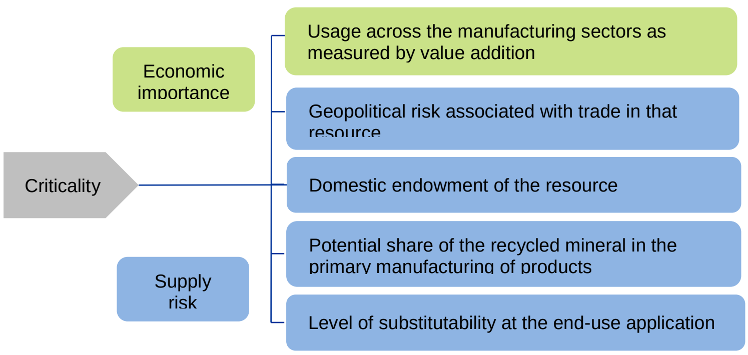


Figure 8: Determining the criticality of resources

As per the Indian RE strategy, some of the prioritized parameters of critical materials are the economic importance based on its usage across different sectors, the environmental impact due to extraction as well as production and embodied energy. Supply risks according to this understanding is determined through limited geological availability and criticality, high import dependency for critical resources and geopolitical constraints. Although 97% of India's resources are produced domestically, it is highly dependent on the import of some critical raw materials. Even if a mineral is used in small quantities in a high value-added manufacturing sector, it can be more critical as compared to a mineral used in large quantities in a low value-added manufacturing sector.

National progress on RE and CE

Globally, the "big five" material consuming countries – China, the United States, India, Brazil and Russia – are responsible for 55% of total material requirement. In the figure below, country size is illustrated proportionally to its share in global material consumption. This goes to say that countries must reduce both absolute consumption and per capita consumption in order to move towards a sustainable development path.

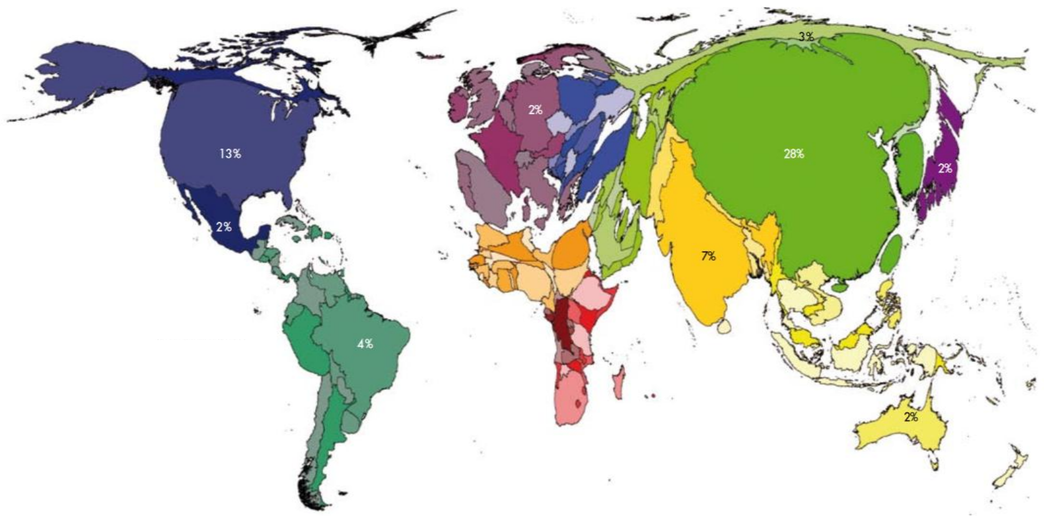


Figure 9: Level of consumption of countries around the world illustrated as inflated geographical land size

Source:https://www.boell.de/sites/default/files/201207_green_economies_around_the_world.pdf

For more information on per capita consumption, you can find out what your personal Ecological Footprint is, by using the footprint calculator: https://www.footprintcalculator.org/

Despite India making progress in its performance on the SDGs, there is an acute lack of data specifically on SDG 12, which concerns sustainable consumption and production processes. To address this data gap is one of the objectives of the intervention and support by the EU-REI project.

Current policies and legislations in India also seek to create change across various lifecycle stages. Concerning the stage of resource extraction, India has introduced many new policies that covered the development of CE or RE concepts. The National Mining Policy of 2008 for instance aims to upgrade mining technology for achieving a more efficient extraction process and points towards zero-waste mining. It was renewed with a new draft in 2018. The Steel Policy of 2017 seeks to achieve higher efficiency to reduce environmental impacts.

Concerning design policies, the National Housing and Habitat Policy came into action in 2007, which strives to achieve ecological design standards for building components, materials and construction methods. The National Design Policy of the same year defined eco-friendliness, ecology and sustainability as key criteria for the India Design Mark (I Mark). Finally, the E-Waste (Management and Handling) Rules were introduced in 2016 in order to restrict the usage of certain hazardous substances in electrical and electronic equipment. They specifically restrict the same six substances at the same maximum concentrations as in the EU, however the scope of products differ. The certification Ecomark is issued by the Bureau of Indian Standards since 1991 and is important in the considerations of the product design stage.

For the production and manufacturing stage the National Manufacturing Policy, which came into action in 2012, pushed the use of clean and efficient technology whereas “Make in India” two years later encouraged higher energy and water efficiency and pollution control technologies through Technology Acquisition and Development Fund (TADF).

Looking at the consumption stage, no comprehensive legislation for (green) public procurement has been brought on its way so far in India. However, the principles are guided by other central legislations, such as the Contract Act of 1872, the Sale of Goods Act of 1930, the Prevention of Corruption Act of 1988 and the Arbitration and Conciliation Act of 1996. In 2018, a Task Force on Sustainable Public Procurement was set up in addition by the Ministry of Finance.

For the end-of-life stage, an overarching programme for sanitation and waste management was established under the name Clean India Mission (Swachh Bharat). Further legislations exist to protect the environment, human health and ensuring sound management of waste streams through Extended Producer Responsibility (EPR). These include the Solid Waste Management Rules (2016), the E-waste Management & Handling Rules (2016), the Plastic Waste Management Rules (2016), the Batteries (Management and Handling) Rules (2001) including their subsequent amendments. Other legislations include the Construction and Demolition Waste Management and Handling Rules (2016) and the Steel Scrap Recycling Policy (2019) which, however, are not based on EPR.

Strategies on RE and CE across selected sectors in India

Various RE and CE related strategies addressing issues in many industries helped to establish a broad framework for enhancing RE in the Indian economy such as the Strategy for Resource Efficiency by NITI Aayog (2017). Its key recommendations addressing all lifecycle stages as well as crosscutting issues were threefold. First the promotion of eco-labelling, standards, technology development, green public procurement, industrial clusters, awareness, second the regulation of economic instruments, viability gap funding, policy reforms across lifecycle stages and thirdly institutional development, including capacity development, institutional set-up and strengthening, database and indicators, resource index as a part of an economic survey. Beyond this strategy of 2017, the National Institution for Transforming India (NITI Aayog) and Ministry of Steel (Mo/Steel), Ministry of Mines (Mo/Mines), Ministry of Housing and Urban Affairs (MoHUA), Ministry of Electronics and Information Technology (MEITY) furthermore released a Strategy on RE for the Steel Sector, the Aluminium Sector, the EEE Sector and the C&D Sector.

- Watch the video on Resource efficiency as part of the **Exercise 3.2**. You will find the link and complementary documents in Part 2 on page 63.

- Try to identify some of the stakeholders that have played or you expect to play a role in India’s Resource Efficiency Policy in **Exercise 3.2**. Find the according documents on page 64.

    - All actors that are affected by the policy or have a potential stake in the action to be brought about by the policy are considered to be stakeholders. While doing this, try to also distinguish three stakeholder groups. First, primary actors are directly affected by the policy (i.e. will gain or lose power, privileges, etc. due to the implementation of the policy). In contrast, the involvement of secondary actors is only temporary or indirect. Finally, the veto players are actors without whose support and participation the targeted result cannot be achieved.

Take-home messages:

- India's growing middle-income class, urbanization and industrialization are major drivers of resource consumption.
- Although most resources are extracted domestically, India remains highly dependent on critical raw materials, which are important for its long-term development.
- India has made important progress in moving towards the sustainable development quadrant by releasing overarching and sectoral strategies on RE and CE.
- However, most strategies are yet to be implemented; this will require concerted efforts from various stakeholders in order to be successful.

Recap questions

- What challenges regarding resource use is India facing currently?
- What benefits can a circular economy have for India?
- Can you name Indian policies and/or legislations that seek to create change in resource use?
- What lifecycle stage do these policies/legislations address?

Useful links and References: Module 3

- https://www.footprintnetwork.org/2015/09/23/eight-countries-meet-two-key-conditions-sustainable-development-united-nations-adopts-sustainable-development-goals/
- https://www.asef.org/images/docs/SustainableDevelopmentGoalsandIndicatorsSmallPlanetPart1.pdf
- https://s3.amazonaws.com/sustainabledevelopment.report/2019/2019_sustainable_development_report.pdf
- http://www.eu-rei.com/pdf/publication/Strategy%20on%20Resource%20Efficiency.pdf
- http://www.eu-rei.com/pdf/publication/Enhancing%20Resource%20Efficiency%20through%20Extended%20Producer%20Responsibility.pdf
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- http://www.eu-rei.com/pdf/publication/NA_EU_Status%20Paper%20&%20Way%20Forward_Jan%202019.pdf
- http://www.eu-rei.com/pdf/publication/NA_MoHUA_Strategy%20on%20RE%20in%20C&D%20Sector_Jan%202019.pdf
- http://www.eu-rei.com/pdf/publication/NA_MeitY_RE%20Strategy%20in%20EEE%20Sector_Jan%202019.pdf
- https://www.eu-rei.com/pdf/publication/NA_MoS_Strategy%20on%20RE%20in%20Steel%20Sector_Jan%202019.pdf http://www.eu-rei.com/pdf/publication/NA_MoM_Strategy%20on%20RE%20in%20Aluminium%20Sector_Jan%202019.pdf
- http://www.eu-rei.com/pdf/publication/NA_EU_Status%20Paper%20&%20Way%20Forward_Jan%202019.pdf
- https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Circular-economy-in-India_5-Dec_2016.pdf
- https://www2.mmu.ac.uk/media/mmuacuk/content/documents/bit/Stakeholder-analysis-toolkit-v3.pdf
- https://www.youtube.com/watch?v=gqhJ4IUhhak&list=PL6AbG-hNM5ylx6AxlxOQhT1YlGB2lXpFL&index=5

Module 4: Tools, standards and indicators for RE and CE

This “Applied and Advanced” module 4 contains the following six sub-modules:

a) Material Flow Analysis
b) Life Cycle Analysis
c) RE and CE Standards
d) RE and CE Indicators
e) Public Procurement
f) Circular Business Models
g) RE and CE Funding.

Each of these chapters provides you with tools or information on relevant standards, indicators or concepts that surround RE and CE. The sub-modules might be specifically useful for entrepreneurs in the field who wish to develop their idea around RE/CE as well as individuals that want to become frontrunners in this area.

This training toolkit is modular, which means that not all of these sub-modules are also necessarily part of your training programme. You can selectively follow only the modules, which are part of your training or read also through modules, which are not covered in order to dive deeper into the topic.

Applied and advanced modules

4	Tools, standards and indicators for RE and CE	
	4a	Material Flow Analysis
	4b	Life Cycle Assessment
	4c	RE and CE Standards
	4d	RE and CE Indicators
	4e	Public Procurement
	4f	Circular Business Models
	4g	RE and CE Funding

Sub-module 4a: Material Flow Analysis

In this module, you will cover the following topics:

- Material Flow Analysis (MFA)
- Types of MFAs
- Steps in MFAs.

At the end of this module, you will be able to:

- relate to salient features of MFA as a decision-making support tools;
- define the steps of MFA; and
- describe and illustrate techniques of analysing and documenting material flows.

Material Flow Analysis

Material Flow Analysis (MFA) is a systematic assessment of the flows and stocks of materials within a system defined in space and time. Flows in any system are thereby based on the law of conservation of matter, thus balancing all inputs and outputs or process over a given timeframe. An MFA analyses the system to make a flow visible, identifies the allocation, the interactions and the stock of resources.

The boundaries of a system can be globally or nation-wide, or at city-level or even on industry or company level. The flows to be analysed can cover for instance products and goods, emissions, agricultural products, waste and effluents as well as primary natural resources such as water, minerals or timber.

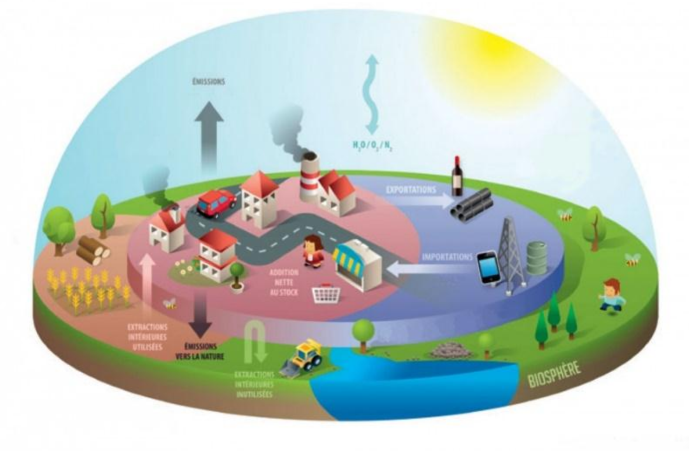


Figure 10: Different materials flows in a closed system

Source: https://sofiesgroup.com/wp-content/uploads/2016/04/MFA_Alsace_MetabolismeTerritoire-900x600.jpg

The objectives of an MFA are to reduce the complexity of systems, quantitatively assess relevant flows and stocks, check mass balances, sensitivities and uncertainties as well as to provide a basis for decision making. This kind of systemic assessment can be performed with five main steps: firstly, the identification of relevant material flows; secondly system analysis; thirdly the quantification of mass flows of matter and indicator substances; and fourthly the identification of weak points and finally the development and evaluation of scenarios, interpretation of the results.

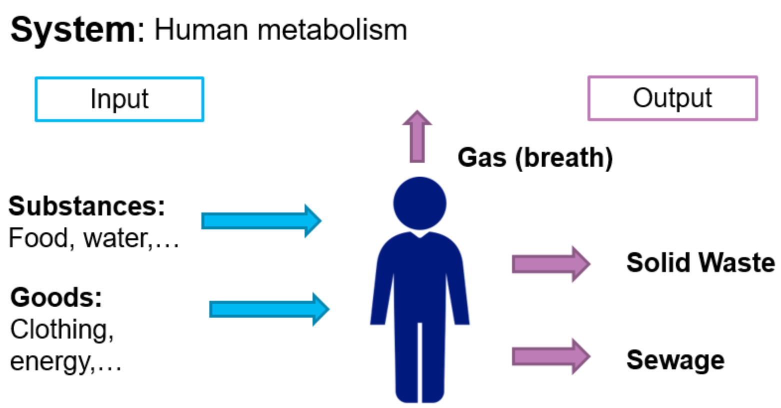


Figure 11: The human metabolism as a system with various input and output flows

The terminology of an MFA can best be described along the lines of an exemplary system such as the human metabolism system as illustrated in Figure 11. Materials are made of substances and goods either as individual or aggregated elements. A substance is a single type of matter (elements, compounds). Goods refer to mixtures of substances that have market value (including energy and services).

A system describes a set of material flows, stocks, and processes within a defined boundary. A process is happening if material is transported, transforms or is stored. If material is stored in reservoirs within the system this amount is called stocks. A flow is the mass per time, while fluxes are the masses per time and cross section. Input and output, finally, are the flows or fluxes across the process boundaries.

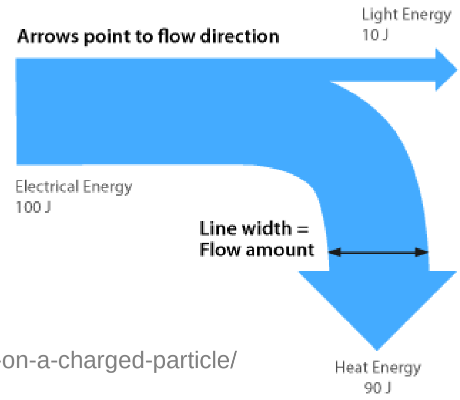


Figure 12: Sankey diagram

Source:https://educatingphysics.com/gcse/electricity/work-done-on-a-charged-particle/

MFA: Types and Steps

A Sankey diagram as shown in Figure 12 is one popular way of visualising MFAs. The diagram displays flow and their quantities in proportion to one another. The width of arrows or lines thereby indicate the magnitude of the flow. Colours can then be used to show a transition from one state of the process to another.

There are descriptive types of MFAs, which quantify material flows in a specific system in order to characterize the throughput of materials. An example of a descriptive MFA would be an economy-level Material Flow Analysis (MFA). In contrast, an exploratory MFA provides an understanding of processes governing material flows to investigate management options. An example of an exploratory MFA would be business-level Material Flow Cost Accounting (MFCA).

- Use the exercise sheet on page 68 to take the **Exercise 4a.1** and if possible, discuss the cloze text afterwards with your group

- Define steps for an MFA in the case study of **Exercise 4a.2.** Use the complementary documents on page 69.

Whereas some types of MFA aim for completeness, other types aim for depth and detail. An economy-level MFA for instance tries to draw a possibly complete picture and covers systems at a larger level (for instance a country). A product level MFA on the other hand looks at specific components on a smaller scale, while going into detail. System level MFAs, which cover whole sectors or industrial parks as analysed systems and business-level MFAs, which analyse factories or processes are aiming for a balance between completeness and detail.

Four steps are central to perform an MFA. The first step defines the problem to be solved by performing an MFA. Secondly, the system is defined, by determining the system boundaries, selecting the relevant processes and selecting the goods and substances that are relevant to observe in an MFA. Thirdly, the specific material flows are defined as well as stocks. To do so, input data such as flows and stocks of goods over time, associated costs, substance concentrations, characterization of uncertainties and the transfer coefficient need to be collected. At the same time, the third step requires the balancing of material by performing consistency checks, calculation of unknown quantities or an uncertainty propagation. The information gained in the third step might lead to a redetermination of the system in the second step. The final step aims to interpret and illustrated the material flow, however before finishing the MFA, the problem might require redefinition of the problem as well as an adjustment of the defined system.

Among the benefits of an MFA are the reduced complexity of comprehensive systems, the good overview of input-output flows cross systems it provides, the optimization potentials and supports for decision-making it helps to identify and the attention it brings to some of the neglected flows due to its balance principle. On the disadvantageous side however, it should be noted that MFAs do not avoid sub-optimisation due to trade-offs, it requires large amounts of data and collection may be time consuming as well as resource-intensive and finally the quality of an analysis largely relies on the reliability of the data.

- Quantify and visualize the material flows of a coffee machine in **Exercise 4a.3.** For complementary documents go to page 72.

Take-home messages

- MFAs are useful tools when analysing specific cases with regards to RE and CE
- MFA requires large amounts of high-quality data
- Although RE and CE are often portrayed as win-win solutions, MFAs often reveal how solutions can create adverse impacts across lifecycle stages

Recap questions

- In your own words – what is a Material Flow Analysis?
- What are applications where you could apply the concept of an MFA?
- Which are the benefits that you would gain from an MFA?

Useful Links and References: Module 4a

- https://seea.un.org/sites/seea.un.org/files/global_material_flow_accounting_manual_final_draft.pdf
- https://publik.tuwien.ac.at/files/PubDat_188894.pdf
- https://www.oecd.org/environment/indicators-modelling-outlooks/MFA-Guide.pdf
- https://iges.or.jp/en/publication_documents/pub/issue/en/3891/3RFS_010_web.pdf
- https://thecitywasteproject.files.wordpress.com/2013/03/practical_handbook-of-material-flow-analysis.pdf
- https://ocw.mit.edu/courses/engineering-systems-division/esd-123j-systems-perspectives-on-industrial-ecology-spring-2006/lecture-notes/lec14.pdf

Sub-module 4b: Life Cycle Assessment

In this module, you will cover the following topics:

- Lifecycle Assessment (LCA)
- Types of LCAs
- Defining steps in LCAs.

At the end of this module, you will be able to:

- relate to the concept and terminology of life cycle assessments (LCA);
- define the steps of a life cycle assessment; and
- interpret the results of life cycle assessments.

Lifecycle Assessments

A lifecycle assessment (LCA) is a framework for assessing the environmental impacts of product systems and decisions from raw material acquisition through the end of life.

The application of LCAs requires on the one hand tools (software for instance Umberto, GaBi, SimaPro and openLCA) and datasets (e.g. GaBi, Ecoinvent, ProBas, ELCD). The application can be guided by „ISO14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines".

There exist a variety of different LCA, which can be distinguished in singular, comparative, attributional and consequential LCAs. A singular LCA analyses the environmental impacts of a single product over all lifecycle stages, whereas a comparative LCA compares the environmental impacts of different products across all stages. An attributional LCA describes the environmentally relevant physical flows to and from a lifecycle system embedded into a static background system, meanwhile a consequential LCA describes how environmentally relevant physical flows will change in response to possible decisions in the analysed lifecycle.

Singular Analyses the environmental impacts of a single product over all lifecycle stages	**Comparative** Compares the environmental impacts of different products across all stages
Attributional Describes the environmentally relevant physical flows to and from a lifecycle system embedded into a static background system	**Consequential** Describes how environmentally relevant physical flows will change in response to possible decisions in the analysed life cycle

Figure 13: Types of LCAs

In the example of a light bulb, a singular approach would for instance analyse the greenhouse gas emissions of an LED light bulb, while with the comparative type the LEDs GHG emissions would be compared to that of an incandescent light bulb. Following the attributional type would pose the question: how much GHG could be avoided by switching from incandescent to LED light bulbs, whereas the consequential type would analyse how much GHG could be avoided by switching in the context of a dynamic system (e.g. A/C).

Performing an LCA requires an understanding of the terminology of the different analysis components. The term functional unit is used to describe how the qualitative and quantitative aspects of the function(s) are normalized in order to allow for comparisons (e.g. drying hands on a daily basis for three years). A system boundary refers to a separation of the analysed system from the background system. Cradle describes the birthplace of a product (e.g. raw material extraction), gate the point of the production process (e.g. the factory gate) and the grave means the end of life (e.g. landfill).

An LCA can be performed along the lines of four main steps. The first step defines the goals as well as scope of the planned analysis. In this step, the purpose and context of the assessment needs to be clarified. Moreover, product, process and activity including the functional unit are defines as well as described. Then, boundaries are identified together with assessing impact categories. A lifecycle inventory analysis is performed during step two of the LCA. This requires the identification as well as quantification of system flows for instance the energy, water and materials usage and emissions of a product. In the third step, a lifecycle impact assessment is performed, where the impact flows for instance on humans and the environment are assessed. The calculation of a global warming potential is an example of such assessment. The fourth and final step of an LCA comprises the interpretation of results. At first, the results of the inventory analysis (step two above) and impact assessment (step three above) are evaluated through a sensitivity analysis and consistency checks. Then uncertainties and assumptions need to be taken into account, finally preferred products, processes and services can be identified, selected and recommended.

- Define steps for an LCA to compare two mobile phones as part of **Exercise 4b.1.** Complementary documents can be found on page 81.

An LCA is particularly useful as it provides quantitative measurements of a product's potential impacts, it allows for an easy identification of most impactful lifecycle stages, it can capture a wide range of different impacts (GWP, HumToxCan, ODP etc.) and represents a standardized process in accordance with ISO14044 which creates maximum transparency and reproducibility.

On the other hand, it needs to be taken into consideration that (i) an LCA is both resource and time consuming (it is sometimes referred to as a „heavy canon“), (ii) the definition of the scope substantially impacts the quality of the LCA and (iii) it is furthermore dependent on consistent, high quality data, which at times is expensive and often based on fast changing innovation cycles (during the emergence of new technologies). As such, LCAs can become outdated rather quickly.

- Use the provided exercise sheets on page 83 to understand the lifecycle of insulation materials. Take into consideration that the **Exercise 4b.2** consists of two parts and takes around 50 min to complete.

Take-home messages

- LCAs are useful tools for modelling impacts/material flows across products and systems, but require large amounts of data
- LCAs are useful tools when analysing specific cases with regards to RE and CE
- Lifecycle stages and impact categories are to be analysed individually and in comparison to each other to get the full pictures of a products impact

Recap questions to ask yourself:

- Give a brief summary in your own words - what is the goal of a lifecycle assessment?
- What are product groups for which the application of an LCA would make most sense to you?
- What are some of the benefits of applying an LCA?

- What are the four steps of a Lifecycle Assessment?

Useful Links and References: Module 4b

- https://cpcb.nic.in/uploads/plasticwaste/LCA_Report_15.05.2018.pdf
- Video: https://www.youtube.com/watch?v=BiSYoeqb_VY
- Finkbeiner, M. (2016). Introducing "Special types of life cycle assessment". In *Special Types of Life Cycle Assessment* (pp. 1-9). Springer, Dordrecht. https://www.springer.com/de/book/9789401776080
- https://link.springer.com/chapter/10.1007/978-94-017-7610-3_2
- https://www.claybrick.org.za/sites/default/files/downloads/SF05%20Clean-Firing%20%28Habla%29.pdf
- https://www.researchgate.net/publication/247152335_Comparative_life_cycle_assessment_of_three_insulation_materials_stone_wool_flax_and_paper_wool
- https://www.lifecycleinitiative.org/wp-content/uploads/2019/03/unep_nairobi_V7-LR.pdf
- http://www.ficci.in/spdocument/20426/IndiaLCADirectory.pdf

Sub-module 4c: RE and CE Standards

In this module, you will cover the following topics:

- Standards
- Standardisation bodies
- Sectoral standards
- Standards and the environment
- Standards on RE and CE.

At the end of this module, you will be able to:

- relate to the relevance of standards, their disadvantages and benefits and to their role within sectoral strategies;
- outline levels on which standardization takes place in India and at international level; and
- understand opportunities for lifecycle considerations when developing standards.

Standards

Standards are an integral to modern day life. They can be defined as documents, established by consensus and approved by a recognized body that provide, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.

The EU distinguishes four major categories of standards. First, the fundamental category which standardizes terminology, conventions, signs or symbols. The second category concerns test methods and analytical method. Specifications for products, services, systems and performance constitute the third category, which is particularly relevant in the context of this module. The fourth category covers organization and management system standards.

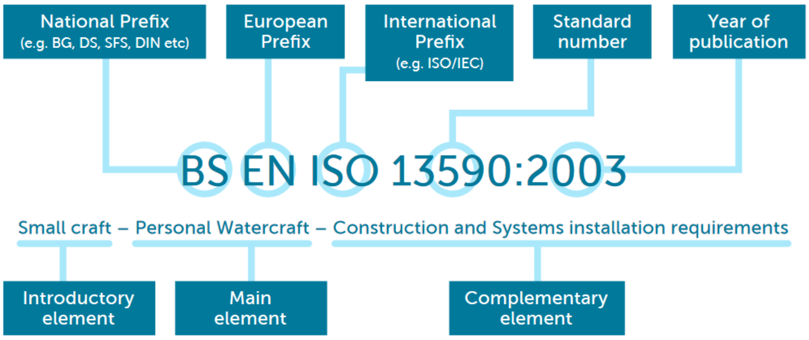


Figure 14: Nomenclature of standards

Source:https://www.ds.dk/~/media/DS/Files/Downloads/Uni/A-World-Built-on-Standards.pdf

Standards are usually developed in a five-step process. The development process begins with the proposal of a standard and its approval, then the stage of drafting and commenting on the specifications, which can take several rounds. The third step requires a public consultation and vote, followed possibly by the formal vote of a draft before the standard is finally published.

International and European standards follow a standardized nomenclature for easy identification. The components of this nomenclature are explained in Figure 14 above.

- Collect some of your thoughts on standards and discuss the general advantages and disadvantages of standards you can think of as part of **Exercise 4c.1** using the complementary documents on page 93.

- Take **Exercise 4c.2** by filling in the Environmental Checklist provided on page 94.

Standards are often economically beneficial but also offer advantages to nature and society. One of the main benefits of standardised production is that it enables economies of scale, which refers to reduced costs per product. At the same time, the standards ensure continuous high quality of products and services, a value highly appreciated by consumers. Based on this, products can be developed towards an optimum performance by experts and practitioners who can capture and built on knowledge and lessons learnt. Based on agreed standards, uniform products can then be sold on the global market. In the course of global trade, standards are able to ensure product safety and thus protection of nature and consumers. Finally, standardisation incorporates a gateway function by indicating compliance and good practice.

On the other hand, however, the uniqueness of products and services can be comprised by the introduction of standards. In addition, over-regulated technical aspects in the production or product development process can possibly lead to additional costs for manufacturers. The instalment of verification processes for testing the compliance with standards moreover requires a functioning eco-system and requires monetary resources. Due to their often technical nature and bulky language standards can be difficult to understand for laymen and put them into disadvantageous positions. In this regard, the introduction of standards can also mean possible market barriers and restriction of free trade of goods and services. Finally,

Standardisation bodies

A variety of standardisation bodies exist on a national, regional and global level. The official Indian standardisation body is the Bureau of Indian Standards (BIS). The most relevant regional standardisation body for India is the South Asian Regional Standards Organization (SARSO). On a global scale, International Standards Organization (ISO) can be considered the most important. However, standards are also developed in other types of institutions such as industrial consortia, Branches of business organizations or companies, Professional associations, Governmental agencies or Formal standardization organizations.

In India, the BIS has developed over 20,000 national standards so far over the past 70 years. Almost half of these standards are product-related whereas the other half are process-related (support) standards such as test methods, terminology or codes of practices. They are not only responsible for the formulation of Indian standards, but also for testing, calibration and training services, the registration scheme for electronic and information tech goods, the foreign manufacturers' certification scheme, the technical information services and finally certification including product hallmarking. The Bureau consists of more than 650 Technical Committees, which operate within 14 division councils that represent sectoral interests. One of their contribution has been the harmonization of a sizeable number of Indian Standards (IS) with ISO/IEC Standards in order to facilitate the acceptance of Indian products in the international market. Following various rounds of consultation from 2014 to 2017 between experts and stakeholders involved in standardisation, the Indian government drafted the "Indian National Strategy for Standardisation". This strategy addresses the four pillars of the quality ecosystem: i) the standards development; ii) the conformity assessment; iii) the technical regulations; and iv) the sanitary and phytosanitary measures and the awareness and education. Moreover, it determines the goals for the upcoming years for each pillar.

Figure 15: National (top, middle) and International (bottom) standard organizations

Currently, few activities and standards exist in the Indian context, which explicitly address RE and CE. Sectors which could apply RE and CE principles have established sector specific standardisation processes carried out by more than 25 other bodies. Important institutions in this context include for instance the Marine Products Export Development Authority, the Agricultural and Processed Food Products Export Development Authority, the Ministry of Environment, Forest and Climate Change or the Quality Council of India (QCI). The different institutes follow their own procedures since there is no uniform system, which would integrate processes into national standards.

To follow their national Standardization Strategy, the BIS is pursuing sector-crossing harmonisation. In addition, several overseas standards organizations have established offices in India to assist the Indian industry in the adoption of their standards to meet international trade obligations. Some of these organizations are for instance the Seconded European Standardisation Expert in India (SESEI), the American Society of Mechanical Engineers (ASME), the International Association of Plumbing and Mechanical Officials (IAPMO) as well as the Institute of Electrical and Electronics Engineers.

Sectoral standards

Some sectors follow their own strategy on RE to address their specific issues and have already accomplished standardisation at different levels. According to the Strategy on Resource Efficiency in Aluminium Sector, one issue identified has been scrap usage, which is diffused and not regulated through standards or end-use restrictions and is further characterised by heavy reliance on imports. As one of the goals, aluminium scrap standards (e.g. as implemented in the European Union and China) should be developed to improve the quality of recycled metal and reduce the processing cost. Relevant ISs in the aluminium sector are the IS 733:1983: Wrought Aluminium and Aluminium Alloy Bars, Rods and Section; the IS 1253:1992: Aluminium for Use in Iron and Steel Manufacture as well as ISO TC-226: Materials for production of primary aluminium.

In the Steel sector it was found that only minimum environmental standards are required and to be introduced for scrap metal facilities across the industry. Consequently, environmental concerns are high especially where end-of-life vehicles and/or white goods are to be processed. Relevant ISs in the steel sector are the ISO TC-17 SC-3 (P): Steels for structural purposes; the ISO TC- 17/SC 11 SC-MTD 16 (P): Steel castings; the ISO TC-5 SC-1 (P): Steel tubes.

In the EEE sector, findings revealed that India has already developed guidelines and standards for new product development in the electronics sector; however, the standards for the use of secondary materials are not yet specified. Consequently, standards are needed for recycling to mitigate the environmental and health impacts of unsafe recycling in the informal sector. Some relevant ISs in the EEE Sector are the IEC TC-111 (P): Environmental standardization for electrical and electronic products and systems; the IEC TC- 59A: Performance of household and similar electrical appliances and the IEC TC- 104 (O): Environmental conditions, classification and methods of testing.

Standards and the environment

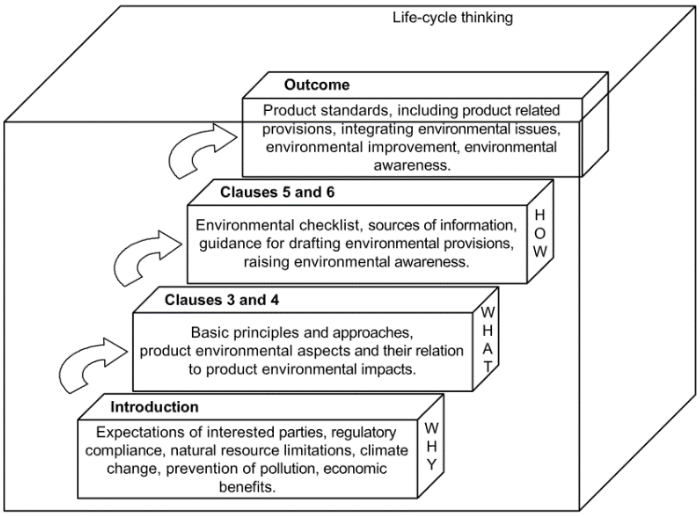


Figure 16: Steps of life cycle thinking

Source: https://boss.cen.eu/ref/CEN_4.pdf

When writing a product standard, it is important to evaluate how products can affect the environment. Ideally, this evaluation is conducted as early as possible in the process of standard development. To this end, the European Union's CEN Environmental Helpdesk (CEN/EHD) provides information, support and useful tools to CEN Technical Committees (TCs) and Working Groups for including environmental issues on a life-cycle-basis in European standards.

The EU's four-step approach for the inclusion of environmental provisions in product standards begins with the consideration of environmental aspects in standard development which are usually are driven by stakeholders interests. Next, the standard writers should be made aware of how it is possible to make an effective contribution to environmental improvement through a product standard and how the product interacts with the environment. Thirdly, writers of product standards should assess the relevant product environmental aspects, based on the application of life-cycle thinking. As an outcome, based on this information and additional guidance, environmental provisions can be drafted in product standards and included as part of technical clauses.

Standards on RE and CE

The European's Joint Research Centre (JRC) launched a technical committee to draft dedicated material efficiency standards for energy-related products. Its publication was scheduled for early 2020. The committee elaborates ten standards on material efficiency aspects for eco-design of energy-related products (ERP). The WEEE Label of Excellence standards for e-waste management introduced in 2011, was gradually transposed into full-fletched EN standards via CENELEC.

In addition, a new standard for the circular economy was launched as "BS 8001:2017 – Framework for implementing the principles of the circular economy in organizations Guide". It provides guidance for organizations to implement the principles of the circular economy. It focusses on smaller "quick wins" and is intended to apply to any organization, regardless of location, size and sector and type. It has furthermore incorporated a holistic approach on rethinking how their resources are managed to enhance financial, environmental and social benefits.

Standardisation on CE at international level

On the international level, a technical committee „ISO/TC 323" was launched in June 2019 which consists of 59 members, including India (BIS). Their scope covers the development of frameworks, guidance, supporting tools and requirements for the implementation of activities of all involved organizations, to maximise the contribution to sustainable development in the context of CE. The committee will work on alternative business models and methods for measuring and assessing circularity. It thereby aims to cover CE comprehensively, including public procurement, production and distribution, end of life as well as wider areas such as behavioural change in society, and assessment, such as some kind of circularity footprint or index. Furthermore, the committee works in cooperation with existing committees on subjects that may support CE.

Take-home messages:

- Standardised production provides benefits for producers, consumers and the environment but can also create market barriers and increase costs
- Standards can be important tools for introducing RE and CE; however, India still lacks specific standards in this field
- By using an environmental checklist, working groups can capture aspects related to RE and CE during the standards development process

Recap questions:

- How would you describe the purpose of a standard?
- Which are the most relevant standardisation bodies in India?
- In what sectors are standards contributing to more resource efficiency? Can you name an example for such a standard?
- What environmental issues need to be considered in an environmental checklist for the development of product standards?

Useful Links and References: Module 4c

- https://www.weeelabex.org/
- https://www.cenelec.eu/
- https://publications.jrc.ec.europa.eu/repository/bitstream/JRC110326/efficiency_trends_2017__final_lr.pdf
- https://boss.cen.eu/ref/CEN_4.pdf
- https://www.cen.eu/Pages/default.aspx
- https://www.ds.dk/media/px5jhney/a-world-built-on-standards.pdf
- https://www.iso.org/standards.html
- https://bis.gov.in/

Sub-module 4d: RE and CE Indicators

In this module, you will cover the following topics:

- RE and CE Indicators
- Circularity Calculator.

At the end of this module, you will be able to:

- relate to the purpose of indicators and explain SMART-principle;
- outline difference between quantitative and qualitative indicators as well as macro-, meso- and micro-level application; and
- recall the terminology of resource use indicators and possible data sources to determine material flows.

Indicators

Indicators present the base to measure a products or services performance and apply standards. They follow the principle: “What gets measured gets done”. Measurement and reporting of these indicators on a regular basis helps focusing on critical aspects, assists decision-making process and improves performance results. The Key Performance Indicators (KPIs) are particularly relevant as they are a small number of agreed-upon metrics that reflect an organization’s critical goals for success.

Indicators should be formulated according to the SMART principle, whereas each letter of the word

Figure 17: SMART principle explained

Source:https://matthewatkin.actioncoach.co.uk/2018/07/09/the-importance-of-kpis/

represents one characteristic of the principle according to Figure 18.

The letter “S” for “specific” refers to the requirement of the indicator to be clearly articulated, well defined and focused. Moreover, it needs to be clear to people with basic knowledge about the issue, programme or initiative. M for “measurable” stands for the capacity of the indicator to be counted, observed, analysed, tested or challenged. Only if indicators are measurable the degree of completion can be determined. In addition, the measured findings should be repeatable and comparable. A for “attainable” points out that an indicator needs to be achievable within the scope of the project/programme. R for “relevant” emphasized the indicators ability to detect change and be related to the specific situation it seeks to describe, whereas an appropriate scale should be used. Finally, T for “time-bound” refers to the indicators need to be attached to a timeframe, including deadlines.

Indicators are either of quantitative or qualitative nature. Quantitative indicators can be expressed in whole numbers, decimals, ratios, fractions, percentages and monetary values. Examples include for instance the number of workshops organised, the amount of resources required per GDP or the recycled content per product. Semi-quantitative indicators seek to describe an element on the basis of weighted scales, e.g. by ranking them from a scale of one (lowest score) to ten (highest score). Qualitative indicators are expressed as either independent statements or as relative terms such as "good," "better" and "best". Two examples for a qualitative CE-related indicator would be the “visible decrease in dependence on critical raw materials” or the “increased collaboration between companies to close materials loops”.

Besides this distinction in qualitative and quantitative indicators, one can also differentiate between macro-level, meso-level and micro-level indicators. Macro indicators are measured on a wider scope such as countries/nations, economies and economic zones, sectors. Meso-level indicators cover for instance industrial parks, clusters, cities and on a smaller scope. And lastly, micro-level indicators focus on the smallest possible units, such as companies, products or processes.

In the context of RE, macro-indicators at country level are usually measured in metric tonnes of materials. One such indicator would for instance be the Total Material Requirement (TMR) which sums up the Indirect flows of imports, added to imports, added to the used domestic extraction and added to unused domestic extraction. Or the Total Material Input (TMI) as another example refers to the Total Material Requirement minus indirect flows of imports. Other macro-indicators are Direct Material Input (DMI), Domestic material consumption (DMC), Total domestic output (TDO), Total material output (TMO). A country‘s resource productivity index is a tool also applied at macro-level, which can provide insights into the degree of economic decoupling either as a Consumption-based resource productivity index (GDP/DMC) or Production-based resource productivity index (GDP/DMI).

For meso-level calculations, the Material Circularity Indicator (MCI) was developed by the Ellen MacArthur Foundations and measures circularity of materials flows on the business and product level. The MCI consists of three variables: the mass of virgin raw material inputs (V), the mass of waste going to landfill or energy recovery (W) and the product’s longevity and use intensity, reflected by a utility factor (X). After calculating, the calculator indicates that a material is most circular the closer the calculated number is to one, with zero in contrast being fully linear. An illustration is shown Figure 19:

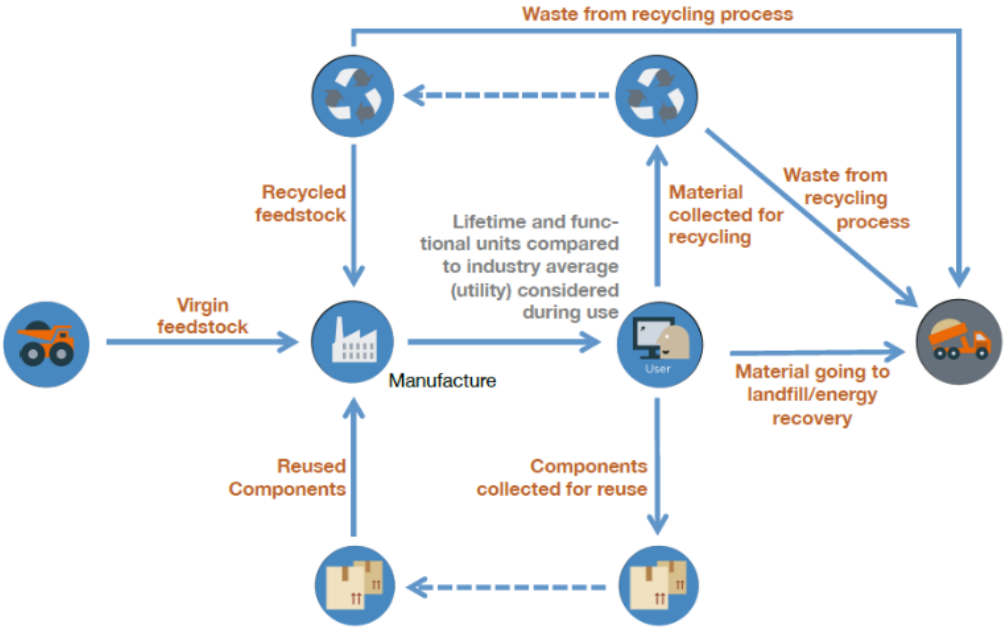


Figure 18: Material Circularity Indicator

Source:https://www.ellenmacarthurfoundation.org/resources/apply/measuring-circularity

Material Circularity Indicator.

For the micro-level analysis, the Circularity Calculator as illustrated in Figure 20 is based on a weighted scale and 15 guiding questions informed by experts' inputs. Since this analysis is based on the experts' views, this tool is highly subjective and there is no right or wrong result. However, it is very useful for gaining a basic understanding and first assessment of a product. The result of the Circularity Calculator indicates that a product is very circular, the higher its calculated score is.

Lifecycle stage	#	Guiding question	Max. Score
Design	1	Is the product made from recycled/reused material?	20
	2	Is the product lighter than its previous version?	2
	3	Is there a complete bill of materials and substances for the product?	5
Production	4	Is there a complete bill of energy for the manufacturing process?	10
	5	Is there a complete bill of solid waste for the manufacturing process?	15
Commercialization	6	What packaging is being used?	5
	7	What is the product's warranty?	10
	8	Is there a rental option for the product?	15
In use	9	Can the usage status and identification of the product be established?	15
	10	Can the product be repaired?	5
	11	Can the product be reused?	10
	12	Does the product help to reduce waste through its use?	5
End-of-life	13	What take-back scheme is available for this product?	15
	14	Is the product separated out from other products at the end of its life?	10
	15	Are the product's materials passed back into the supply chain?	10

Figure 19: Circularity Indicator

- For **Exercise 4d.1** use the flowchart and complementary documents on page 96 to allocate macro-level resource use indicators.
- Apply the circularity calculator on page 100 on the case study of Marudhar Caffeinated Caps as part of **Exercises 4d.2**.

Take-home messages:

- Indicators can help benchmarking different products, processes or systems to assess RE and CE on a systematic basis
- Indicators should be formulated according to the SMART principle
- Qualitative indicators can help in the decision making process, but usually rely on expert opinion and are less suitable for objective benchmarking

Recap questions:

- What is the core idea of the SMART principles and what does it stand for?

- Which are some tools to measure circularity indicators?
- What is the difference between qualitative and quantitative indicators?
- What are suitable data sources for ‘material input’ and ‘material output’?

Useful Links and References: Module 4d

- https://matthewatkin.actioncoach.co.uk/2018/07/09/the-importance-of-kpis/
- https://iges.or.jp/en/publication_documents/pub/issue/en/3891/3RFS_010_web.pdf
- https://www.oecd.org/environment/indicators-modelling-outlooks/MFA-Guide.pdf
- https://www.boell.de/sites/default/files/201207_green_economies_around_the_world.pdf
- https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Project-Overview_May2015.pdf
- https://www.ellenmacarthurfoundation.org/resources/apply/measuring-circularity
- https://iris.unive.it/retrieve/handle/10278/3688992/104510/Int_J_Sustainable_Eng_06_2017.pdf
- https://www.ellenmacarthurfoundation.org/resources/apply/circularity-indicators

Sub-module 4e: Public Procurement

In this module, you will cover the following topics:

- Public procurement
- Types of environmentally oriented public procurement
- Principles of public procurement
- Steps in the public procurement process.

At the end of this module, you will be able to:

- understand the importance of clearly defined criteria in the evaluation of tender proposals;
- assess the importance of green public procurement in the Indian context with regards to sustainable development;
- define different types of environmentally-oriented public procurement (GPP, SPP, CPP); and
- map out the four steps of public procurement and understand how green/sustainability/circular considerations can be included in them.

Procurement

In general, Public Procurement (PP) seeks to match supply and demand in order to deliver goods and services, which the public sector is procuring. Some key principles are followed in PP. One is, for instance, to choose the highest value for money in order to spent taxpayers' money responsibly by identifying the Most Economically Advantageous Tender (MEAT). Moreover, fairness is a second important principle and seeks to commit to non-discrimination, equal treatment, transparency and proportionality.

In 2011, India's economy valued 1.823 trillion USD of which the total government spending roughly has a share of over 30%. By adopting environmentally friendly public procurement policies, this purchasing power can leverage RE/CE and increase the demand for more sustainable goods and services.

There are three types of environmentally oriented public procurement. Firstly, there is Green Public Procurement (GPP) where public authorities seek to procure goods and services with a reduced environmental impact throughout their entire lifecycle. In contrast, with Sustainable Public Procurement (SPP) public authorities seek to find an appropriate balance between the three pillars of sustainability – economic, social and environmental – when procuring goods and services. Finally, Circular Public Procurement (CPP) sets a special focus on goods and services, which contribute to slowing, narrowing or closing loops within supply chains whilst minimizing environmental impacts and waste. How to include some of the aspects environmentally friendly PP in the procurement process is illustrated in Figure 20.

- **Exercise 4e.1** consists of three parts. Learn more about GPP, SPP and CPP by thinking of all the aspects to consider when organizing a workshop. You will find complementary documents on page 104.

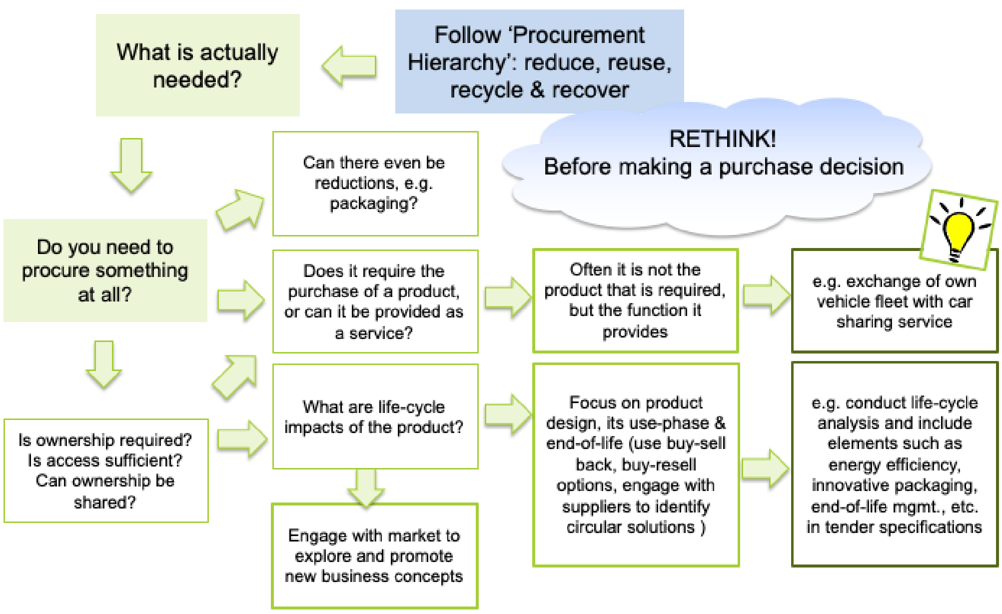


Figure 20: Public Procurement Considerations

The PP process moves along the lines of four steps in which various criteria or specifications require definition as pictured in the figure below. In order to integrate RE/CE aspects, it is necessary to call into question how green, sustainable or circular considerations can be integrated in each of these steps.

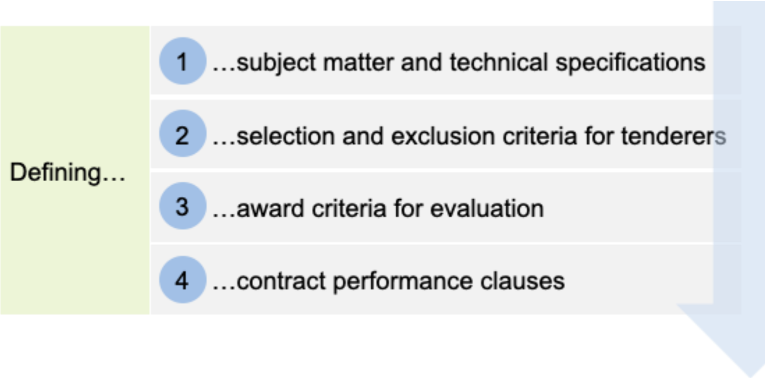


Figure 21: Steps of public procurement

As part of the initial step, which defines subject matter and technical specifications, a needs assessment is required. While understanding what exactly should be produced, RE/CE aspects can be integrated in the procurement of products, services and works. Regarding the procurement of products, the impact of materials and production should be considered, as well as packaging, transport, energy and water consumption during the use-phase, moreover the durability of the product and opportunities for recycling or reusing the product at the end of its life. While procuring services the technical expertise required to provide the service in an environmentally friendly way should be taken into account as well as the materials used in carrying out the service, the energy and water consumed, and waste generated as well as management procedures to minimise the environmental impact of the service. When procuring works, the environmental impacts need consideration e.g. in respect of land use or traffic planning and an Environmental Impact Assessment may need to be carried out.

As a second step, the selection criteria for the tendering process are defined. The objective of this step is to create a framework that ensures a tenderer's ability to perform the contract they are tendering for, taking into account their experience and competence related to environmental aspects. Some of the exclusion criteria would be the non-compliance with applicable laws, Grave professional misconduct which renders integrity questionable as well as any significant/persistent deficiencies in performance under a prior contract and also the inability to submit supporting documents. Selection criteria on the other hand should cover Human and technical resources, Experience and references, the Educational and professional qualifications of staff, the Environmental management systems applied (e.g. ISO 14001), the Supply chain management/tracking systems as well as Samples of products and a Conformity assessment.

The award criteria for evaluation are defined in the third step, whereas the criteria should be verifiable and not confer an unrestricted freedom of choice (careful use of labels). Moreover, the award criteria should ensure the possibility of effective competition and be advertised in advance, including sub-criteria and weightings. The price may then be calculated on the basis of lifecycle costs to identify the most economical choice in accordance with MEAT. However, where bidders cannot obtain a label, other appropriate forms of evidence should be accepted.

For the fourth and final step, environmental considerations can be included in the contract performance clauses, specifying that goods are to be supplied or services performed in a way that minimizes environmental impact. It can further be stated that the environmental performance may be linked to penalties or incentives under the contract. Regarding procured goods, this step aims to ensure the delivery of goods in the appropriate quantity and outside of peak traffic times, a take-back scheme for packaging and regular reporting on GHG emissions or resource use. Concerning services or works, the contract performance clauses aim to overlook how the service or work is performed, as well as training of contractor staff, transport of products and tools to the site and furthermore the disposal of used products or packaging.

The procurement of „green" textbooks in China is a case example of integrated RE/CE aspects in the procurement process. The Chinese government already began with the adoption of GPP policies in 2003. The Chinese Ministry of Environmental Protection (MEP) & State Administration of Press, Publication, Radio, Film and Television (SAPPEFT) the jointly initiated the Green Printing Initiative. Following the Initiative, relevant provisions of the „PRC Environmental Protection Law" and „Printing Industry Management Regulations" were introduced. Finally, a "Leading group" was established to facilitate the implementation of Green Printing for school textbooks. The group was since then responsible for the coordination of relevant departments as well as the supervision and inspection of “green” printing. The government saw a huge potential for the reduction of environmental impacts of the printing industry and introduced eco-friendly printing of textbooks for all primary and middle school students which summed up to 16.56 million. In that way the government experienced Electricity savings of 355,000 kWh, the reduction of printing ink consumed by 1 ton/100 million Yuan in output value and the reduction of pollution caused by printing industry. This process of course required major adaptations of the printing industry such as financial and technical challenges for printing companies in the beginning. But support mechanisms were provided to support the transition and the initial cost increases were soon offset through material and energy savings.

- Read through the tender example on page 106 in order to take **Exercise 4e.2**, which will take around 50 min to complete.

Take-home messages:

- Public Procurement can be a powerful tool to aggregate and leverage market demand for more resource efficient and circular products, and thus for eco-innovation
- Clear criteria need to be defined in order to evaluate tender proposals on an equal, transparent basis
- Green/sustainable/circular considerations can be included at each step of the tender process
- Guidance document on GPP criteria developed by the European Commission are available online

Recap questions:

- What is the difference between GPP, SPP and CPP
- For which products is it especially important to integrate sustainability aspects in the procurement process?

Useful Links and References: Module 4e

- https://ec.europa.eu/environment/gpp/pdf/CP_European_Commission_Brochure_webversion_small.pdf
- https://ec.europa.eu/environment/gpp/index_en.htm;
- https://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm
- https://www.greengrowthknowledge.org/sites/default/files/downloads/best-practices/UNEP_sampling_successes_green_public_procurement_case_studies.pdf

Sub-module 4f: Circular Business Models

In this module, you will cover the following topics:

- Circular business models
- Types of interventions in a circular business model
- value dimensions of a circular business model
- Circular business model case studies.

At the end of this module, you will be able to:

- understand the definition of a business model and its components;
- outline how the abstract concept of circular economy can be implemented and create value through circular business models;
- be able to identify potential intervention points to create a circular business model; and
- be able to apply the business model canvas to create and redesign business models.

Business models

A business model generally illustrates how a company makes money or in other words: „A business model describes the rational of how an organization creates, delivers, and captures value.“ [2]

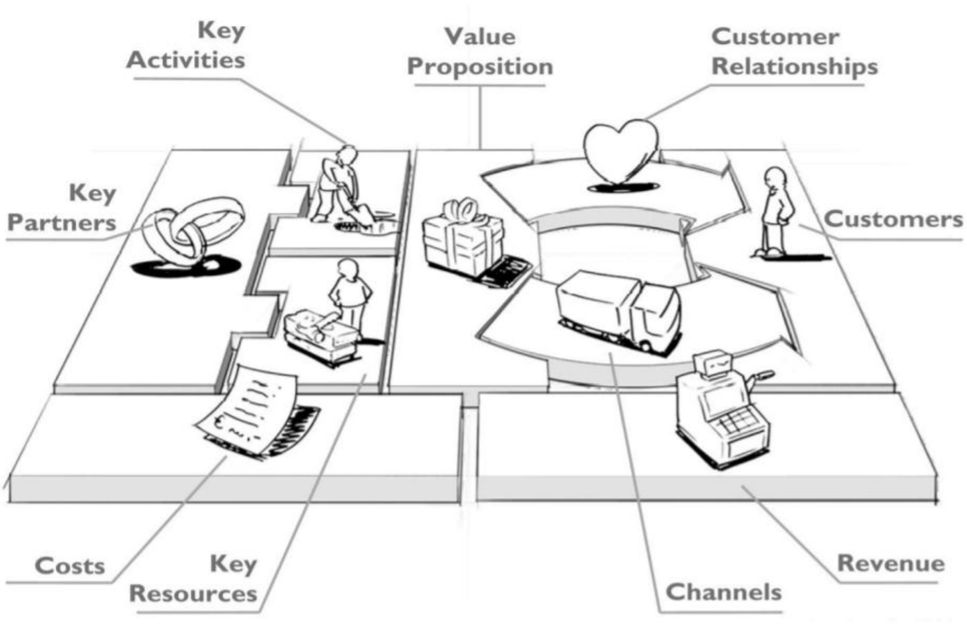


Figure 22: Components of a Business Model Canvas

Source:https://www.researchgate.net/publication/321764939_Best_Practice_Examples_of_Circular_Business_Models

Each business model is individual and even companies, which are active in the same industry can have very different business models. Companies can even have various business models depending on a certain customer segment, product, region, etc. For example, an off-grid solar energy business model can look entirely different depending on the circumstances. A company could either sell components for solar systems, energy solutions or lease solar systems. Each of these options would require an individual business model.

Some of the areas that a business model aims to cover are shown in the figure above. The nine business model components for instance seek to indicate who the customers are, how the communication with them takes place and how they receive a product or service with its defined value. At the same time, it describes the key activities of a company and key resources as well as the key partners linking activities with resources. Finally, the cost and revenue structures are portrayed.

Circular business models

Generally speaking, circular business models aim to retain value of products and services for as long as possible. To this end, companies need to adjust the elements of their business model to implement circular interventions (i.e. in line with

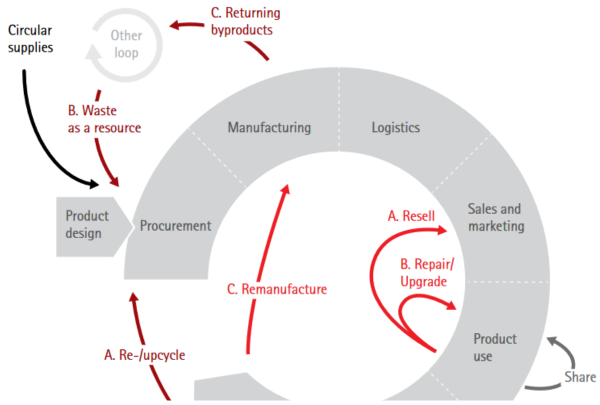


Figure 23: Interventions in circular business models

Source:https://www.accenture.com/t20150708t060455__w__/us-en/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/dualpub_14/accenture-circular-economy-pov.pdf

[2] (Osterwalder, A. & Pigneur, Y. 2010, p.14.)

the CE strategies of closing, slowing and narrowing loops). This will enable businesses to maintain and capitalise on a product's value and the material beyond a single life. Circular business models usually look for value creation in different places than linearly operating ones. Circular business models can also be established through various interventions in the value chain. Typical types of interventions would be the supply of circular input material, product life extension e.g. by repairing, upgrading or reselling, sharing platforms, product service systems (PSS), e.g. by offering access but retaining ownership of a product or the recovery of resources out of disposed products or by-products.

By introducing maintenance services, reusing, refurbishing or recycling processes the resources are kept circulating. CE activities that occur close to the customer and the products use phase often require smaller efforts for keeping up a products value and can be understood as tight circles compared to activities which appear farther away from the customer and require extensive efforts such as recycling. According to the Ellen MacArthur Foundation „ the tighter the circles are, the larger the savings should be in the embedded costs in terms of material, labour, energy, capital and the associated rucksack of externalities, such as GHG emissions, water, or toxic substances.“ [3]

The Ellen MacArthur Foundation also suggests four intervention points and/or ways to increase value creation. The first refers to the power of the inner circle just described. As an early intervention this keeps products alive and operating for as long as possible. It requires products to be designed in a way that they are easy to maintain and repair, and create business models to support that. The modular “Fairphone” is an example of this first intervention point put into practice, by enabling the repair or replacement of single phone parts.

The second intervention point is called the power of circling longer. It aims to keep products in as many consecutive cycles as possible and prolongs the time of each cycle, it further offers high product quality, easy repairs and upgrades or service schemes. It also includes using parts as spare parts or building blocks for other products and can cover setting up a return system for consumable products, such as bottles or cans. Reusing clothes is one example for the second intervention point.

The power of cascade use describes the third intervention point and points towards a diversified reuse of products and materials within and between industries. Royal DSM, a Dutch company active in nutrition, health and sustainable living developed, for instance, cellulosic bio-ethanol, a by-product of co-fermenting sugars derived from crops.

Finally, the power of pure circles aims for uncontaminated material streams since this is key in maintaining the quality of the materials for many consecutive cycles. As the example of DSM Niaga shows, who developed a carpet material out of single or simple combinations of either pure polyester, a mix of polyester and polyamide, or wool pure materials are easier recyclable. Circular business models can interlink with these four intervention strategies in different ways. Extending product life or Sharing platforms for instance use the power of the inner circle and the power of circling longer, while resource recovery does use all powers except the first.

Interventions in a circular business model can be applied and create value at all stages as illustrated below. By collecting and reintegrating resources with a circular approach the need for primary raw material is reduced at an early stage in the value chain. With the sale of a product, its use phase can then be accompanied by maintenance, repair or remanufacturing services. Additional sales can be acquired by arranging refurbishment and selling replacement components. At a later stage, the recovery of materials as well as feeding them back into the value chain can close the loop.

[3] (Ellen MacArthur Foundation, 2013, p.30.)

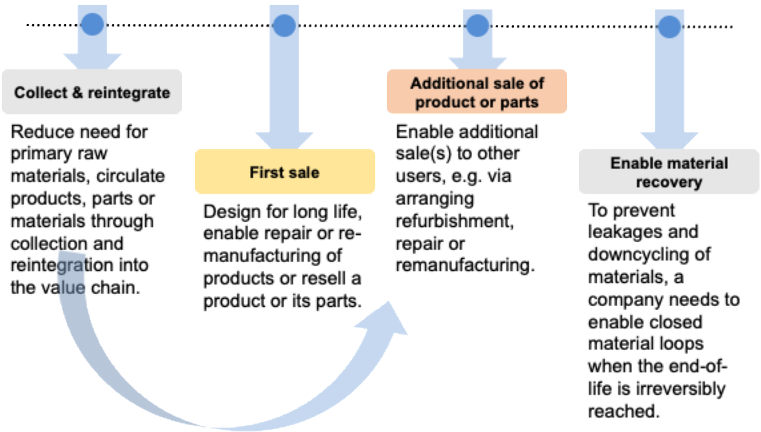


Figure 24: CE interventions at different stages of the value chain

Three value dimensions of a circular business model can be distinguished: the first dimension of value proposition, the second of value creation and delivery as well as the value capturing dimension. The first dimension calls into question what value is proposed and to whom. To understand the value here, it needs to be clear what kind of product or service is offered, what value is proposed and to which customer does the company cater as well as in what way it affects relationships with customers or partners. A central question of the second dimension is how the value is created and delivered. This includes what activities the company carries out, what the company can do itself regarding internal capabilities and what can be outsourced to external partners or channels. How value is captured is the focus of the third dimension and looks at the companies cost structure as well as generated revenues and how they are generated.

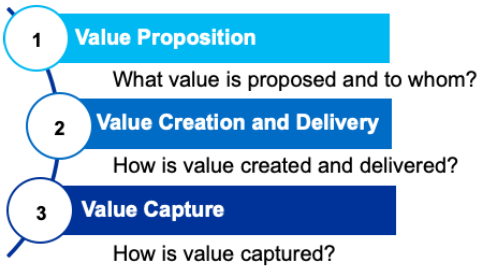


Figure 25: Value dimensions of a circular business model

- Examine the business model canvas of Tomato in **Exercise 4f.1**. After filling in Circular intervention possibilities in the table on page 114, discuss the results with the group.

Case Study Bharat Earth Moving Equipment

Bharat Earth Moving Equipment was founded in 1973 and sells machinery and engines. 35% of their costs lie in overhead, whereas 65% are related to material use. The focus of their CE efforts are on component recovery and remanufacturing for instance of engine blocks. The knowledge about state of their products during use time is thereby crucial. They have set up a deposit scheme for engine cores in order to increase collection rates.

- The company Bharat Earth Moving Equipment is further analysed in **Exercise 4f.2.** Complete the business model canvas on page 116.

Take-home messages:

- Business models capture how a company creates value
- Depending on the business models, certain components might be more important than others
- There are various intervention points for circular business models, such as making products more durable, circling them longer, cascade their use, making them easier recyclable
- Other circular business models include the concepts of sharing or product-as-service

Recap questions:

- What is the main function of a business model (canvas)?
- Which are some of the circular interventions that can be integrated in a business model?
- What are the three value dimensions of a circular business model?
- How many of the nine building blocks of a company's business model can you name?

Useful Links and References: Module 4b

- Video: https://www.youtube.com/watch?v=QoAOzMTLP5s#action=share
- Circular Business Model: Ellen MacArthur Foundation 2013, Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition, Ellen MacArthur Foundation, UK. https://www.werktrends.nl/app/uploads/2015/06/Rapport_McKinsey-Towards_A_Circular_Economy.pdf
- Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons. https://www.academia.edu/download/32253198/businessmodelgenerationpreview.pdf
- https://www.researchgate.net/profile/Julia_Nussholz/publication/336173562_A_circular_business_model_for_material_reuse_in_buildings_Implications_on_sustainable_value_creation/links/5da063fda6fdcc8fc34741a0/A-circular-business-model-for-material-reuse-in-buildings-Implications-on-sustainable-value-creation.pdf

Sub-module 4g: RE and CE Funding

In this module, you will cover the following topics:

- RE & CE financing in the EU
- Focal areas of RE and CE funding
- Assessment of financing options
- Funding challenges
- Selecting possible funding areas
- Assessing funding options.

At the end of this module, you will be able to:

- recall possible areas for funding in RE and CE context;
- relate to available funding sources in India; and
- assess rational and business case of RE & CE.

RE & CE Financing

The circular economy offers a number of opportunities for companies, like reduced manufacturing costs, increased resilience and hedge risks and new revenue streams. Yet, as company structures and strategies are often rooted in the linear approach, the shift can be challenging and may require initial investments. Special financing instruments and public sector support can help to overcome these challenges.

The European Investment Bank (EIB), a joint Initiative to support the development and implementation of circular economy projects and programmes in the European Union, announced in July 2019 a 10 billion EUR initiative to accelerate the transition towards a CE. Within this context, a five-point method has also been developed that will enable the finance industry and other stakeholders to 1) identify circular economy investment opportunities, 2) measure and quantify the 'degree' of circularity of a project and/or entity (incremental economic, social and environmental impact of the circularity embedded in project), 3) evaluate and measure how relevant an entity's circular economy project is to that entity's transition to a circular business model, 4) compare the circularity and linearity of projects and/or entities in terms of economic, social and environmental benefits: the incremental benefit of a circular project compared to a linear project and 5) assess whether a linear project can be transformed into a circular one at a comparable risk and return level.

Special financial products and instruments support companies and institutions on the path to a circular economy as financing can be adjusted to the specific needs. The European Fund for Strategic Investment can assist innovative project with medium to high level of risk, while the InnovFin financing tools is suitable for SMEs, larger companies or research institutions with higher-risk taking potential. The EU Circular Economy Action Plan and the corresponding EU Circular Economy Package is in the centre of financing tools on a European level. Priority areas are plastics, food waste, critical raw materials, construction and demolition and biomass and bio-based products.

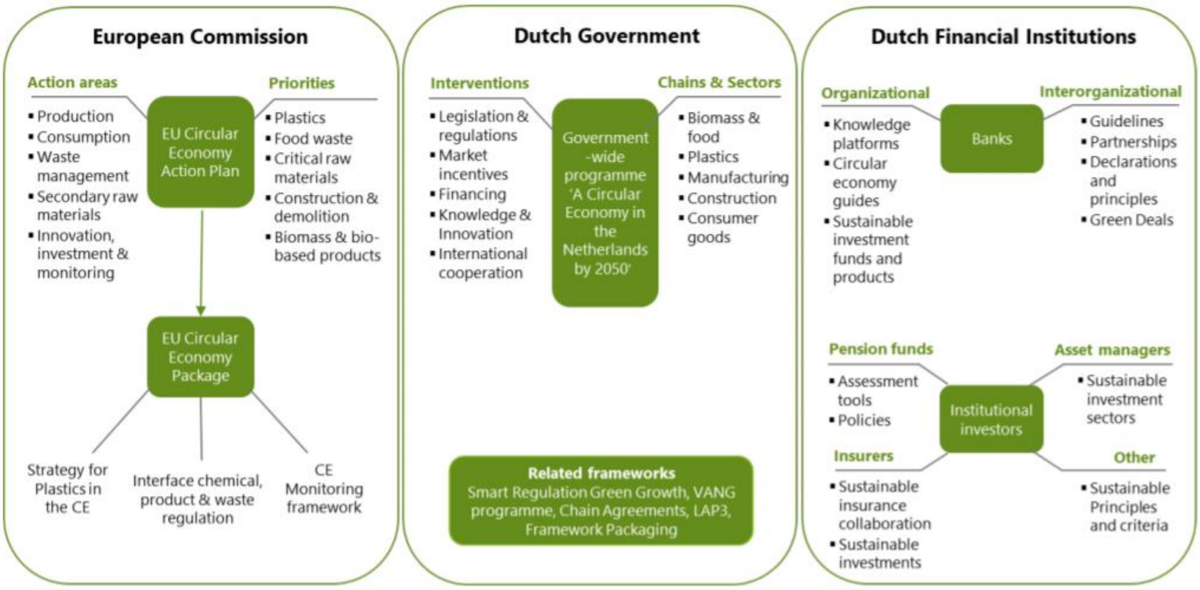


Figure 26: Dutch funding framework

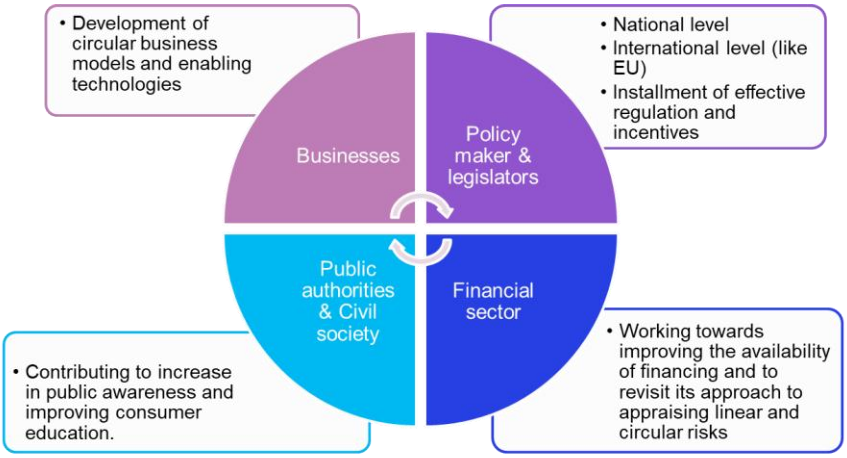
Source: Quick Scan – Taxonomy Circular Economy, Ministry of Infrastructure and Water Management, Netherlands, May 2019

The national governments of the EU member set translate these guiding principles to more specific programmes with respective intervention areas and key sectors, which finally get taken up by the national financial institutions. In the case of the Netherlands, interventions resulting from the EU framework include market incentives, international cooperation and knowledge and innovation interventions in the chains and sectors of plastic, manufacturing, construction and consumer goods. The Dutch financial institutions reacted to the governmental programmes. Banks established knowledge platforms, CE guides and sustainable investment funds and products. Institutional investors initiated assessment tools and policies for circular investment funds and sustainable insurance collaborations and investments.

The EIB set a number of eligibility criteria to get access to CE financing instruments. These include the circular design and production of products, i.e. the application of reduce/recycle strategies in design and production phases. Substituting virgin materials with secondary or recycled materials or reducing input of hazardous substances to facilitate reuse and recycling are examples for such approaches. The circular use and life extension of products and services is a second criteria, covering the application of reuse repair, repurpose, refurbish, remanufacture strategies in the use phase, for instance, the repurposing and refurbishment of abandoned buildings and redundant assets up to generally accepted industry standards. The third criteria is directed towards the after-use phase and addresses the circular value recovery. More specific the application of recycle/recover strategies, like recovery of materials and chemicals from waste, residues and by-products or the recovery of bio-resources, chemicals and nutrients from bio-waste, bio-residues and wastewater sludge. Finally, circular support, the support and facilitation of all circular strategies in all lifecycle phases, is elemental for circular business models.

Especially during the initial phase, several challenges may arise for financing circular economy initiatives as experience in the EU shows. Many businesses are likely to wait until high commodity prices create business case for CE transitions and while market forces alone able to create circular economy the bear a risk of a slow transition and high opportunity costs. Especially public sector intervention and support is crucial in order to pre-empt potential supply crises, reduce the dependence on strategic imported resources and realise the societal and environmental benefits from a transition to a circular economy. Within the EU the development of clear taxonomy of CE projects is considered for funding.

The systemic approach that involves various stakeholders seeks to overcome these and other challenges. Businesses with circular business models and enabling technologies are involved as well as policy makers and legislators who aim for the instalment of effective regulations and incentives on national and international level. The financial sectors in this model are working towards improving the availability of financing and to revisit its approach to appraising linear and circular risks. Public authorities and civil society are contributing to increase in public awareness and improving consumer

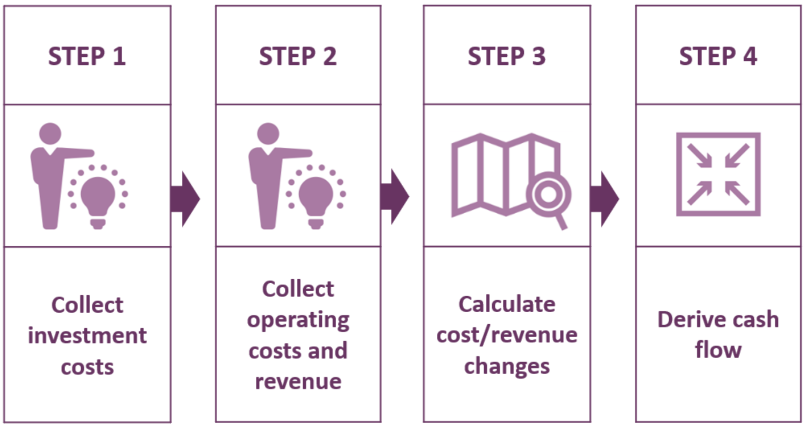


education.

Figure 27: systemic approach for funding of RE & CE

Efficient use of resources is not sufficient for companies to shift to a circular economy. More so, redesign or even adopting new business models is inevitable. The company Ultimaker from the Netherlands for instance is recognised as a highly innovative manufacturer that develops 3D printers as well as associated and has received a loan of 15 million EUR for their circular design business model.

The assessment of funding options is a crucial step for business owner when making investment decisions. When making an investment decision the full understanding of the same is as importynt as the identification of cash flows of specific projects. To make these decisions, a simplified approach can directly address the analysis of project cash flows. To find the most appropriate loan or other type of finance for financing investments the option of loans should be evaluated in some cases. More advanced investment decisions on a large scale can be made by performing a cost-benefit and



scenario analysis.

Figure 28: Simplified investment decisions

A next step is to gain an overview of the different financing instruments that are actually available and applicable. A distinction is made between equity capital, debt capitals, grants and donations and hybrid capital which are each tailored to different financing needs. Incorporation as a for-profit company is a pre-requisite to get access to equity capitals. In exchange for a certain sum of money, the investor receive share in the social or environmental enterprise and of the future profits and certain control and voting rights (depending on legal form of the enterprise). The specific rights are usually outlined in the contract between investor and investee and equity capital is not repaid to the investor in the normal course of the business (unlike debt capital). Depth capitals are only an option for enterprises that promise to deliver stable and predictable cash flows over the coming years, in this regard the enterprise has to pay fixed annual interest rates on the borrowed money. The borrowed money has to be repaid over/after a fixed period of time, whereby this period can short-term or long-term. The nature of depth capitals can take many forms, from traditional bank loans to loans from social banks, investors and funds but in all cases personal guarantees are normally required for small businesses, making personal credit history very important.

Grants and donations are suitable for start-up or activities in the research and prototyping phase. Grants can come from public bodies, public/private trusts and foundations and donations may be regular or one-off, raised through events and direct mails or left as a legacy. Grants and donations share the same disadvantages, including a short-term orientation, high fundraising costs, lack of predictability and often being linked to a specific purpose. Hybrid capital offers very attractive financing option for social and environmental entrepreneurs and includes elements of equity capital, debt capital and grants. Hybrid capital financing instruments include forgivable loans/recoverable grants, convertible grants and revenue-sharing agreements. An overview of the different financing options is

	Equity	Debt	Grant
Payments	Dividend payments, profit sharing	Repayment and interest	No repayment, no taxes
Time frame	Various terms	Short- and long-term oriented	Short-term oriented
Investment phase	Growth-phase	Growth-phase	Start-up phase
Independent use of funds	Depends on leadership decision	Yes	Mostly tied to social impact
Investor involvement	Take ownership of company	Cash only	Mostly cash only
Collateral	Not needed	Depending on kind of loan	Not needed

given in the table below.

Figure 29: Overview of financing instruments

- As part of **Exercise 4g.1** discuss the following questions:
  - Can you think of companies/ventures operating in India that are investing in RE/CE
  - What funding are would you assign them to?

In India, a number of financing instruments for funding of RE and CE activities are currently available for instance the NewGen Innovation and Entrepreneurship Development Centre (NewGen IEDC), or the Atal Incubation Centres (AIC) and Atal Tinkering Laboratories by Atal Innovation Mission (AIM), or the Scale-up Support to Establishing Incubation Centres (Niti Aayog). In addition there is the National Clean Energy Fund (NCEF) Refinance by IREDA, as well as Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM) by the Council of Scientific & Industrial Research, moreover the Start-up Schemes and Technology Incubation and Development of Entrepreneurs (TIDE) Multiplier Grant Scheme by MeiTY and the Small Industries Development Bank of India (SIDBI) - 4E Financing Scheme and Sustainable Finance Scheme. Slowly but steadily, these instruments seek to target CE-related intervention and thus foster a transition towards a closed-loop economy in India.

- In **Exercise 4g.2** identify possible challenges of seeking or offering funding for RE/CE by forming two groups, representing two different perspectives on funding
  - Perspective of a financing institution
  - Perspective of funding seeker

When seeking or offering funding for RE and CE activities a number of possible challenges may arise as already briefly described in the beginning of the section. Having a closer look at the challenges from different perspective can help to overcome and avoid problems and thus safe time and money.

From a funding seeker perspective, it needs to be considered that RE and particularly CE measures require investments. The transformation process towards a circular business is costly (i.e. funds and upfront investment for business innovation, plus high costs of secondary products and raw materials, as opposed to the often lower cost of virgin resources) while the returns can rarely be predicted precisely. So far, only limited capital is directly available to fund seekers for investments in RE measures as conventional credit lines may not make loans available for small SMEs/start-ups and may be reluctant to disperse money for RE measures (also because of lack of comparable track records).

From the perspective of the financial institution RE, and especially CE, investments are a relatively small and new niche business and CE funding providers are yet to build a track records and gain experience. Financial institutions and investors mostly still lack knowledge of RE technologies, even more so about CE, and providing finance for projects targeting operating cost savings are still considered unconventional. Existing procedural frameworks in banks vary for RE loans and often high transaction costs for investments are required.

There are three case studies on page 122. Split in groups of five, read through all of them and select one as part of **Exercise 4g.3.**

Take-home messages:

- Select possible RE &CE funding areas such as (1) circular design and production, (2) circular use and life extension, (3) circular value recovery, and (4) circular support
- RE investment instruments becoming increasingly available in India; though limited for CE but under development
- Assess and match the funding needs with external financing instruments

Recap questions:

- What are possible areas for funding in RE and CE?
- What sources for funding for RE/CE activities are there in India?
- Can you name relevant parameters for picking financing instruments?

Useful links and References: Module 4g

- EIB Circular Economy Guide: https://www.eib.org/de/publications/the-eib-in-the-circular-economy-guide
- The Value Hill Business Model Tool: https://www.scienceandtheenergychallenge.nl/sites/default/files/workshops/attachments/NWO%20Sc4CE%20-%20Workshop%20Business%20Models%20-%20Paper%20on%20Circular%20Business%20Models.pdf

PART 2

In this part of the handbook you will find:

- Handouts, templates and exercise sheets for your further use
- Exercise solutions

Each module is supported with a variety of exercises that are an integral part of internalising the content of the training programme. To conduct the exercises you may need additional documents such as case studies, exercise sheets and flipchart templates in case you are working in groups.

In order to check your results, you can use the solution part of the handbook. However, keep in mind that oftentimes there are no final answers to some of the questions, which is especially true for brainstorming activities.

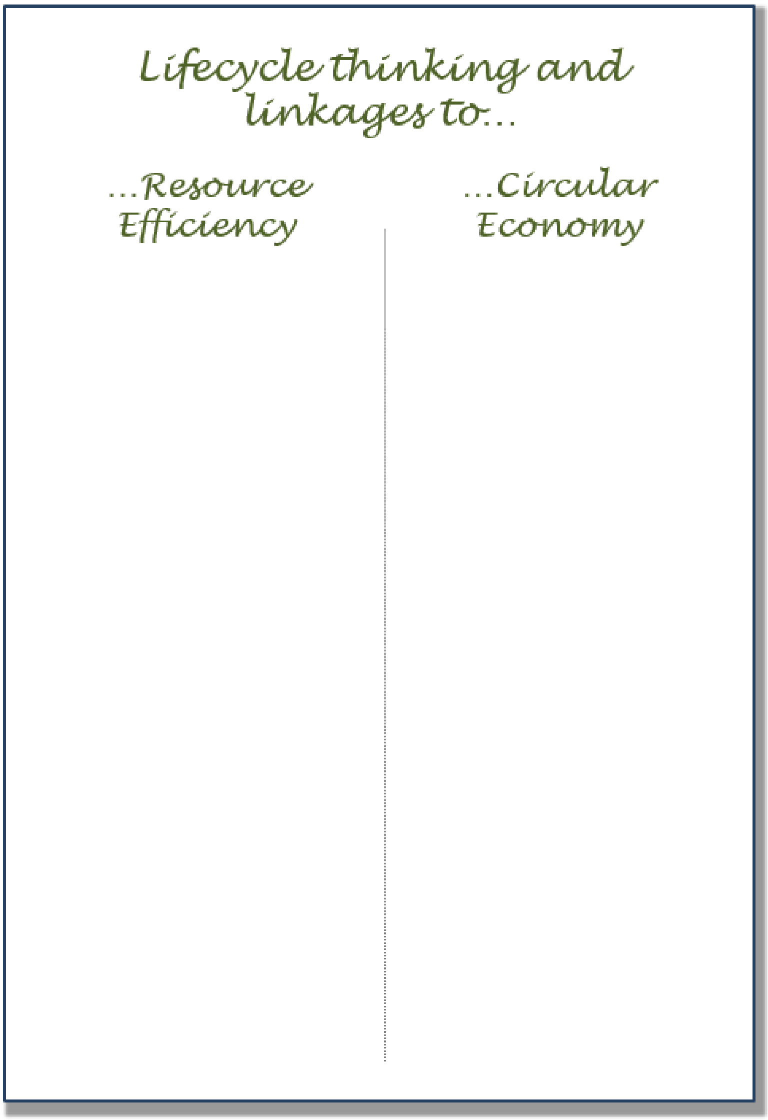
Handouts, templates and exercise sheets for your further use

Module 2

Exercise 2.2: Brainstorming (on flipchart)

Discuss the following questions:

- How does lifecycle thinking connect to the concepts of RE and CE?
- How do the concepts overlap, and how are they different from one another?
- Can you think of practical, real-life examples of RE and CE?



Module 3

Exercise 3.1: Video on Resource Efficiency in India

Required time: 5 minutes

Introduction

https://www.youtube.com/watch?v=gqhJ4IUhhak

Watch the video and take notes on the following aspects about resource efficiency in India:

Challenges in current resource use in India:

Opportunities for the Indian economy:

Key sectors for resource efficiency in India:

Potentials for increasing RE in across these sectors:

Task 3.2: Identifying key provisions and stakeholders of the Indian National Resource Efficiency Policy

Estimated time requirement: 55 minutes

Introduction

In 2019, the Indian government issued the Draft National Resource Efficiency Policy (NREP) to "create a facilitative and regulatory environment to mainstream resource efficiency across all sectors by fostering cross-sectoral collaborations, development of policy instruments, action plans and efficient implementation and monitoring frameworks." (Draft National Resource Policy, p. i). In a first step, NREP addresses abiotic resources, specifically non-energy minerals. Other resources are planned to be integrated in a next step. The policy aims to create a collaborative institutional structure to replace or consolidate the currently isolated interventions taking place in this field, and to strengthen and take forward the country's resource efficiency agenda and sustainable development. This will require concerted efforts from different stakeholders. In this exercise, you will analyse the key provisions of the policy and identify the most important stakeholders, which will be responsible for implementation of the policy and their relationship between each other.

Table 1: Exercise structure

Part	Task	Time
1	Form groups and analyse the summary of the Draft National Resource Efficiency Policy with respect to status, concerns and opportunities. Discuss the key provisions with your peers and capture your notes in table 2.	15 min
2	Based on the stakeholder mapping methodology presented in figure 1 below, please map out, classify and link those stakeholders, who need to be involved for the implementation of the policy. Please use the prepared flipchart for this exercise.	40 min

Figure 30: Stakeholder mapping methodology

Background information

Strategy on Resource Efficiency in India

India's economy is marked by rapid economic growth with a GDP of 2.6 trillion USD. This economic growth has decreased poverty and promoted human development. However, it also came along with an augmented use of natural resources: India increased its material consumptions six times from 1970 to 2015 and is expected to double it again by 2030 in order to hold pace with population growth, increased urbanization and new aspirations of the growing middle and upper classes. The rising need for natural resource extraction has been accompanied by increased greenhouse gas emissions, land degradation, destruction of natural environment and loss of biodiversity as well as serious levels of resource depletion. Environmental degradation in turn has negative impacts on the economy, livelihoods as well as quality of life. Another compelling argument for RE and CE is the fact that many Indian industries depend on imports for many critical raw materials.

In the current policy landscape, there are multiple policies addressing the issue of resources, however, they are all isolated interventions and fail to capture the opportunities of resource efficiency across all stages of the life cycle. Most policies and interventions (e.g. eco-labelling, financial support for R&D, etc.) focus on energy efficiency or environmental issues, but do not yet directly address RE, circular business models or the use of secondary raw materials. Also, many policy interventions still focus on the end-of-life stage and end-of-pipe solutions. What is essentially missing is the integration of lifecycle thinking in an integrated and holistic manner to address the larger resource efficiency agenda. Collaborative institutional structures need to be formed and strengthened to take this agenda forward and to achieve the goals of NREP, such as:

- (i) reduction in primary resource consumption to achieve the Sustainable Development Goals,
- (ii) creation of higher value with less material use through resource efficient and circular approaches,
- (iii) waste minimization,
- (iv) material security, and
- (v) creation of green employment opportunities and business models.

A primary step in the implementation of the Policy and its goals is the creation of the National Resource Efficiency Authority (NREA) with the mandate to drive the agenda of resource efficiency across the country. NREA will be based on a collaborative structure with a core working group housed in MoEFCC, and a members group consisting of representatives from different ministries, state/union territory governments, government agencies and other stakeholders. An inter-ministerial National Resource Efficiency Advisory Board (NREAB) will provide necessary guidance on the aspects critical to the implementation of resource efficiency across all sectors.

It is crucial to have influence, participation and collective action of all major stakeholders including industry, policy makers, government agencies, academic, civil society organizations including non-profit institutions, think tanks and business groups, consumers, and technology developers to implement the policy in an integrative, comprehensive and effective manner.

Worksheet 1

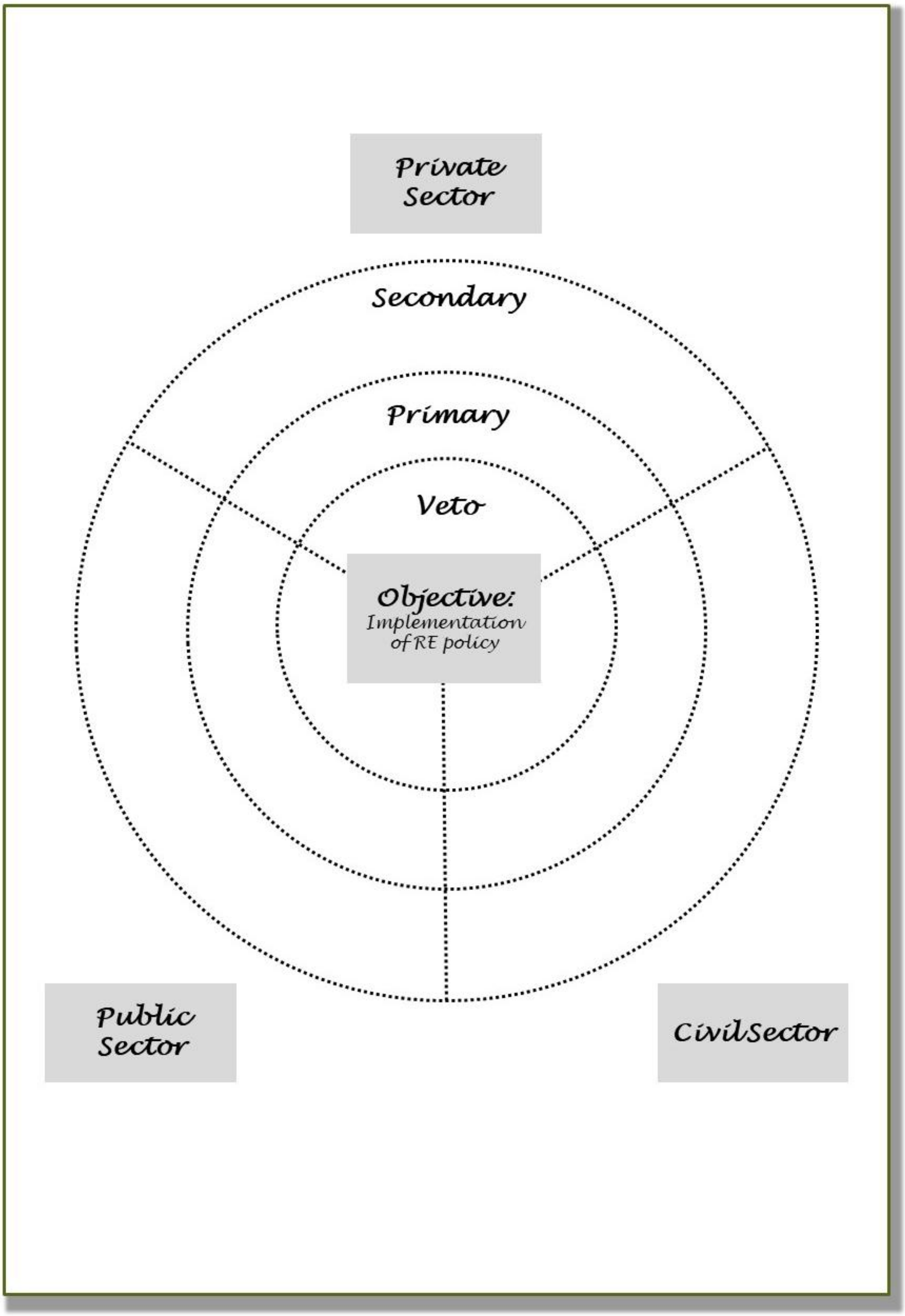
Table 2: Exercise template

Status	
Concerns	
Opportunities	

Worksheet 2

Part 2: Mapping key stakeholders

Please use the prepared flipchart to map out stakeholders and capture your results.



Module 4a

Exercise 4a.1: Terminology of material flow analysis

Task

Please read the cloze text passage below and place the appropriate word in the gap from the choices below.

Material Flow Analysis (MFA) is the study of physical _________ or _________ of ______________ into, through and out of a given ____________. It is based on methodically organised accounts in physical units, and uses the _________________________________ to analyse the relationships between material flows (including energy), human activities and environmental changes. Material flows can be analysed at various __________ and ___________ scales depending on the issue of concern and on the objects of interest of the study. The analysis can be applied to the global or the national economy, an industry, an enterprise, a city or a river basin.

An MFA gives a complete and consistent set of information about all ________ and _______________ of a particular _________ within a ____________. It connects the sources, the pathways and the intermediate and final sink of a material. Through balancing ____________ and _____________, the flows of wastes and environmental loadings become visible, and their ____________ can be identified. The _________ or ________________ of material stocks is identified to either take countermeasures or to promote further _________________.

System (2x)	Sources	Stocks	Depletion
Utilization	Flows (2x)	Output	Materials
Spatial	Material	Temporal	Principle of mass balancing
Inputs			Flux
Accumulation			

Exercise 4a.2: Defining basic steps in a material flow analysis

Estimated time requirement: 10 minutes

Introduction

Material flow analysis (MFA) is a systematic assessment of the flows and stocks of materials within a system defined in space and time. Flows in a system are based on the law of conservation of matter, thus balancing all inputs and outputs or process over a given timeframe. Analysing a system makes all flows visible and helps identify the allocation, the interactions and the stock of resources. By conducting material flow cost accounting (MFCA), the costs of different materials, substance or goods in a system can be identified. This may uncover inefficiencies and savings potentials.

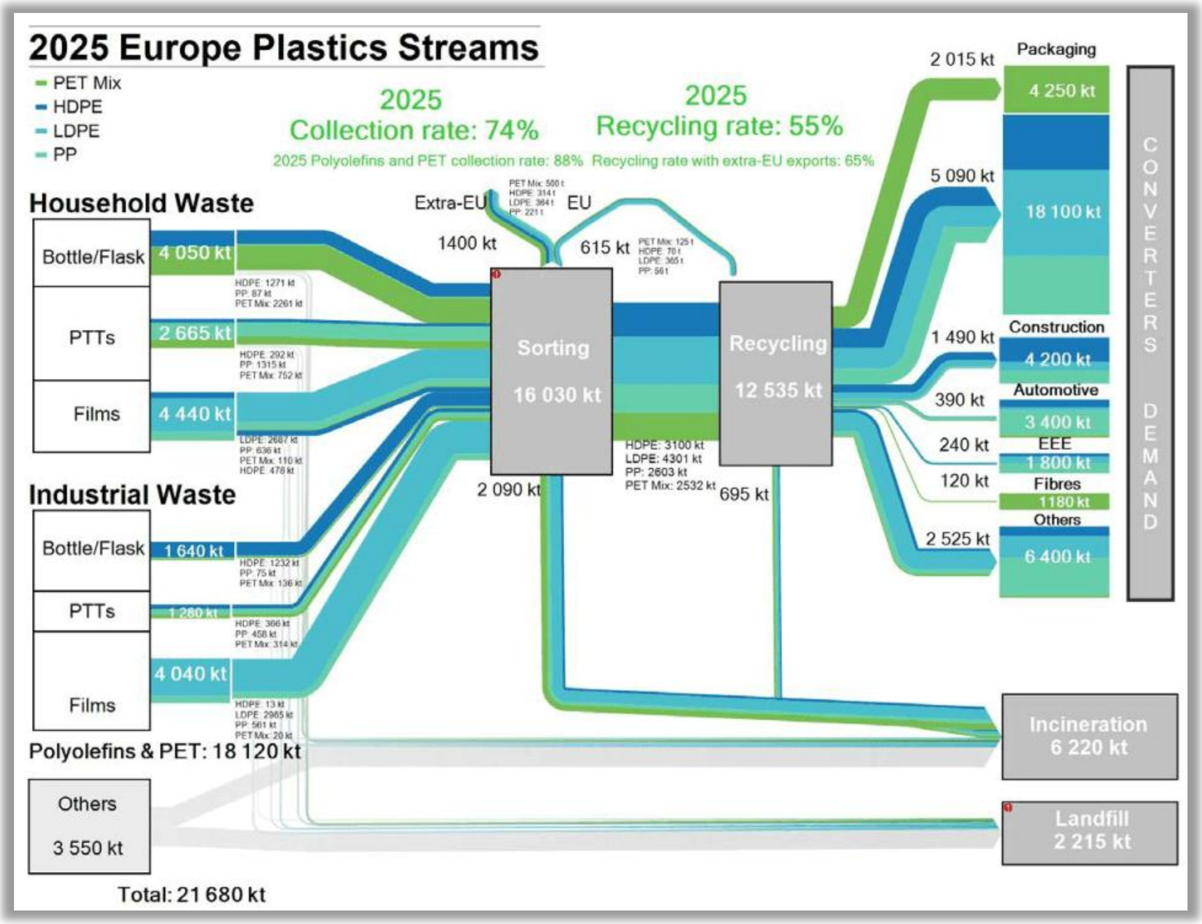


Figure 31: Example for an MFA on plastics streams in Europe in 2025

The application of MFCAs is guided by the standard „ISO 14051:2011 Environmental management — Material flow cost accounting — General framework". Similar to the structure of LCAs, the standard suggests conducting an MFCA in four steps. In step 1, the overarching problem is defined, thus outlining the context and reason for conducting the exercise. In step 2, the system is defined. Step 3 comprises the definition of material stocks and flows, followed by interpretation and illustration (step 4). It should be highlighted that the steps are interlinked and can be revisited iteratively throughout the analysis, e.g. in order to adjust the overall system, re-determine goods/substance or redefining the problem. Details steps are displayed in the figure below.

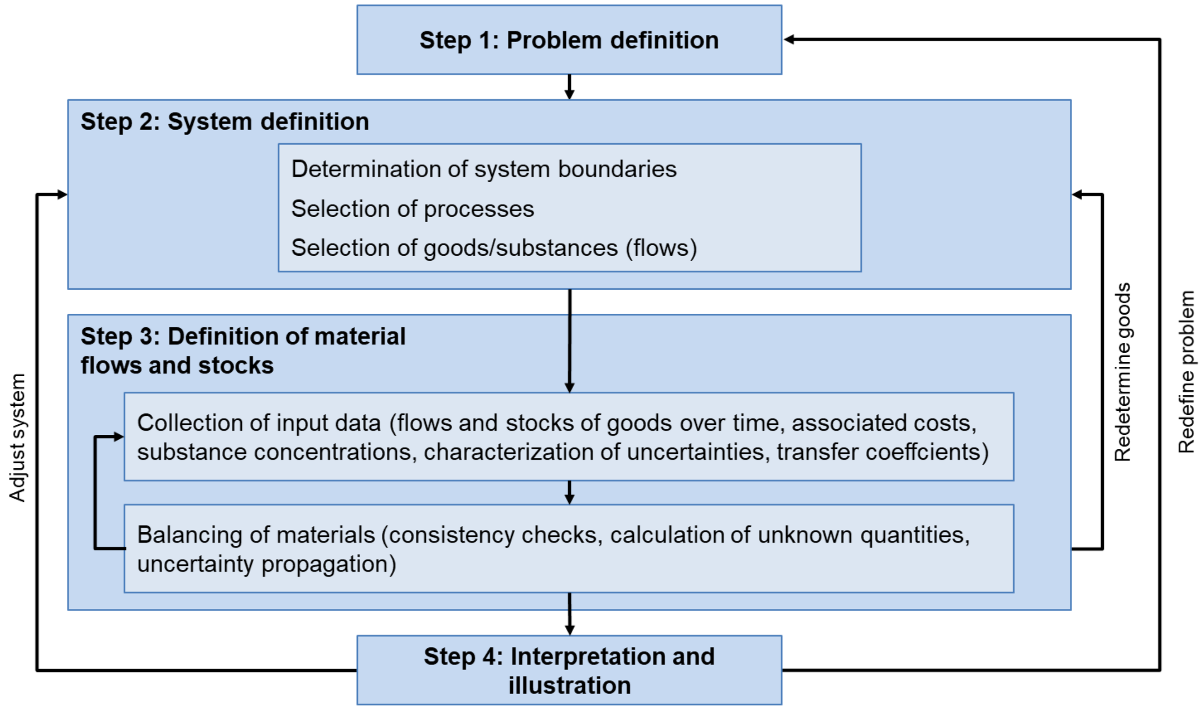


Figure 32: Steps and activities in a simplfied MF(C)A

Task

Please form groups of two to three people and examine the case study on Sainest Tubes, a manufacturer of carbon steel and seamless pipes. In June 2012, the Indian National Productivity Council followed and documented Sainest Tubes conducting an MFCA. Based on this case study, please define the activities in steps 1-4 by referring back to the MFA terminology presented (e.g. goods, flows, system boundaries). For this exercise, you should focus on the observation that “the abrasive cutting machine was running when not loaded” as well as the corresponding solution and savings as highlighted in table 1 (please ignore the investments). Results should be captured in the template below (figure 1).

Table 3: Case study Sainest Tubes

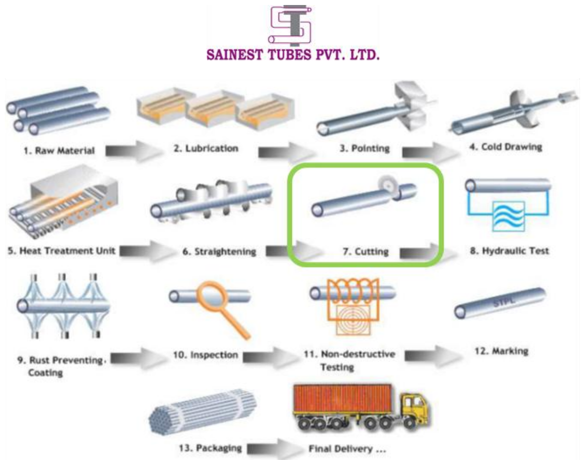
SAINEST TUBES PVT. LTD.

Observation	Solution	Investments (INR)	Savings (INR/year)
Process scrap due to insufficient gripping	Additional vertical pneumatic cylinder is attached for sufficient gripping	1,000	6,58,944
The abrasive cutting machine was running when not loaded	Switch off machine when idle	2,400	1,10,160
Insufficient cooling of annealed material, which reduces the furnace loading capacity	An additional cooling zone was introduced, so loading could be increased by 50%	35,000	78,00,000
6 Men @ unloading at blast furnace	Introduced pneumatic cylinder & 3 Men used for unloading	50,000	4,50,000

Step 1: Problem definition

Step 2: System definition

Step 3: Definition of material flows and stocks



Step 4: Interpretation and illustration

Figure 33: Exercise template

Exercise 4a.3: Material Flow Analysis of a Coffee Machine

Estimated time requirement: 80 minutes

Introduction

This exercise about Material Flow Analysis (MFA) will provide you with a better understanding about the tool and its application. Upon completion of this exercise, you will be able to describe and illustrate simple techniques of analysing and documenting material flow, identify sources of waste retrace waste and improvement potentials as well as select appropriate improvement measures, considering lifecycle implications. In addition, you will review and use different modes of visual presentations of MFA for further analysis and identification of improvement potentials.

Table 4: Structure of the exercise

Part	Tasks	Time
1	Analyse the production process described in the case study Quantify the process flows Visualise your findings using a process flow or Sankey diagram by populating the Charts A-D with data	30 min
2	Analyse the results; identify and compile at least three measures for improvement by populating table 4 Pitch the results to the “management board” (the group) by writing down your ideas on a flipchart and briefly presenting them (10 min preparation and five min presentation per group)	30 min
3	Reflect upon and re-assess the proposed improvement measures in terms of their lifecycle implications by populating table 4	20 min

Background information

Imagine that you have been engaged as a consulting team by a client who loves enjoying hot coffee in the morning, sometimes consuming several cups in course of the day. It is important to the client that the brewed coffee is of a consistent quality. The client wants your support in enhancing the efficiency in their coffee making process. As a first step, you are tasked to analyse and map out the material flows of the process, focusing on water and materials. Upon analysis, you will present your findings to the management board.

Description of process

First coffee is ground in the electrical coffee grinder (using about 400 Watts per hour). To grind one full load of coffee (about 90 g) it takes about two minutes. The ground coffee is then transferred to a coffee machine. A portion of left over coffee remains after grinding.

A single-time use paper filter is put into the percolator of the coffee machine and the ground coffee placed in the filter. Cold water is filled into the coffee maker. Once the machine is switched on, the water is pumped to a heating coil. The heated water runs through a small pipe on top of the percolator and drips onto the coffee in the filter paper. The coffee passes through the percolator and drips into the coffee pot beneath. After about fine minutes, the process is complete.

The energy consumption is about 1000 Watt per hour. The coffee is ready for consumption and can be poured into the coffee cup. One pot of coffee is sufficient for about two cups of coffee. After the process the filter paper containing wet spent coffee powder is thrown into a dustbin and replaced with a new paper filter for the preparation of the next pot of coffee.

During the process, some of the water added to the machine evaporates from the open percolator. Not all coffee in the coffee pot is actually served, since the coffee cups used by the client differ in size. Around 10% remains in the pot, each time. Since this unserved coffee gets cold quickly, it is often poured away. Based on some measurements, you have collected following additional data:

Table 5: Data points

Data point	Weight
Coffee beans (used for grinding)	90 grams
Water introduced into the coffee machine	850 grams
Dry paper filter	2 grams
Residues from grinding	2 grams
Coffee made (with concentration of 1% coffee extract)	800 grams
Residual water in coffee machine	4 grams
Evaporated water	13 grams
Coffee grounds (= wet filter and wet used coffee)	123 grams

Further analysis of the coffee grounds shows that moisture content of paper filter after use is 50% of its dry mass; the moisture content of the wet used coffee is about 50%.

For the purpose of this exercise, the packaging of the coffee and the necessary energy for the process, as well as the waste heat produced are not taken into account. The same applies for the steps of filter production, coffee planting, roasting, storing and purchasing, water treatment, disposal of the filter and drinking.

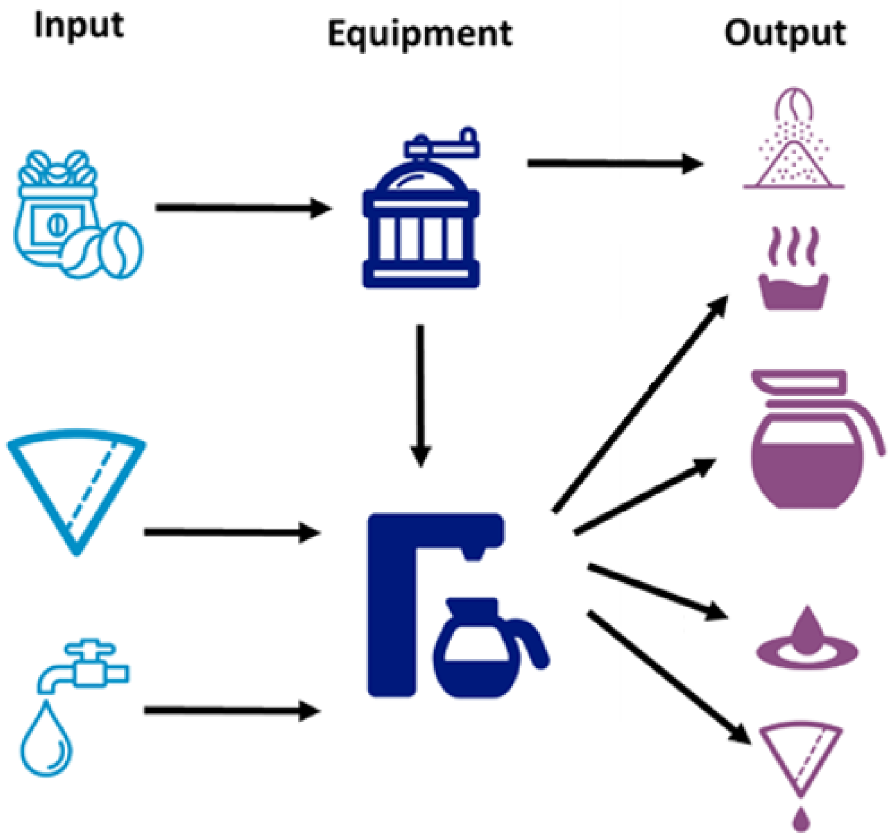
Material flows and stocks

Table 6: Input and output data

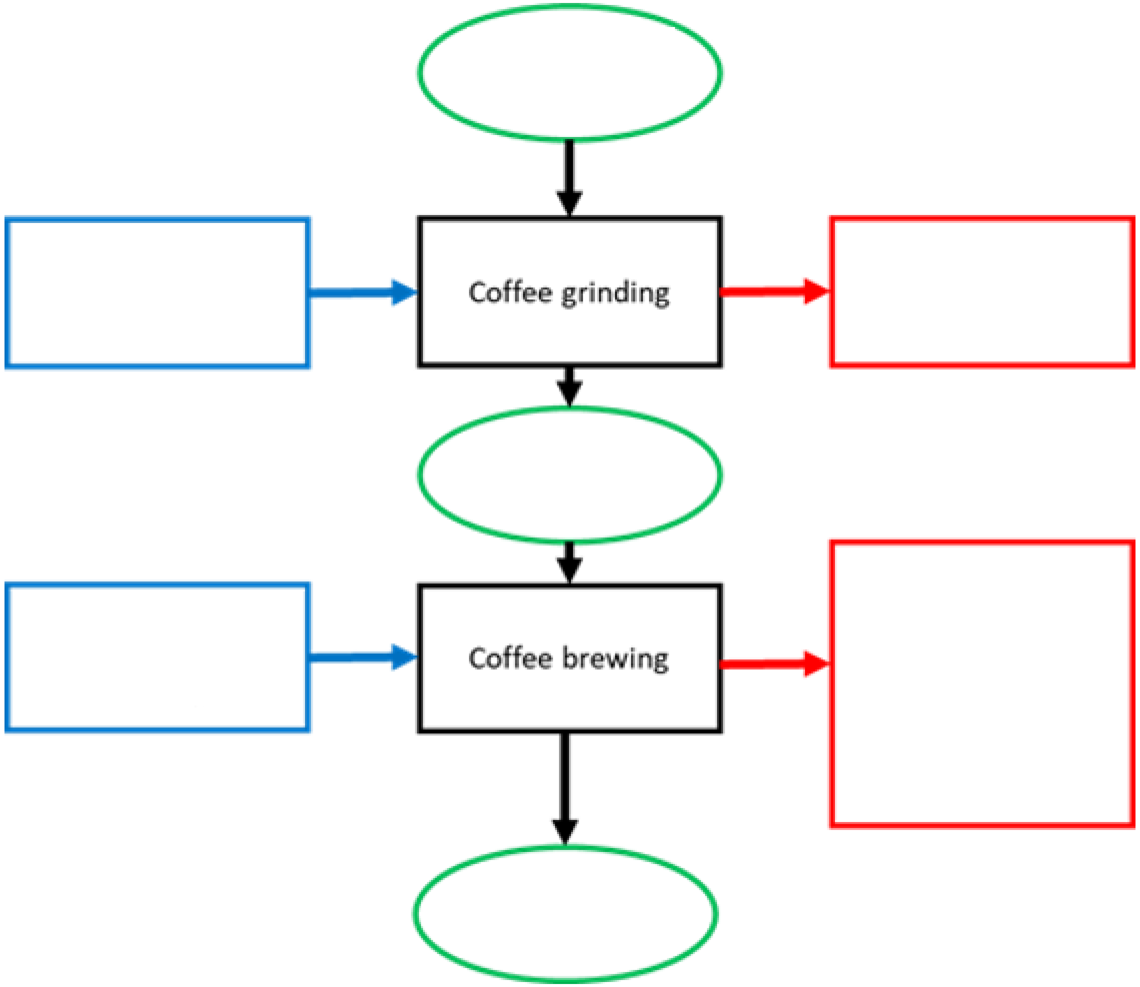
Equipment	
Balance period	
Process steps	
Input	
• **Coffee beans**	
• **Water**	
• **Dry filter**	
Input ∑	
Product output	
• **Water**	
• **Coffee extract**	
Product output ∑	
Non-product output	
Residual coffee powder (grinding)	
Coffee grounds	
• **Filter**	
• **Coffee**	
• **Water**	
Residual water in coffee machine	
Evaporated water	
Non-product output ∑	
Output ∑	

Process flow

Template chart A: overview

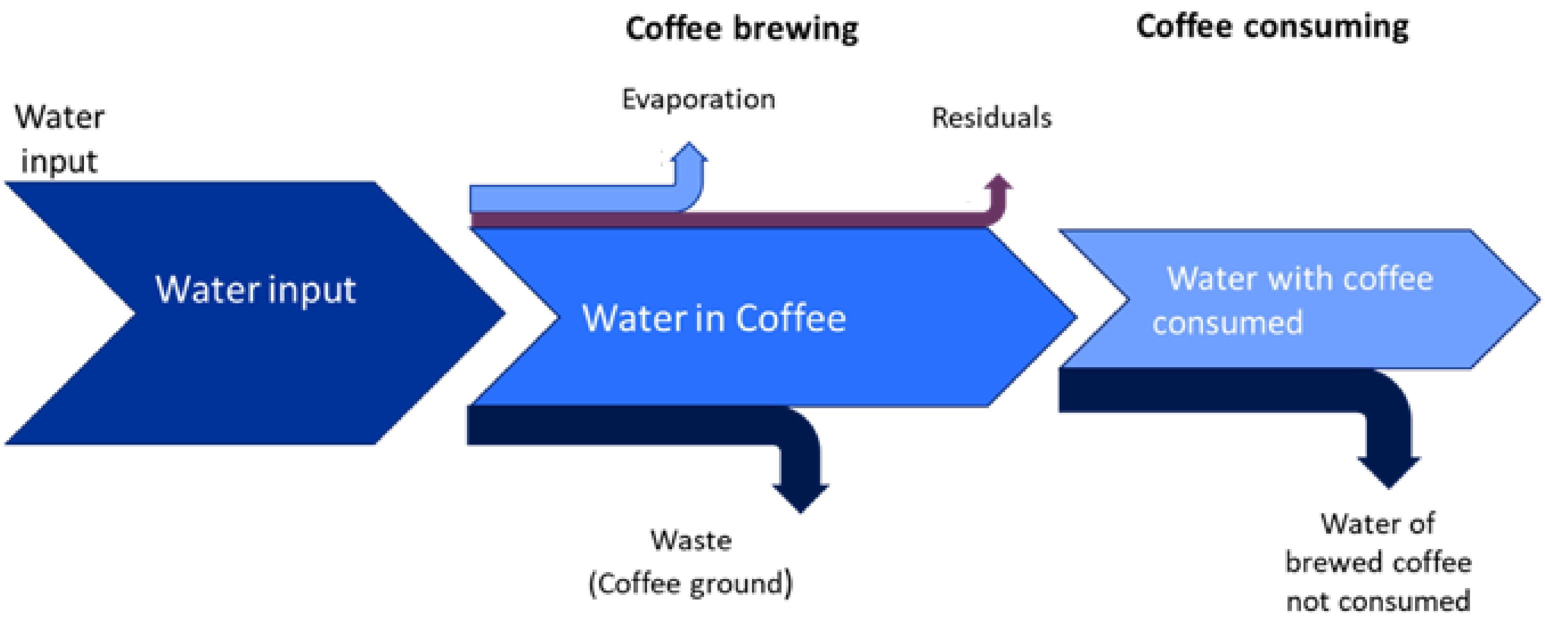


Template Chart B: overview



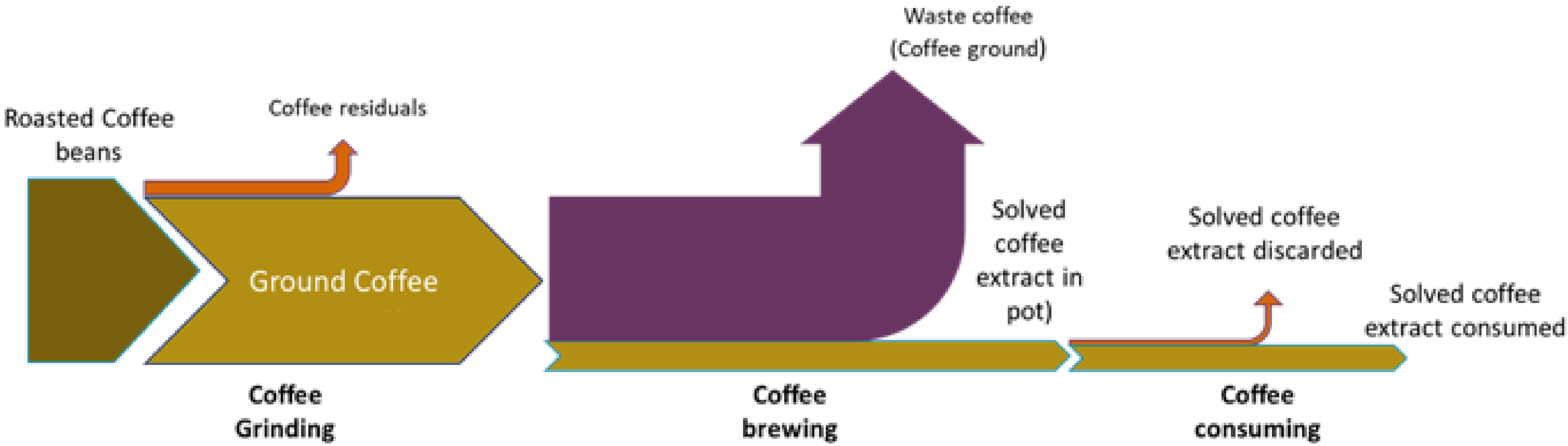
Process flow – Sankey diagram

Template chart C: Water efficiency



Process flow – Sankey diagram

Template chart D: Material efficiency (coffee)



Measures for process optimization and impacts on lifecycle stages

Table 7: Exercise template

Measures for process optimization	Impacts on lifecycle stages
Good housekeeping	
Technology modifications	
Substitution of raw and process materials	
Reduce, reuse, recycle	
Product modifications	
Other organisational measures	

Module 4b

Exercise 4b.1: Defining basic steps in a lifecycle assessment

Estimated time requirement: 10 minutes

Introduction

Lifecycle Assessments (LCAs) is a framework for assessing the environmental impacts of product systems and decisions from raw material acquisition through the end of life. A simplified lifecycle of a product typically starts with the extraction of raw materials, followed by production, distribution, consumption/use and the end of life. Typical environmental impacts analysed as part of LCAs can include (but are not restricted to) greenhouse gas emissions (e.g. measured in CO2-equivalents), water requirements (e.g. in m^3), land use requirements (e.g. in km^2) and energy requirements (e.g. in kWh).

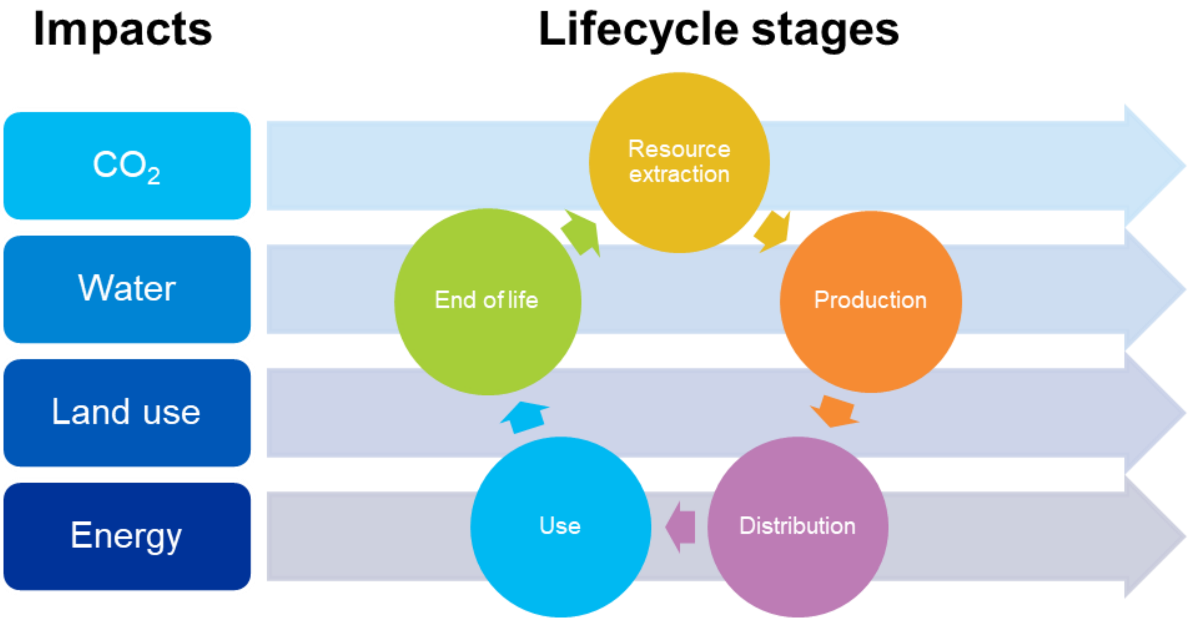


Figure 34: Conceptual framework of a simplified LCA

According to the standard “ISO14044:2006 Environmental management — Lifecycle assessment — Requirements and guidelines”, LCAs are conducted in four steps. In step 1, the goal and scope of the LCA are define. In step 2, a lifecycle inventory analysis is conducted. Step 3 comprises the actual lifecycle assessment, followed by interpretation (step 4). Details steps are displayed in the figure below.

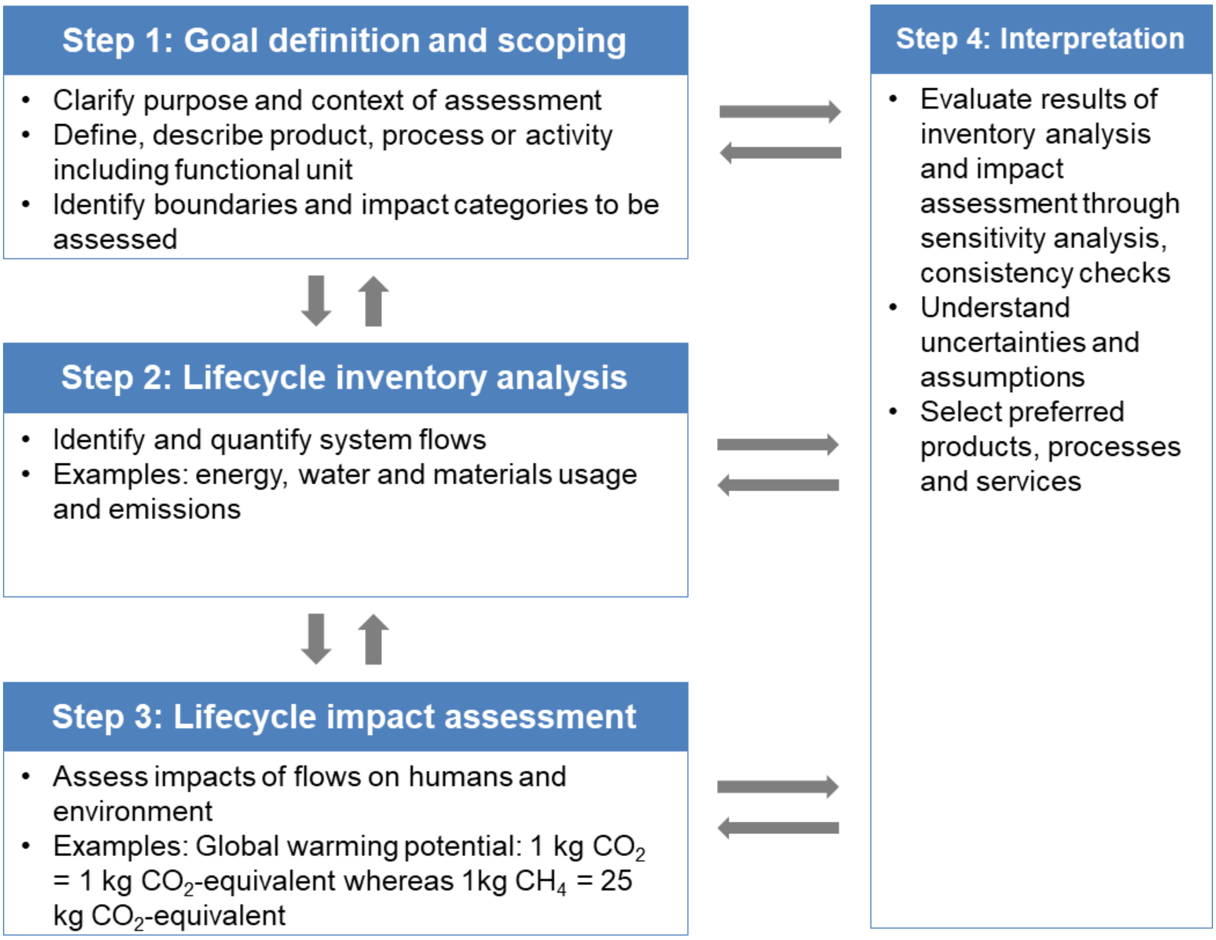


Figure 35: Steps and activities in a simplfied LCA

Task

Please form groups of two to three people and examine the template on the next page. Using the example of a comparative LCA for two mobile phones of your choice, please define the activities in steps 1-4 by referring back to the terminology presented earlier (e.g. functional unit, impact categories). Think of fictional examples in each step and capture your thoughts by using the templates displayed in figure 3 below. Note that quantities (e.g. CO2-equivalents) can be entirely fictional and will be discussed with the entire course upon completion. Finally, discuss where you expect the largest impacts to occur.

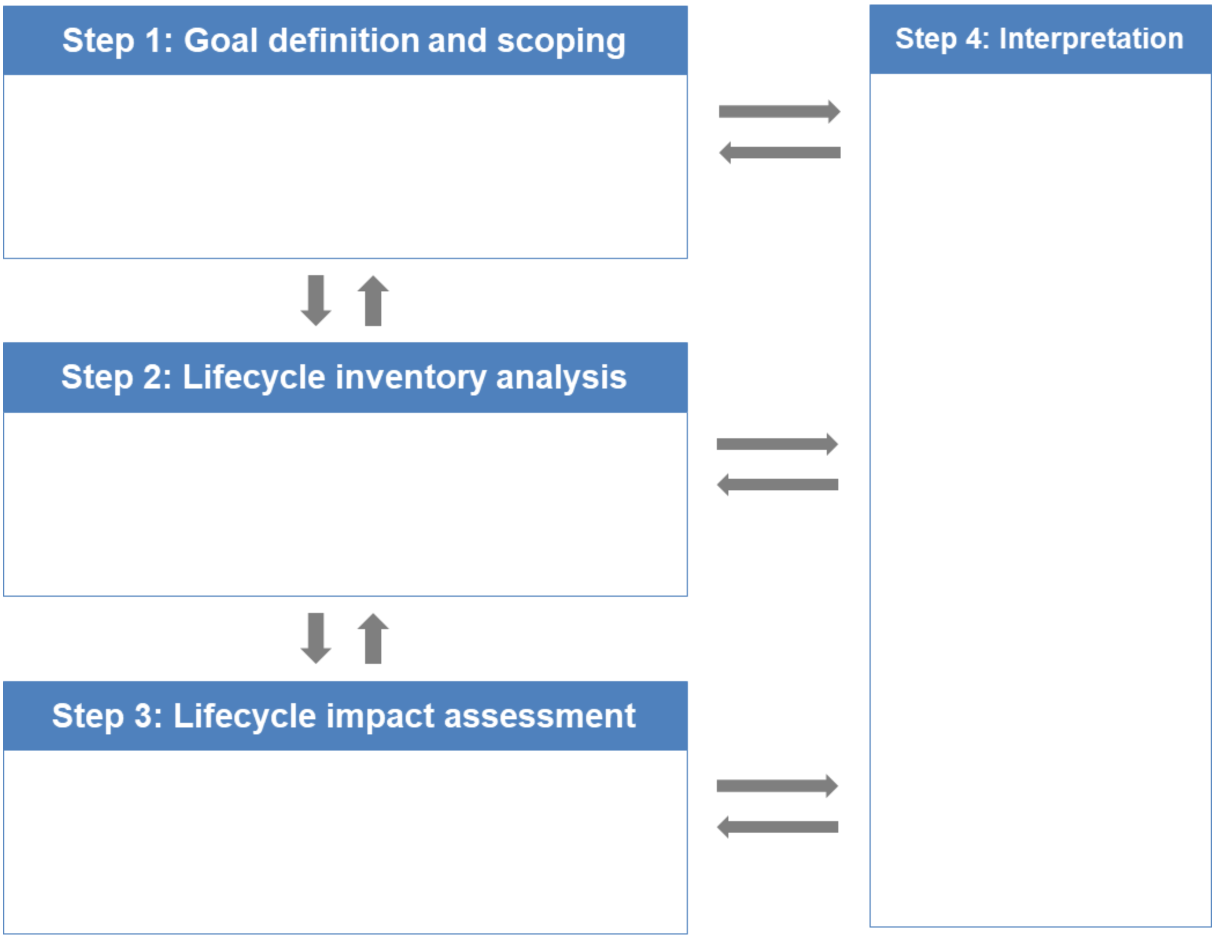


Figure 36: Exercise template

Exercise 4b.2: Lifecycle Assessment of insulation materials (1/2)

Estimated time requirement: 30 minutes

Introduction

A lifecycle assessment (LCA) is a tool, which helps to quantify environmental impacts of your product or service. By analysing the inputs (e.g. energy and raw material) and outputs (e.g. waste and emissions) that occur during a product's life cycle, the impacts on specific aspects can be assessed holistically.

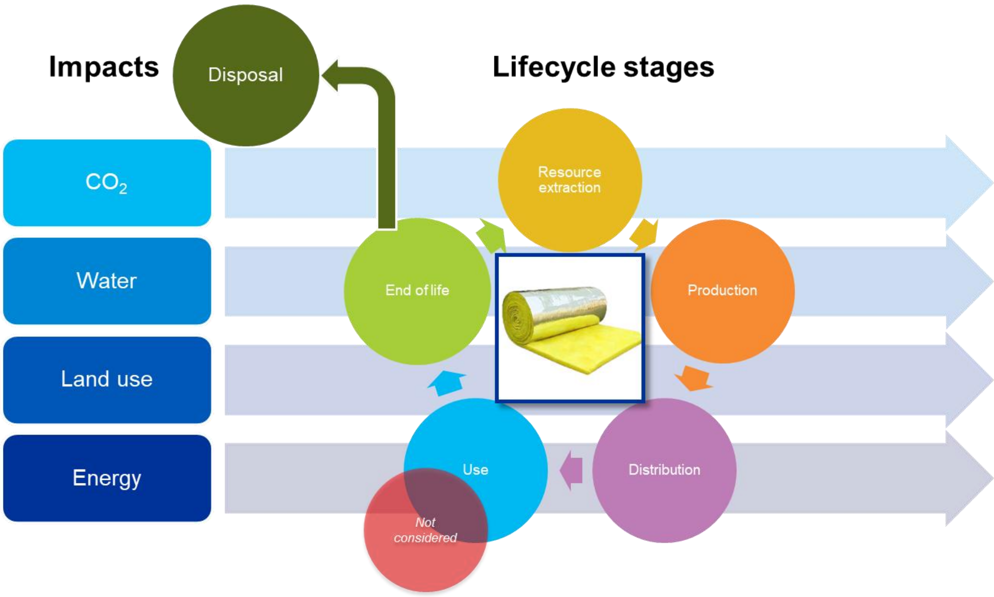
In this exercise, you will take a closer look at the impact of three different insulation materials across their life cycle. After completing this exercise, consisting of four parts, you will be able to interpret different sections of a LCA and discuss the results and the illustration of these results.

All information on the inventory derive from a study by Schmidt et al. from 2003 and have been simplified for the purpose of this exercise[4]. Please work on the following tasks individually; the results will be discussed with the group.

4 https://www.researchgate.net/publication/247152335_Comparative_life_cycle_assessment_of_three_insulation_materials_stone_wool_flax_and_paper_wool

Structure of exercise

Part	Tasks	Time
1	Please read the background information and the explanatory notes carefully. Compare the insulation material based on their functionality (according to the actual amounts of material that must be installed to achieve the thermal resistance of 1m²K/W). Note your findings on worksheet 1.	15 min
2	Rank the different product systems with respect to their different impacts levels (whereby 1=best, 2=medium, 3=worst, n/a= no information available). Use the information provided in table 2 and note your findings on worksheet 1.	10 min
3	Identify which materials have the largest and which the smallest global warming potential. Indicate your findings by labelling the x-axis on the figure of worksheet 2.	5 min



Background information

Proper insulation of buildings can save significant amounts of energy and resources and therefore can contribute to a lower demand for energy resources and a reduction in pollution emissions.

Three different insulation materials for attics were assessed according to their impact during their life cycle to compare the global and regional emissions and environmental impact, as well as potential health effects:

Stone wool insulation	Flax insulation	Paper wool insulation
•Briquettes produced from natural rocks (low energy requirements) •Mixed with industrial waste (e.g. recycled material from cement and steel production) •Binder and impregnation oil are added in small amounts to achieve desired technical properties •Product is cured in a polymerization chamber and finally cut into the desired dimensions. •Medium energy requirements of production process •Finished insulation material: widely homogenic •Used in construction sector: frequently	•Based on flax plant (*Linum usitatissimum*) •Large-scale agricultural production •Large amounts of additive material needed to achieve the requested and desired technical properties (mostly polyester, also diammonium hydrogen phosphate and borax) •Binder materials are melted and then mixed with flax raw material during production process •Finished insulation material: no uniform product •Used in construction sector: most sold product based on recycling material	•Based on shredded newsprint •Additives like Aluminium hydroxide, borax and boric acid needed to achieve the requested and desired technical properties. •Newsprint industry and the paper wool industry draws from the same pool of resources: every kilo of old newsprint leaving the system must be replaced by a corresponding amount of virgin fibers •Final production under medium energy demands •Finished insulation: small differences in the recipes, larger differences for production of newsprint, paper recycling schemes may differ significantly •Used in construction sector: most sold product based on “grown” biomaterial

Explanatory notes

Table 8: Explanatory notes

Lifespan	• Expected to be 50 years. • By the end of life of the material a basic scenario of low-grade recycling (e.g. incineration or composting) was assumed due to uncertainties regarding future disposal technologies.

<table>
<tr><td>Functional Unit</td><td>

- Described by the ISO 14040 is the “the quantified performance of a product system for use as a reference unit in a life cycle assessment study”.
- In this case: the amount of insulation required for an additional thermal resistance of $1\ \frac{m^2K}{W}$ over the lifespan of the materials. The functional unit values for each material are as follows:

Material	Functional Unit (kg)	Corresponding insulation thickness (mm)
Rock wool	1.184	37
Paper wool	1.280	40
Flax	1.260	42

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<tr><td>Environmental impact categories</td><td>

- **Global warming potential**
  - As g CO_2-equivalent
  - Also accounts for emissions of other greenhouse gases, as methane (CH_4) and nitrous oxide (N_20)
- **Acidification**
- **Nutrient enrichment**
- **Waste generation**
  - Generation of solid waste
  - Generation of hazardous waste
    - ➢ Both aspects included only to a limited extend due to a high level of uncertainty during data acquisition
- **Energy consumption**
  - Fossil fuels (incl. feedstock)
    - ➢ Includes consumption of mineral resources during the production phase!
  - Renewable fuels
  - Electricity
  - Total energy consumption
- **Water consumption**
    - ➢ Included only to a limited extend due to a high level of uncertainty during data acquisition
- **Health aspects**
  - Carcinogenicity (tested with animals)
  - Lung disease

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<tr><td>Lifecycle stages</td><td>

- For this comparison the following lifecycle stages were included:
  - Production,
  - packaging and transportation,
  - installation and,
  - dismantling and disposal phase.
- 50-year use phase was excluded as it was assumed that no interventions would be necessary during that time.
- All three material perform about equally well in terms of the insulation properties.
- Despite their environmental performance during all the lifecycle stages each of the

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	material has overall a positive environmental performance as the energy savings through insulation overweigh.

Table 9: Life cycle impacts for the three material to fulfill the same functional unit

Impact category	Unit	Stone wool	Flax	Paper wool
Global warming potential	g CO_2-equivalent	1449	2357	819
Acidification	g SO_2-equivalent	12.3	17	5.5
Nutrient enrichment	g NO_3^- equivalent	12.0	12.6	5.5
Generation of solid waste	g non-hazardous waste	53	122	30
Generation of hazardous waste	g hazardous waste	0.5	0.4	1.7
Energy consumption				
Fossil fuels (incl. Feedstock)	MJ	14.61	27.84	6.75
Renewable fuels (incl. Feedstock)	MJ	1.07	15.31	15.35
Electricity	MJ	3.07	6.58	4.14
Total energy consumption	MJ	20.75	49.73	26.24
Water consumption	g water	3907	5771	822
Health aspects				
Carcinogenicity	Animal evidence	Yes	Not tested	Yes
Lung disease (non-malignant)	Human evidence	No	Yes	Not tested

Worksheet 1

Task 1: Compare the insulation material based on their ***functionality*** (according to the actual amounts of material that must be installed to achieve the thermal resistance of 1m²K/W).

1. Best functionality: ……………………………………
2. Medium functionality: ……………………………………
3. Lowest functionality: ……………………………………

Task 2: Rank the different product systems with respect to their different impacts levels (whereby 1=best, 2=medium, 3=worst, n/a= no information available). Use the information provided in table 2 and note your findings in the table below:

Table 10: Ranking of the three insulation materials with respect to different impacts

Impact category	**Unit**	**Stone wool**	**Flax**	**Paper wool**
Global warming potential	g CO_2-equivalent			
Acidification	g SO_2-equivalent			
Nutrient enrichment	g NO_3^-equivalent			
Generation of solid waste	g non-hazardous waste			
Generation of hazardous waste	g hazardous waste			
Energy consumption				
Fossil fuels (incl. Feedstock)	MJ			
Renewable fuels (incl. Feedstock)	MJ			
Electricity	MJ			
Total energy consumption	MJ			
Water consumption	g water			
Health aspects				
Carcinogenicity	Animal evidence			
Lung fibrosis (inhalation)	Animal evidence			
Lung disease (non-malignant)	Human evidence			
Cancer (IARC)	Human evidence			

Worksheet 2

Task 3: Identify which materials have the largest and which the smallest global warming potential. Indicate your findings by labelling the x-axis on the figure below:

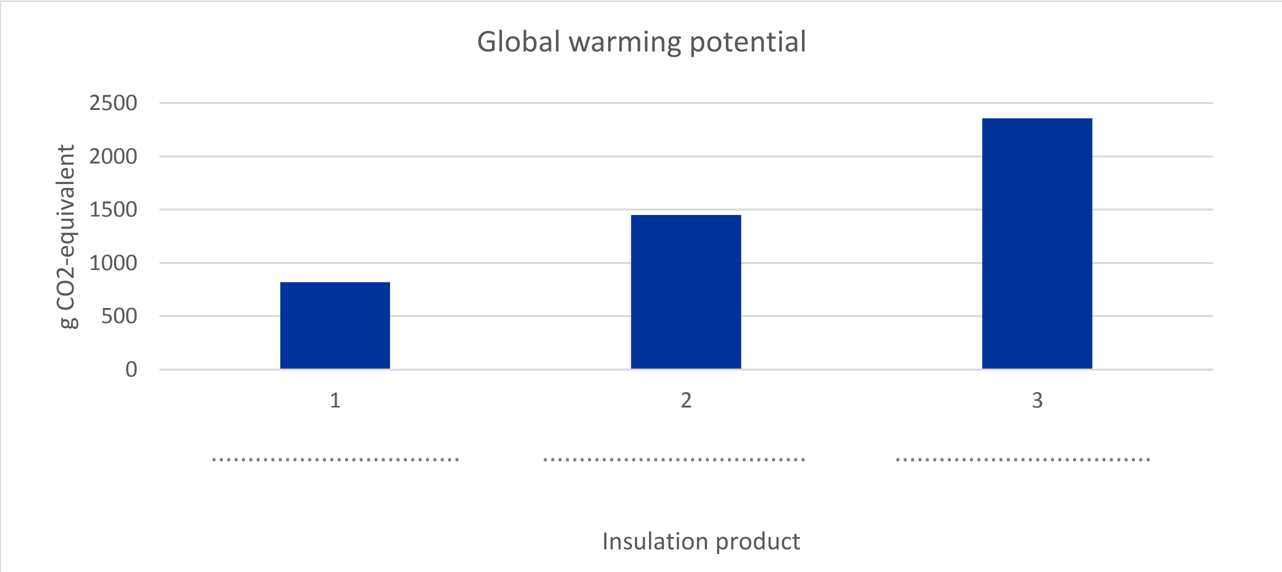


Figure 37: Global warming potential of the individual insulation products

Exercise 4b.2: Lifecycle Assessment of insulation materials (2/2)

Estimated time requirement: 20 minutes

Introduction

This second part on lifecycle assessments (LCA) will focus on the material with the biggest global warming potential: flax insulation.

Please form groups of four to five persons and work on the task below.

Part	Tasks	Time
4	Simplified overview of the life cycle of flax insulation products is presented in the figure in the background information, as well as Inventory results for emissions to air for the three insulation materials. Analyse the provided information and discuss possible reasons for the high impact potential of flax. Identify lifecycle stages that have particular high impact. Note your findings on worksheet 3.	20 min

Flax insulation

- Based on flax plant (*Linum usitatissimum*)
- Large-scale agricultural production
- Large amounts of additive material needed to achieve the requested and desired technical properties (mostly polyester, also diammonium hydrogen phosphate and borax)
- Binder materials are melted and then mixed with flax raw material during production process
- Finished insulation material: no uniform product
- Used in construction sector: most sold product based on recycling material

Background information

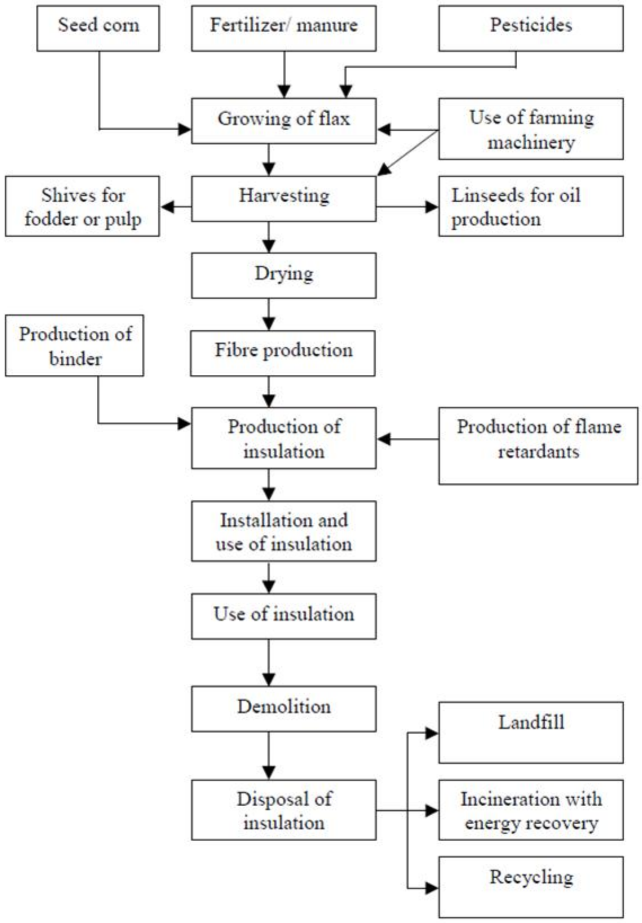


Figure 38: Simplified overview of the life cycle of flax insulation products (Source: Schmidt et al. 2003)

Table 11: Inventory results for emissions to air for the three insulation materials

Emission to air	Unit	Stone wool	Flax	Paper wool
CO_2 (fossil)	g	1421	2142	805
CO	g	105	2.0	1.0
SO_x	g	6.08	11.57	2.88
No_x	g	2.47	7.44	3.74
N_2O	g	0.02	0.41	0.01
CH_4	g	1.04	4.19	0.57
HCl	g	0.06	0.04	0
H_2S	g	0.03	0	0
Ammonia	g	2.37	0.02	0
Hydrocarbons (except CH_4)	g	0.21	2.2	1.22
VOC	g	0.7	0.85	0.39
Particulates	g	1.19	1.54	5.08

Worksheet 3

Task 4: Analyse the provided information and discuss possible reasons for the high impact potential of flax. Identify lifecycle stages that have particular high impact.

Space for your notes

Module 4c

Exercise 4c.1: Discussing Standards

Estimated time requirement: 20 minutes

Introduction

Standards are an essential part of modern everyday life. They generally be defined as documents, established by consensus and approved by a recognized body, that provide rules, guidelines or characteristics for activities or their results for common and repeated use. Standards aim at the achievement of the optimum degree of order in a given context, for example with regard to resource use in manufacturing consumer products. From an economic point of view, standards offer a wide range of general advantages but can also create disadvantages if used improperly.

Structure of exercise

Please form groups of two to three people and discuss the general advantages and disadvantages of standards from an economic point of view. Use the table below to capture your findings.

Advantages	Disadvantages

How are standards relevant to RE and CE? Please provide a brief written answer.

Exercise 4c.2: Environmental checklist

Estimated time requirement: 30 minutes

Introduction

When writing a product standard, it is important to evaluate how products can affect the environment. Ideally, such evaluation is conducted as early as possible in the process of standard development. In order to facilitate this evaluation, the European Union's CEN Environmental Helpdesk (CEN/EHD) has developed various support tools. One key tool an environmental checklist, which can guide working groups in identifying aspects during the standards development process.

Structure of exercise

Please form groups of two to three people and analyse the background text carefully with regard to the impacts along the lifecycle stages of clay bricks. Based on the background text above, go through the checklist in table 1 below and identify the environmental aspects relevant to the product (reference flow: 1 kg of clay brick). Fill in each box if there are significant product environmental inputs and outputs by using the information presented in the text above. In addition, please fill in other relevant aspects and provide at least three recommendations on how to include environmental considerations in the comments section.

Background

You have recently joined Technical Working Group (TWG) RECE-2025 for revising the European standard "CEN -EN 771-1: Specification for masonry units - Part 1: Clay bricks" with special regard to environmental considerations. During the inception meeting of the TWG, it was agreed to identify potentials for including environmental specifications by analysing the lifecycle of a standardised clay brick based on publicly available LCA data from the University of Pretoria, South Africa. Following this LCA, the environmental impacts are illustrated by using impact category indicators (e.g. emissions as kg of CO_2 equivalent, water, land use and energy) in order to compare results and understand critical processes and resources.

Note: The information presented in the text below has been modified and simplified for the purpose of this exercise. Details about the original LCA can be found on the following webpage: http://claybrick.org/ An illustration of the lifecycle stages of a clay brick is presented in the figure below. All environmental impacts are normalized to a reference flow of 1 kg of clay brick.

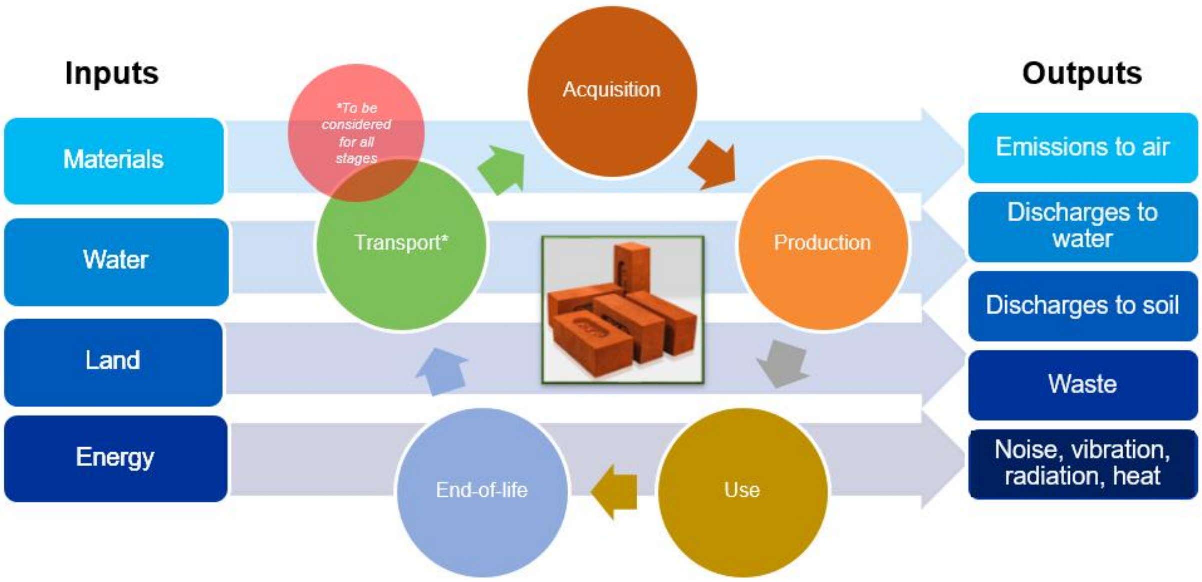


Figure 39: Simplified lifecycle of a clay brick

Lifecycle of a clay brick

The main component of the bricks is clay, which is mined from open cast mines usually during periods of little rainfall. 1 kg of clay bricks results in 0.15 m³ of tailings during raw material extraction at the mining site, 0.38 l of water consumption and 0.018 kWh of energy (resulting in 0.06 kg of $CO_{2\text{-eq}}$ emissions). The mined clay is stockpiled for a number of weeks to allow it to weather. This weathering eases the subsequent milling process and helps to save energy. The clay particles are reduced in size by milling and mixed with additives to lower salinity and increase plasticity, requiring 0.01 kWh of energy and emitting 0.02 kg $CO_{2\text{-eq}}$ in the process.

The dry mix is then transported (requiring 0.002 kWh of energy and emitting 0,004 kg $CO_{2\text{-eq}}$) to the manufacturing facility. Subsequently, 0.08 l of water is required for dust settling and irrigation within the factory. After forming of the bricks, drying is required (using 0.015 kWh of energy and emitting 0.03 kg $CO_{2\text{-eq}}$). To make bricks more durable they are burnt in a tunnel kiln. Tunnel kilns are continuously fired and brick packs move in the course of 48 to 72 hours through various temperature zones. Maximum firing temperature can vary from 1,050 °C to 1,180 °C whereby 0.026 l fresh water per brick is used. Further, 0.012 kWh of energy are needed and the production processes emits 0.16 kg of $CO_{2\text{-eq}}$.

The finished clay bricks are transported from the production facility to the construction site together with other building materials. Besides gasoline for the vehicle during transport (4.03 kWh, 0.84 kg $CO_{2\text{-eq}}$), the construction of a brick wall requires 0.05 m² per 1 kg of brick. For the purpose of this LCA, it is assumed that the brick wall will require no maintenance over its lifespan and no resources are required in the use phase of the product. At the end of life, the brick wall is demolished. From 1 kg of clay brick, an average of 63.3 % is landfilled and 36.7% is recycled. During demolition and landfilling, emissions of 2.34 kg $CO_{2\text{-eq}}$ are released and 14.88 kWh of energy are consumed. The land use requirements of landfilling translate into 0.0717 m². For demolition and recycling only 0.0007 m² of land are needed. In addition, total of 0.34 kg $CO_{2\text{-eq}}$ are emitted and 1.45 kWh of energy are used during recycling.

Table 12: EU Environmental Checklist

Technical working group:				Title of standard:				Date of last modification of the environmental checklist:			
Environmental Issue	**Stages of the lifecycle**										**All stages**
	Acquisition		**Production**		**Use**			**End-of-Life**			
	Raw materials and energy	**Pre-manu-factured materials & components**	**Production**	**Packaging**	**Use**	**Maintenance and repair**	**Use of additional products**	**Reuse/ Material and Energy Recovery**	**Incineration without energy recovery**	**Final disposal**	**Transportation**
Inputs											
Materials											
Water											
Energy											
Land											
Outputs											
Emissions to air											
Discharges to water											
Discharges to soil											
Waste											
Noise, vibration, radiation, heat											
Other relevant aspects											
Risk to the environment from accidents or unintended use											
Customer information											
Comments:											

NOTE 1 The stage of packaging refers to the primary packaging of the manufactured product. Secondary or tertiary packaging for transportation, occurring at some or all stages of the lifecycle, is included in the stage of transportation.

NOTE 2 Transportation can be dealt with as being a part of all stages (see checklist) or as separate sub-stage. To accommodate specific issues relating to product transportation and packaging, new columns can be included and/or comments can be added.

Module 4d

Exercise 4d.1: Assigning macro-level resource use indicators

Estimated time requirement: 20 minutes

Introduction

Indicators are important instruments for monitoring and evaluating the progress made towards resource efficiency and circular economy. While indicators can be used at various levels (micro, meso, macro), many countries have started to define metrics for measuring resource use at the national level. Resource use indicators are essential to conducting Material Flow Analysis (MFAs), which typically distinguishes between six different kinds of metrics: total material requirement (TMR), total material input (TMI), direct material input (DMI), domestic material consumption (DMC), total domestic output (TDO) and total material output (TMO). For definitions, please have a look at table 1. When measuring a country's GDP in relation to its DMC, we can derive an indication about the degree of resource productivity and economic decoupling. To account for the indicators various data sources can be used. Most material flows are statistically observed, while other, indirect flows associated to exports or imports must be estimated. After completing this exercise, you will be familiar with the terminology of resource use indicators and with possible data sources to determine material flows.

Structure of exercise

Part	Task	Time
1	Please form groups of two to three people and examine the template on the next page. Based on the definition presented in table 1, please allocate the six macro-level indicators (TMO, TMI, DMC, TDO, DMI, TMR) to the slots 1-5 in figure 1 on worksheet 1.	10 min
2	Material inputs and output can be accounted for by using various data sets. Examples are listed on worksheet 2. Allocate the examples of data sets to each category: i) material inputs and ii) material outputs. Add two additional data sets to each category respectively.	10 min

Background information

Indicator	Definition
Total material requirement (TMR)	= Indirect flows of imports + imports + used domestic extraction + unused domestic extraction
Total material input (TMI)	= Total material requirement - indirect flows of imports
Direct material input (DMI)	= Total material input - unused domestic extraction
Domestic material consumption (DMC)	= Direct material input - exports
Total domestic output (TDO)	= Domestic material consumption + unused domestic extraction
Total material output (TMO)	= Total domestic output + exports

A country‘s **resource productivity index** can provide insights into the degree of **economic decoupling**:

- **Consumption-based** resource productivity index = GDP/DMC
- **Production-based** resource productivity index = GDP/DMI

Figure 40: Definitions of resource use indicators applied in MFAs

Worksheet 1

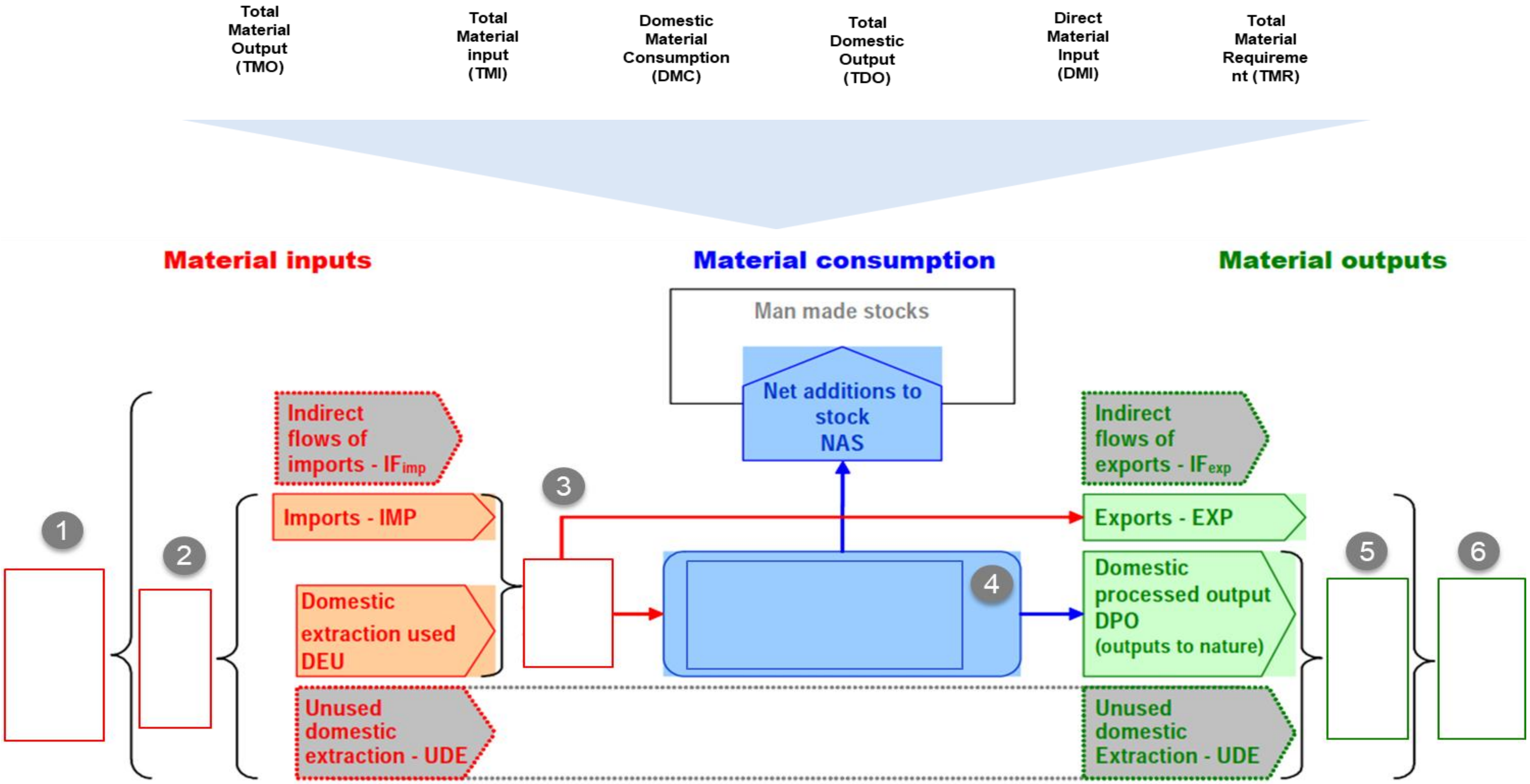
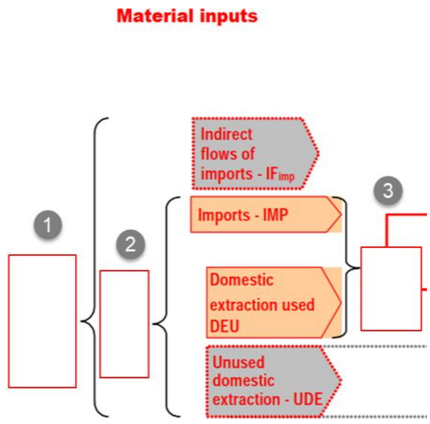


Figure 41: Exercise template for allocation of resource use indicators (adapted from: https://www.oecd.org/environment/indicators-modelling-outlooks/MFA-Guide.pdf)

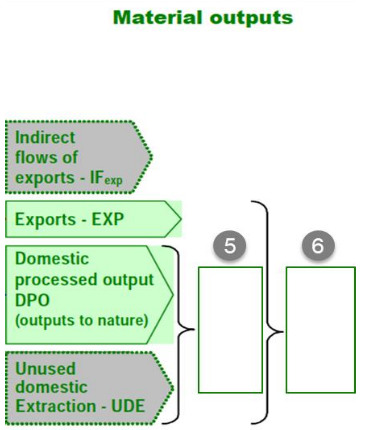
Worksheet 2

Data Sources

Agricultural statistics (cereals, vegetables etc. produced)	Environmental accounts for air emissions	Energy statistics and balances (extraction of fuels)
Energy statistics (emission inventories)	Forestry statistics (timber harvested)	Agricultural statistics for fertilizer use



Data Sources for Material Input:



Data Sources for Material Output:

Exercise 4d.2: Applying the Circularity Calculator

Estimated time requirement: 30 minutes

Introduction

“What gets measured, gets done” is a popular management mantra. While the origins of this saying are debated, it is of utmost importance for contemporary management education. In fact, literature is teeming with management handbooks which provide ample advice on how to measure, monitor and evaluate business or product performance. In 2015, the British home improvement company Kingfisher launched a project to develop an indicator which would allow to capture the circularity performance on a product level. Based on the resulting indicator system, researchers from the University of Bath, United Kingdom, developed a circularity calculator.[5]

After completing this exercise, you will be familiar with the methodology and different aspects of the circularity calculator. You will also be able to describe strengths and limitations of the tool.

Structure of exercise

Part	Task	Time
1	Please form groups of up to two to three people and examine the two case studies on the next page. Use the information on the Circularity Indicator system presented in table 1 and score both products based on the product descriptions below. Enter your scorings in table 3 on Worksheet 1.	20 min
2	Discuss the following questions in your group and note your findings on the flipchart. Guiding questions: • Does the methodology capture all necessary circularity aspects and if not, which aspects are missing? • Are the weightings (max scores) adequate or how should they be changed? • Which of the criteria did you find most difficult to assess and why?	10 min

[5] Source and further information: https://iris.unive.it/retrieve/handle/10278/3688992/104510/Int_J_Sustainable_Eng_06_2017.pdf

Background information

The indicator system is comprised of a number of variables along a product's lifecycle. In order to assess a product's performance, each variable is assigned with a guiding question and is measured on a weighted scale. Overall, a product can score a maximum of 152 points, indicating highest circular performance. Using this weighted scale, the indicator system is somewhat more qualitative in nature as it requires experts' inputs in order to translate a product's performance into a measurable format. Table 1 presents the indicator system including its weighting and guiding questions.

Table 13: Circularity Indicator

Lifecycle stage	#	Guiding question	Max. Score
Design	1	Is the product made from recycled/reused material?	20
	2	Is the product lighter than its previous version?	2
	3	Is there a complete bill of materials and substances for the product?	5
Production	4	Is there a complete bill of energy for the manufacturing process?	10
	5	Is there a complete bill of solid waste for the manufacturing process?	15
Commercialization	6	What packaging is being used?	5
	7	What is the product's warranty?	10
	8	Is there a rental option for the product?	15
In use	9	Can the usage status and identification of the product be established?	15
	10	Can the product be repaired?	5
	11	Can the product be reused?	10
	12	Does the product help to reduce waste through its use?	5
End-of-life	13	What take-back scheme is available for this product?	15
	14	Is the product separated out from other products at the end of its life?	10
	15	Are the product's materials passed back into the supply chain?	10

Marudhar Caffeinated Caps Pvt. Ltd. is a fictional producer of coffee capsules based in Kalinganagar, Odisha. The company was established in 2011 and has quickly become a market leader, supplying customized single-use coffee capsules to global players in the foodstuffs industry (e.g. Mestlé). By adopting an ambitious Corporate Social Responsibility strategy, Marudhar Caffeinated Caps has embarked on a mission to continuously improve the quality of their products, increase material efficiency and reduce impacts on the environment. As part of its research and development program the company has recently launched a reusable coffee capsule. A detailed comparison of the disposable "Chug'n'Chuck" and new "KeepCap" capsules is presented in table 2.

Table 14: Comparison between "Chug'n'Chuck" and "KeepCap" capsules

	"Chug'n'Chuck" capsules 	**"KeepCap" capsules** 
Design	The disposable capsules are made from 100% virgin multi-layer plastics. Coloured coatings are used to distinguish and market different types of coffee (e.g. Cappuccino, Espresso). Marudhar Caffeinated Caps approached their suppliers of coatings agents to identify the types of substances used in the production of different colours. After two years of consultations and discussions, the suppliers submitted a bill of substances, however, without specifications about the exact formula.	The outer shell accounts for 35% of the total product weight and is made entirely from recycled stainless steel. The sieve-cap and inner shell are made from virgin stainless steel. The rubber sealing is directly sourced from an organic farm in Tamil Nadu. A complete bill of materials used can be found on the company's website.
Production	The capsules are formed by thermoforming multiple layers of plastics to 1.25 mm thickness. Solid waste production and energy consumption is monitored on a company level. A material flow analysis indicated that material losses of 5% (waste) occur during the manufacturing process, mainly owing to offcuts and occasional quality rejects.	The capsules are formed by applying hydraulic pressure to sheets of stainless steel of 0.75 mm thickness for sieve-cap, outer and inner shells. Since the KeepCap was launched only two months ago, estimations for the generation of solid waste and energy usage in the production process do not yet exist.
Commercialization	Capsules are sorted by colour, stacked in hundreds, bailed in single-use plastics (foil) and delivered to customers where they are filled and sealed. Capsules are packaged in printed cardboard boxes (100% virgin fibres) of ten and sold to end-consumers via online channels and stores. No warranty is given due to the products' single-use character.	The components of the capsules (sieve-cap, inner shell, outer shell) are individually wrapped in single-use plastics (LDPE, non-recycled) and subsequently boxed in small carton boxes (100% recycled materials). The product is directly marketed via Marudhar Caffeinated Caps' online shop and retail outlets. A warranty of one year on heat-induced deformations to the outer and inner shell is provided.
In use	Marudhar Caffeinated Caps are made for singular use and replace previous coffee making practises such as filter coffee. The company has no further information about the use phase of the product.	The product is designed to be long-lasting and reusable, serving at least 2,500 individual coffee servings throughout its lifetime. Marudhar Caffeinated Caps has no further information about the use phase of the KeepCap. However, contact details of customers ordering via the company's online shop are available. In case of damage, the products individual components (outer and inner shell, sieve-cap and rubber sealing) can be replaced.
End of life	Since Chug'n'Chuck capsules are entirely made of plastic, they are subject to Extended Producer Responsibility (EPR) systems across most of the core markets (e.g. through the Packaging and Packaging Waste Directive in the EU). This includes the obligation of collection and, in some parts, recycling rates (e.g. 70% by 2030 in the EU). After using, the spent coffee ground stays in the capsule and needs to be scooped out manually by the consumer to ensure separation at source.	Marudhar Caffeinated Caps has evaluated the introduction of a take-back scheme but found it too uneconomical due to low volumes and long latency periods in the rate of return. Consumers are not expected to remove the rubber sealing prior to disposal. Most of the KeepCaps core markets are characterised by comparatively well developed collection infrastructure combined with automated separation into metallic and non-metallic fraction. In addition, steel recycling rates in many markets have recently met an all-time high (e.g. 79.5% in the EU).

Worksheet 1

Table 15: Exercise template

Lifecycle stage	#	Max score	Score of “Chug’n’Chuck” capsules	Score of “KeepCap” capsules
Design	1	20		
	2	2		
	3	5		
Production	4	10		
	5	15		
Commercialization	6	5		
	7	10		
	8	10		
In use	9	15		
	10	5		
	11	10		
	12	5		
End of life	13	15		
	14	10		
	15	10		
SUM				

Module 4e

Exercise 4e.1: The greenest workshop

Estimated time requirement: 20 minutes

Introduction

Public authorities are major consumers. By using their purchasing power to choose environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production. This is the fundamental approach to green purchasing. Although green purchasing is a voluntary instrument across most countries around the world, it has a key role to play for the transition towards a circular, more resource-efficient economy. It can leverage demand for more sustainable goods and services, which otherwise would be difficult to market. Green purchasing therefore sends a strong stimulus for eco-innovation.

To be effective, green purchasing requires the inclusion of clear and verifiable criteria for products and services in the public procurement process. In this exercise, you will examine how workshops like this one can be made more sustainable and develop criteria based on which proposals can be evaluated. Broadly speaking, we can distinguish between different types of green purchasing approaches: Green Public Procurement (GPP), Sustainable Public Procurement (SPP) and Circular Public Procurement (CPP). For more information, please refer to figure 1 below.

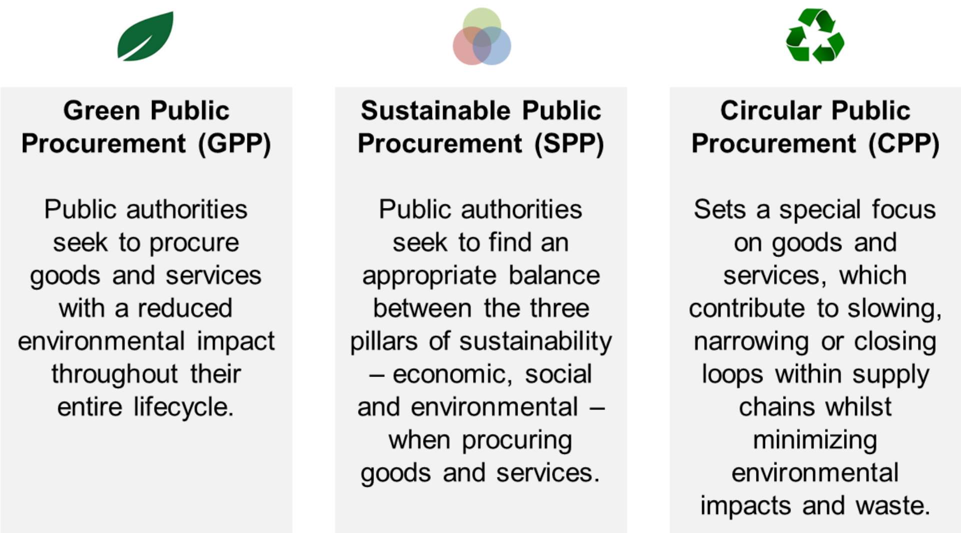


Figure 42: Approaches to green purchasing

Please read the tasks below and use the template in table 2 on the next page in order to capture your results.

Table 16: Structure of exercise

Part	Task	Time
1	Write down all the different products or services, which are required to organise this workshop .	10 min
2	Specify criteria for products and services, based on which more environmentally-friendly alternatives can be procured.	5 min

3	Please classify the criteria in accordance with the three approaches (GPP, SPP, CPP) mentioned above. Note that some criteria can be assigned to more than one category.	5 min

Table 17: Exercise template

Part 1: Products/services	Part 2: Criteria	Part 3: Classification

Exercise 4e.2: Greening tenders

Estimated time requirement: 50 minutes

Introduction

Public authorities are major consumers. By using their purchasing power to choose environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production. This is the fundamental approach to green purchasing. Although green purchasing is a voluntary instrument across most countries around the world, it has a key role to play for the transition towards a circular, more resource-efficient economy. It can leverage demand for more sustainable goods and services, which otherwise would be difficult to market. Green purchasing therefore sends a strong stimulus for eco-innovation.

To be effective, green purchasing requires the inclusion of clear and verifiable criteria for products and services in the public procurement process. In this exercise, you will examine how a simplified version of a tender for the construction of a new girls hostel at IIT Madras could be made more sustainable and develop criteria that do not only consider economic aspects based on which the proposals could be evaluated.

Case study: Construction of New Girls Hostel at IIT Madras

Please read the tasks described in table 1. Complete the tasks by using the templates (table 2, table 3) in order to capture your results.

Table 1: Structure of exercise

Part	Task	Time
1	Write down products or services that need to be procured to construct the girls hostel at Madras IIT (table 2).	10 min
2	Specify how sustainability improvements could be included in the tender example (table 3).	40 min

Table 2: Exercise template part 1

Products	Services

Table 3: Exercise template part 2

	Tender specification	Sustainability improvements in tender specification
Definition of the contract tender (object of the contract)	Scope of work**:** Planning & construction of New Girls Hostel (G+8) by replacing rear wing of Sarayu Hostel at IIT Madras Tenderer: IIT Madras Engineering Unit Validity of the tender: Three months Time Period for completion: 12 months Date and time of submission of tender: 27.02.2020 at 3:00 PM Date of opening of the tender document: 28.02.2020 at 3:10 PM	
Minimum requirements	- The building work shall be carried out complying in all respects with the requirements of relevant by-laws of the local body under the jurisdiction of which the work is to be executed or as directed by the Engineer-in-Charge and	

	nothing extra will be paid on this account. - The contractor shall comply with all legal orders and directions of the local or public authority or municipality and abide by them. - Sample of all materials, fixtures etc., shall be approved in advance from the Engineer-in-Charge before taking up the respective work. - The contractor shall produce all the materials in advance so that there is sufficient time for testing and approving the materials and clearance of the same before their use in work.	
Selection and exclusion criteria	- The applications will be evaluated for conformity to the eligibility criteria. - Misleading or false representation or deliberately suppressed the information in the forms, statements and enclosures required in the application for eligibility. - Record of poor performance such as, slow progress of work, abandoning of work, not properly completing the contract, or financial failures/weaknesses etc.	
Estimated costs	- Up to Rs. 78.00 Lakhs	

Other contractual provisions and approaches	- Child labour is strictly prohibited. - Movement of labour should be restricted to the areas where work is carried out. Workers should be made to confine themselves to the work areas and should not wander into nearby areas/buildings/forests. - The work should be executed during day time only. If the work is required to be carried out in the night, necessary permission of the Engineer-in-Charge shall be obtained. The contractor will make his own arrangement for lighting the area and no extra amount for carrying out the work during night is payable. To the extent possible engaging women labour in the night shift should be avoided. - Water for construction shall be arranged by the contractor. The contractor will not be allowed to use any of the water resources available within the campus nor will be permitted to dig any bore well inside the campus.	

Module 4f

Exercise 4f.1: Freshwatching

Estimated time requirement: 60 minutes

Introduction

Freshwatching is an ideation technique that was developed in the Netherlands and serves to get a fresh look at existing business models. How it usually works is that you take the business model of your own company and mix and match, or overlay it with the business model(s) of another company which can be outside your business or industry in order to generate new ideas and perspectives.

We want to use the Freshwatching exercise in a slightly different way: we want to utilise it in order to have a fresh look at existing business models through our circular economy (CE) goggles, and identify possible entry points for change. We will take the existing business model of the Indian restaurant aggregator and food delivery start up *Tomato* and apply typical CE business model entry points in order to see how things would possibly change.

Background

The business model of the Indian "*Tomato*" (see table 1) is to provide a seamless online ordering, payment and table booking service. Customers can get food delivered from the restaurant of their choice to their home or any other place. Tomato runs a subscription/premium programme in selected cities offering promotions and complimentary food. In addition, the company provides comprehensive information about restaurants, menus, ratings, etc. and offers promotions for restaurants.

tomato

The key customer base of tomato comprises users who look for restaurants of various cuisines and who like to try new restaurants. Typically, its users prefer home delivery or eating out. On the supply side, Tomato engages with restaurants who want to advertise their services and do not have a delivery service on their own. For more information, please refer to the business models canvas in table 2 below.

which we you can see in the business model canvas chart below. As a recap, the business model canvas portrays a business model in its single components describing its overall value proposition.

Once we had a look at the business model and have understood the value creation of Tomato, we then look at Circular Economy models, such as sharing platforms, product as service, cascade use, power of the inner circle, etc. and brainstorm possible entry points of these business models into our existing one.

Structure of exercise

Part	Task	Time
1	Form groups of three to five people. Examine in table 1 below in order to understand *Tomato's* business model. Discuss questions regarding *Tomato's* business model within your group.	15 min
2	Brainstorm potential CE entry points to the business model within your group. For starters, you can find inspirations in questions such as:	15 min

	• What else could you offer to customer segments? • Are there other customer segments that you could address? • What other ways are there to generate revenue streams (e.g. subscriptions, etc.)? • What else could you leverage with your existing channels?	
3	After the brainstorming, pick the two ideas that you like best and do a quick thought experiment as to how this change in Tomato's business model would affect other areas, such as key resources, partners, cost structure or revenue flow. Capture your findings in table 2 below.	15 min
4	Share and discuss your ideas and thoughts with the other group(s).	15 min

Table 1: Tomato business model canvas

Offer	
Value proposition	• Online ordering, payment and table booking service • Deliver food from the restaurant of your choice to your home or any other place • Subscription/premium programme in selected cities offering promotions and complimentary food • Information about restaurants, menus, ratings, etc. • Promotions for restaurants, etc.
Customer segments	• Users who look for restaurants of various cuisines and who like to try new restaurants • Users who prefer home delivery or eating out • Restaurants who want to advertise their services • Restaurants who do not have their own delivery service
Relationships customers/partners	• Partnerships and close network of restaurants • Customers • (Delivery) staff
Value creation & delivery	
Key activities	• Creating and managing technology infrastructure • Coordination, order and payment platform for food • Managing logistics to process orders • Delivery
Key resources/capabilities	• Interactive technology platform • Big network & and good partnerships with restaurants • Large database of users • Subscription customers • Delivery personnel

Key partners	• Restaurants • Drivers
Channels	• Mobile application • Website
Value capture	
Costs	• Technology setup & maintenance • Fixed costs (e.g. salaries, office rent, etc.) • Fuel expenditure • Vehicle fleet (bicycles & motorised vehicles) • Advertising/promotions
Revenue flows	• Restaurants pay commission • Customers pay premium • Advertising / marketing

Table 2: **Exercise template**

Offer		**Circular intervention possibilities**
Value proposition	• Online ordering, payment and table booking service • Deliver food from the restaurant of your choice to your home or any other place • Subscription/premium programme in selected cities offering promotions and complimentary food • Information about restaurants, menus, ratings, etc. • Promotions for restaurants, etc.	
Customer segments	• Users who look for restaurants of various cuisines and who like to try new restaurants • Users who prefer home delivery or eating out • Restaurants who want to advertise their services • Restaurants who do not have their own delivery service	
Relationships customers/partners	• Partnerships and close network of restaurants • Customers • (Delivery) staff	
Value creation & delivery		
Key activities	• Creating and managing technology infrastructure • Coordination, order and payment platform for food • Managing logistics to process orders • Delivery	
Key resources/capabilities	• Interactive technology platform • Big network & and good partnerships with restaurants • Large database of users • Subscription customers	

	• Delivery personnel	
Key partners	• Restaurants • Drivers	
Channels	• Mobile application • Website	
Value capture		
Costs	• Technology setup & maintenance • Fixed costs (e.g. salaries, office rent, etc.) • Fuel expenditure • Vehicle fleet (bicycles & motorised vehicles) • Advertising/promotions	
Revenue flows	• Restaurants pay commission • Customers pay premium • Advertising / marketing	

Task 4f.2: Circular Business Model Canvas

Estimated time requirement: 30 minutes

Introduction

Circular business models aim to create product systems that keep resources at maximum utility for as long as possible. In a CE, companies need to develop offers and value propositions with the idea of increasing resource efficiency, product life extension and closing material loops in mind. Further, companies need to adjust the elements of their business model to facilitate circular strategies, such as repair, refurbishment, remanufacturing, and recycling. These strategies can be operated in their own business models or enabled through partner networks and extended value chains. The value proposition includes products that are more durable, easy to repair, reuse and remanufacture, as well as services that enable collection of products. This way, companies can maintain and capitalize on the embedded value in products and materials beyond a single life. The three key elements of circular business models address i) the company's value proposition, ii) the approach to value creation and delivery as well as iii) the modes of capturing value (see figure 1 below).

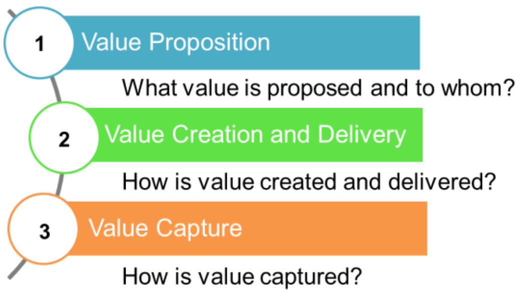


Figure 43: Three key elements of circular business models

Structure of exercise

Please read the tasks below and use the templates on the next pages in order to capture your results.

Part	Task	Time
1	Form groups of two to three people and analyse the case study of Bharat Earth Moving Equipment Pvt. Ltd. with regard to opportunities for adapting a circular business model by using the circular business model canvas template below. Focus on the three marked up cells.	20 min
2	Put the case study in policy Indian context by discussing the following aspects (use template in table 2): • Which policies and legislations are relevant for which aspect of the circular business model? • What policies and legislations exist in India today? • What policies and legislations are needed in the future to support circular business models?	10 min

Caste study: Bharat Earth Moving Equipment Pvt. Ltd.

BHARAT EARTH MOVING EQUIPMENT

Bharat Earth Moving Equipment's remanufacturing activity began in 1973, and has since grown to encompass twelve locations around the world, employing over 3,600 people in a business model with an emphasis on component recovery.

The CE framework places emphasis on the importance of designing effective products and systems rather than aiming solely for efficiency. Bharat Earth Moving Equipment has employed this strategy in their own product design, and rather than aiming to use less and less material, increasing amounts of consideration goes into creating a product that is intended to be remanufactured a number of times. In addition, the company estimates that 35% of their costs lie in overheads, while the majority – 65% – are materials costs. So salvaging materials gives a greater business advantage for the company over their competitors, where goals are often focused on driving down overhead costs.

Bharat Earth Moving Equipment has a number of examples of this in their product portfolio. One of the most well-known involves an engine block with a removable sleeve in the cylinder bore. When the component is recovered, this material can be removed and replaced to return the engine to as-new performance. Previous techniques for remanufacturing engine blocks have involved re-boring the engine cylinder and using a larger piston, but this can only be done up to three times before the quality of the product is affected. Additive manufacturing is also another option in use – cylinder bores can be resprayed with metal to return them to as-new condition.

In order to intercept products before they break, it is crucial to have consistent knowledge of the condition of the key components. Typically, this is monitored through regular and simplified maintenance process between the dealer and the customer, but Bharat Earth Moving Equipment are now beginning to make use of digital technology to add a 'Product Link' service to units in the field. This enables the manufacturer to monitor a number of criteria related to the general status of the item, such as fuel levels and potential risks, allowing closer and more detailed tracking of the customer's assets adding value and lowering owning and operating costs while creating a more effective reverse cycle.

In terms of pricing, Bharat Earth Moving Equipment is able to offer customers significantly lower prices on remanufactured parts when compared to their new products. However, an important part of the pricing structure of remanufactured components is a core deposit, approximately equal to that of the unit itself. Increasing core recovery rates is a challenge for any manufacturer engaging in remanufacturing activity, so offering an economic incentive to return the component keeps the embodied energy and materials within the company's network. This in turn enables it to salvage parts from returned cores, driving down remanufacturing costs. True to the definition of remanufacturing, the company's remanufactured products are rebuilt and tested to the same standards – and sometimes higher – as new products, and are sold with the same warranty.

Other than increasing recovery rates for cores, which is a continual opportunity for improvement, one of the key obstacles with the practice of remanufacturing is in the customer understanding and perception of the process and term. This issue exists outside of the heavy machinery industry, and can affect sales due to the misconception that remanufacturing results in inferior quality or performance, or the even safety risks. Bharat Earth Moving Equipment's brand reputation and offer of a warranty with the product goes some way to overcoming this issue, but there is still widespread misunderstanding and misuse of the term.

Part 1: Circular business models canvas – the case of Bharat Earth Moving Equipment

Circular Business Model Canvas BHARAT EARTH MOVING EQUIPMENT

Value Proposition	Collect & reintegrate (reduce primary materials)	First sale (with prolonged use)	Collect & reintegrate (organize take-back)	Additional sale of product or parts	Enable material recovery
Offer		Machines and services to develop infrastructure	Return of 'core'	Remanufactured machine	
Value Proposition		Low life-cycle costs, repair, and upgrade services	deposit in exchange of core	"like new machine" warranty	
Customer segments		Construction industries	Machine owners	After market	
Relationships customer/ partners		Close, e.g. maintenance and performance optimization	Close, e.g. performance optimization	Close	
Value Creation & Delivery					
Key activities		Material acquisition, manufacturing	on-site disassembling service	Quality checks, remanufacturing	
Key resources/ capabilities		Manufacturing technology, design for remanufacturing	Transport	Remanufacturing technology	
Key partners		Suppliers and dealers	Dealers for return	Remanufacturing tech. developers	
Channels		Dealers	Dealers	Dealers	
Value Capture					
Costs		Material costs, fix costs	Deposit, reverse logistics	Remanufacturing (tech. and labour)	
Revenue flows		Sale machines and services	None	Sales of machines and services	

Part 2: Policies supporting circular business models

Table 18: Policies supporting circular business models

Question	Notes
Which policies and legislations are relevant for which aspect of the circular business model?	Extended Producer Responsibility for End of Life Vehicles promote collection and recycling Tax reductions for repair/remanufacturing services create favourable conditions for prolonging lifetime
What policies and legislations exist in India today?	RE strategy on steel (provisions yet to be transposed into legislations) RE strategy on aluminium (provisions yet to be transposed into legislations)
What policies and legislations are needed in the future to support circular business models?	Tax on raw materials Tax breaks on repair/remanufacturing services

Module 4g

Exercise 4g.3: Calculation of Financing Factor of RE investments

Estimated time requirement: 60 minutes

Introduction

In this exercise you will assess various RE investment options by calculating and comparing key indicators such annual savings, payback periods, returns on investment as well as net present value. On page 3 of these instructions, you will find further guidance on how to perform the calculations.

Task

Part	Task	Time
1	After organizing yourself in groups, read through the case studies handed out to you. Select only one of the three case studies and perform the calculations.	30 min
2	Discuss the results among the group members: Which investments would you prefer? Also, assess what other influencing factors would need to be taken into account.	20 min
3	Visualise and present your results.	10 min

Case study 1:

In an automobile component manufacturing company two investment options are under discussion:

- Option 1) is the installation of cascade rinsing system. After implementing the new system water from second rinse tank (low pollution level (low TDS)) is transferred to the first rinse tank, while fresh water is filled in the second rinse tank water and water from the first rinse tank (high TDS) is drained. Before both of the rinse tanks had been filled with fresh water. After investing Rs.150,000 on this project the company reduced their annual consumption of water which was 1,188 kl to 80% of that amount. This measure is expected to operate three years.
- Option 2) is the installation of 30 water flow meters. Each meter costs around Rs.100,000. Due to this new measure the annual water consumption could be reduced by 2,000 kl. Before the measure is applied the company uses 2,500 kl per month. The measure is expected to operate four years.

Please find the annual savings in rupees, the simple payback period and the return on investment (ROI). Water costs are Rs. 635 per kl. Which of the options would you chose?

Case study 2:

An electroplating company is considering two investment options:

- In Option 1) a compressed air system is replaced by a simple low wattage blower fan. The investment for this fan is Rs. 100,000. Before the installation of the fan energy consumption is 15,000 kWh per month. The installation of the fan reduces this amount by 5 %. Electricity costs for 1 kWh are Rs.7.88. The fan is expected to operate five years.
- Option 2) comprises of the setup of three energy efficient diesel generator sets. Each set costs Rs. 300,000. These three new sets would reduce the amount of diesel used by 5 %. Currently the company needs 60,000 ltr per year. The cost for 1 litre of diesel is Rs. 50. The diesel generator sets are expected to operate five years.

Please calculate the net present value (NPV) and the discounted payback period of the two options. The discount rate applying is 9 %. Which of the options would you chose?

Case study 3: Pickling plant

A pickling plant is considering the investment in an acid recovery system. With an investment of Rs. 550,000 the company could reduce its acid use of currently 70,000 litres per year by 17 %. The recovery system is expected to operate six years. The cost of 1 litre of acid is Rs. 10.

Please calculate the annual savings, simple payback period, return on investment (ROI), the discounted payback period and the net present value (NPV). A discount rate of 12 % applies.

Please find below some hints on how to perform the calculations:

Annual savings - Definition:

- The annual savings are the difference between the before and after costs of operation with regard to the implementation of the RE measure:

$$Annual\ savings = costs\ (before) - costs\ (after)$$

Simple payback period - Definition:

- Simple payback represents the number of years it will take for the cash inflows from an investment project to “pay back” the initial investment. It is calculated by dividing the total initial investment by the first-year savings from the project.

$$Simple\ payback\ = \frac{Initial\ investment}{First\ year\ savings}$$

Return on Investment (ROI) -Definition:

- The ROI takes into account the lifetime of a project, the amount invested, and the total savings obtained. The ROI expressed as a percentage. If you have an ROI of 30 % it means that over the lifetime of the project, you get the money invested back as well as 30 % extra of the investment sum. If you invest US$ 1, with an ROI of 30 % you will have saved US$1,30 at the end of the project

$$ROI\ = \frac{(Total\ savings - Estimated\ measure\ cost)}{Estimated\ measure\ cost} * 100$$

NPV - Definition:

For the calculation of the NPV you have to sum up annual savings of an investment which have been multiplied with a so called Present Value Interest Factor (PVIF), and then subtract the initial investment costs. If the NPV for a project is greater than zero, the project is considered to be profitable over the time period of interest. If NPV is less than zero, the project is considered NOT to be profitable over that time period.

$$PVIF = \frac{1}{(1+r)^t}$$

r = discount rate (15 % in this example)

t = relevant year

The following table shows you how such a calculation can be performed:

Year	Annual savings	Present value interest factor	Present value
1	$3,450	X 0.8696	$3,000.12
2	$3,450	X 0.7561	$2,608.545
3	$3,450	X 0.6575	$2,269.375 +
			$7,877.04
		Less *initial investment*:	- $1,980,000
		Net present value:	**+$5,897**

Worksheet - Case study 1:

Please fill your answers into this answer sheet:

Option 1:

Investment sum:	Rs.	
Usage of water before:	kl per year	
Usage of water after:	kl per year	
Price of water:	Rs. per kl	
Lifetime of measure:	yrs	
Annual savings:	Rs.	
Simple payback period	yrs	
Return on investment (ROI)	%	

Option 2:

Investment sum:	Rs.	
Usage of water before:	kl per year	
Usage of water after:	kl per year	
Price of water:	Rs. per kl	
Lifetime of measure:	yrs	
Annual savings:	Rs.	
Simple payback period:	yrs	
Return on investment (ROI):	%	

Worksheet - Case study 2:

Please fill your answers into this answer sheet:

Option 1:

Investment sum:	Rs.	
Usage of electricity before:	kWh per year	
Usage of electricity after:	kWh per year	
Price of electricity:	Rs per kWh	
Lifetime of the measure:	yrs	
Discount rate:	%	

NPV:

Year	Annual savings (Rs.)	PVIF	Present value (Rs.)
Total			Rs.
		Initial investment minus	Rs.
NPV			**Rs.**

Option 2:

Investment sum:	Rs.	
Usage of diesel before:	ltr per year	
Usage of diesel after:	ltr per year	
Price of diesel:	Rs per ltr	
Lifetime of the measure:	yrs	
Discount rate:	%	

NPV:

Year	Annual savings (Rs.)	PVIF	Present value (Rs.)
Total			Rs.
		Initial investment minus	Rs.
NPV			**Rs.**

Worksheet - Case study 3:

Please fill your answers into this answer sheet:

Investment sum:	Rs.	
Usage of acid before:	ltr per year	
Usage of acid after:	ltr per year	
Price of acid:	Rs. per litre	
Lifetime of the measure:	yrs	
Discount rate:	%	
Annual savings:	Rs	
Simple payback period:	yrs	
Return on Investment (ROI):	%	

NPV:

Year	Yearly savings	PVIF	Present value
Total			Rs.
		Initial investment minus	Rs.
NPV			**Rs.**

Exercise Solutions

Module 3

Exercise 3.1: Video on Resource Efficiency in India

Required time: 5 minutes

Introduction

https://www.youtube.com/watch?v=gqhJ4lUhhak

Watch the video and take notes on the following aspects about resource efficiency in India:

Challenges in current resource use in India:

- Significant increase in consumption and production needs constant material flow
- Per capita material usage increased 2.5 times since the 1980s
- Comparatively low rate of resource efficiency
- Finite resources can lead to an economic crisis
- While only 3% of resource is imported, the major share of some critical materials are imported (such as phosphate, cobalt and nickel)
- This makes India vulnerable to supply shocks
- High rate of extraction of domestic resources could lead to depletion of resources and towards an increasing dependency on supply from other countries (and therefore on unstable global market prices)
- Careless exploitation of critical natural resources can further have negative social and environmental implications (like increased GHG emissions)

Opportunities for the Indian economy:

- India economy is vast in diversity of sectors, sizes and resource footprints

Key sectors for resource efficiency in India:

- Automobile industry
- Construction industry

Potentials for increasing RE in across these sectors:

- Optimization of **production processes**
- **Reuse** of demolition debris (reduces needs for new materials)

Task 3.2: Identifying key provisions and stakeholders of the Indian National Resource Efficiency Policy

Task 1: Status National Resource Efficiency Policy

Form groups and analyse the summary of the Draft National Resource Efficiency Policy with respect to status, concerncs and opportunities. Discuss the key provisions with your peers and capture your notes in the table below:

Model solution

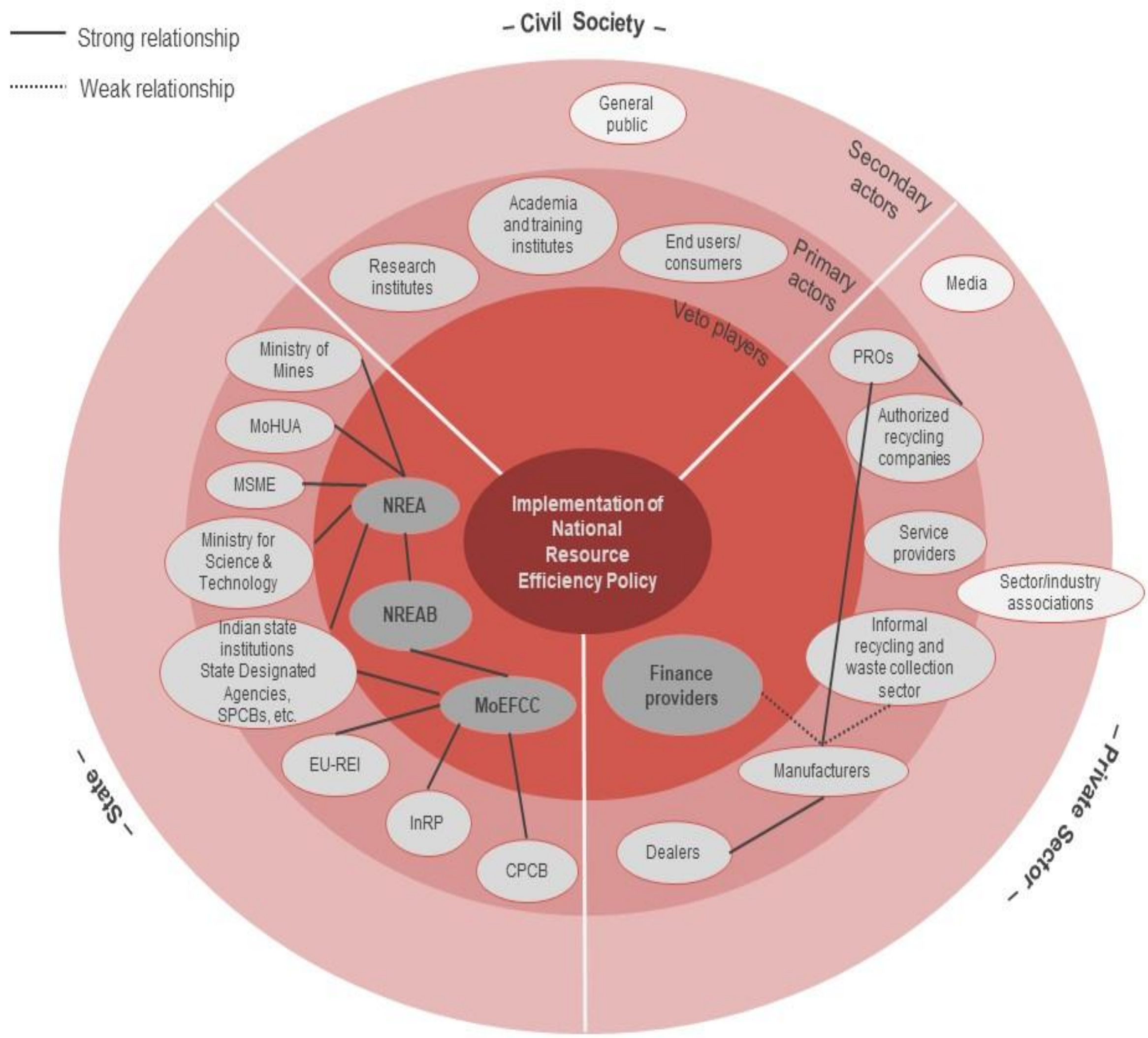
Status	• Draft National Resource Policy published in 2019 by MoEFCC addressing the sustainable consumption and production of abiotic resources, specifically non-energy minerals • Lack of concerted policy efforts integrating all beneficial aspects of RE and CE • Primary focus on the end-of-life stage
Concerns	• India increased its material consumptions six times from 1970 to 2015 and is expected to double it again by 2030 • impacts of increased resource use: rising greenhouse gas emissions, land degradation, destruction of natural environment and loss of biodiversity as well as serious levels of resource depletion • negative impacts on the economy, livelihoods as well as quality of life • economic dependency on imports for many critical raw materials
Opportunities	• reduction of primary resource consumption to 'sustainable' levels • creation of higher value with less material through resource efficient and circular approaches • waste minimization • material security • creation of green employment opportunities and business models

Task 2: Stakeholder mapping

Imagine that you are MoEFCC and you would like to know which stakeholders are involved in the implementation of the National Resource Efficiency Policy. In order to get a clearer overview of all the actors involved, use the stakeholder mapping methodology presented in figure 1 below. You can use this methodology to map out, classify and link those stakeholders, who need to be involved for the implementation of the policy. Please use the prepared flipchart for this exercise.

Model solution

Mapping of stakeholders in the public, private and civil society sectors (the mapping is indicative and by no means complete).


Strong relationship
Weak relationship
– Civil Society –
General public
Secondary actors
Academia and training institutes
Research institutes
End users/ consumers
Primary actors
Media
Veto players
Ministry of Mines
MoHUA
MSME
NREA
Ministry for Science & Technology
NREAB
Indian state institutions State Designated Agencies, SPCBs, etc.
MoEFCC
EU-REI
InRP
CPCB
Implementation of National Resource Efficiency Policy
PROs
Authorized recycling companies
Service providers
Sector/industry associations
Informal recycling and waste collection sector
Finance providers
Manufacturers
Dealers
– State –
– Private Sector –

Module 4a

Exercise 4a.1: Terminology of material flow analysis

Task

Please read the cloze text passage below and place the appropriate word in the gap from the choices below.

Material Flow Analysis (MFA) is the study of physical **flows** or **fluxes** of **materials** into, through and out of a given **system**. It is based on methodically organised accounts in physical units, and uses the **principle of mass balancing** to analyse the relationships between material flows (including energy), human activities and environmental changes. Material flows can be analysed at various **temporal** and **spatial** scales depending on the issue of concern and on the objects of interest of the study. The analysis can be applied to the global or the national economy, an industry, an enterprise, a city or a river basin.

An MFA gives a complete and consistent set of information about all **flows** and **stocks** of a particular **material** within a **system.** It connects the sources, the pathways and the intermediate and final sink of a material. Through balancing **inputs** and **outputs**, the flows of wastes and environmental loadings become visible, and their **sources** can be identified. The **depletion** or **accumulation** of material stocks is identified to either take countermeasures or to promote further **utilization**.

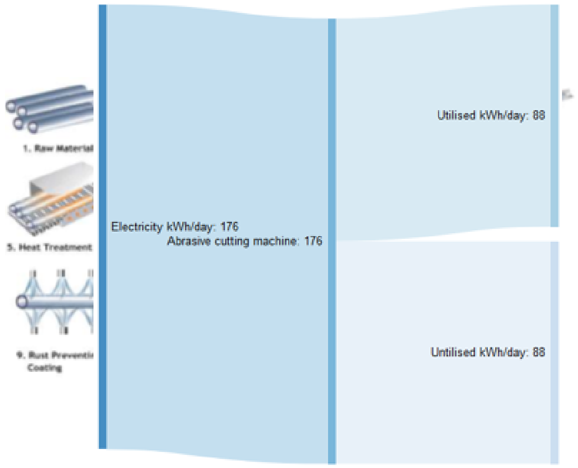
Exercise 4a.1: Defining basic steps in a material flow analysis

Step 1: Problem definition
High production costs due to process ineffciencies

Step 2: System definition
Process:
- Abrasive cutting

Flows in cutting process:
- Electricity consumption (kWh/day)

Step 3: Definition of material flows and stocks
Input data:
- Power of abrasive cutting machine = 22,032 kW
- Electricity price = 5 INR/kWh
- Abrasive cutting machine running for 8 hrs/day
- Abrasive cutting machine running idle for 4 hrs/day



Step 4: Interpretation and illustration
Calculation of savings:
- Turning off abrasive cutting machine while idle results in savings of 22,032 kW * 4 hrs/day * 5 INR/hr = 440,64 INR/day
- 440,64 INR/day * 250 working days in India = savings of 1,10,160 INR/year

Figure 44: Exercise template

Exercise 4a.3: Material Flow Analysis of a Coffee Machine

Material flows and stocks

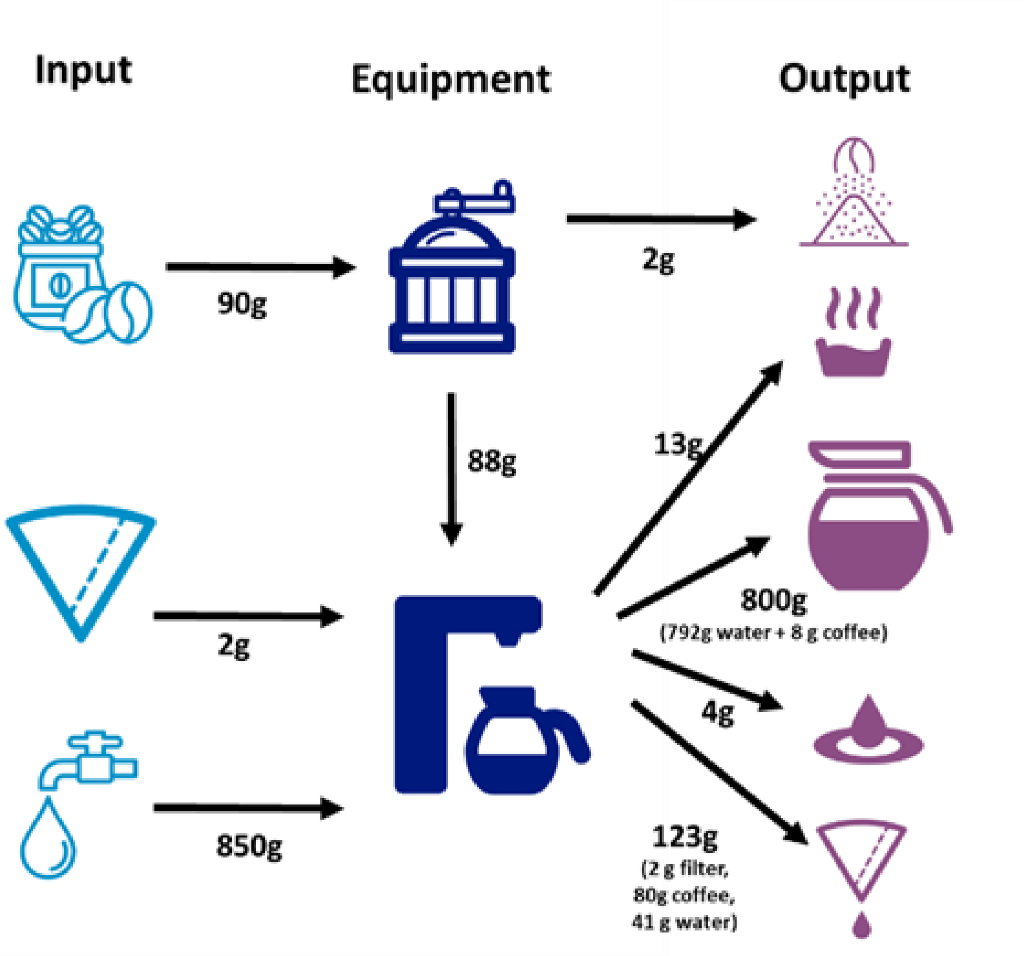
Table 19: Input and output data

Equipment	**Coffee grinder, coffee machine including pot.**
Balance period	One brew as representative period comprising all relevant activities and materials in usual amounts.
Process steps	“coffee making”, including coffee grinding, brewing and drinking.

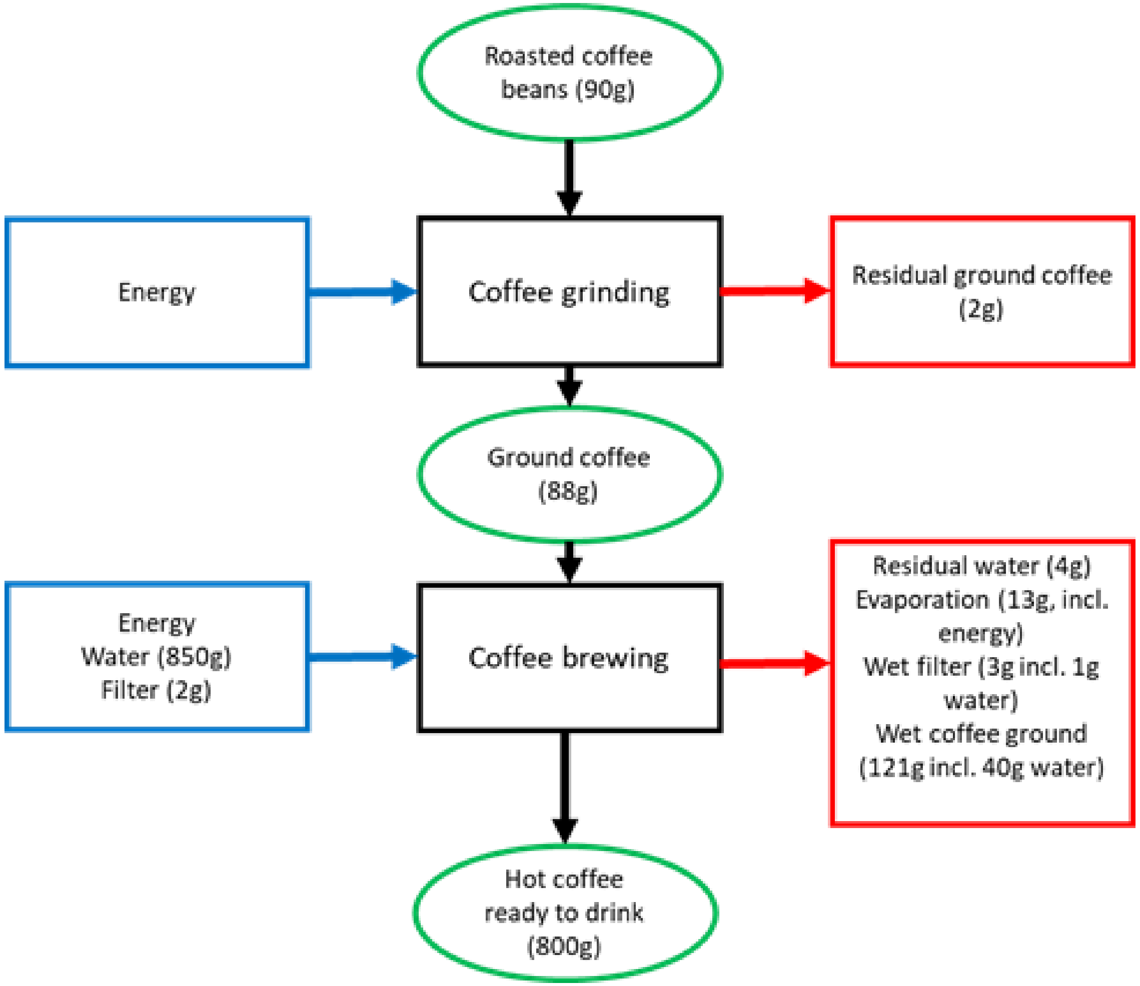
Input	
• **Coffee beans**	90 grams
• **Water**	850 grams
• **Dry filter**	2 grams
Input ∑	942 grams
Product output	
• **Water**	792 grams
• **Coffee extract**	8 grams
Product output ∑	800 grams
Non-product output	
Residual coffee powder (grinding)	2 grams
Coffee grounds	
• **Filter**	2 grams
• **Coffee**	80 grams
• **Water**	41 grams
Residual water in coffee machine	4 grams
Evaporated water	13 grams
Non-product output ∑	65 grams
Output ∑	**942 grams**

Process flow

Template chart A: overview (trainer notes)

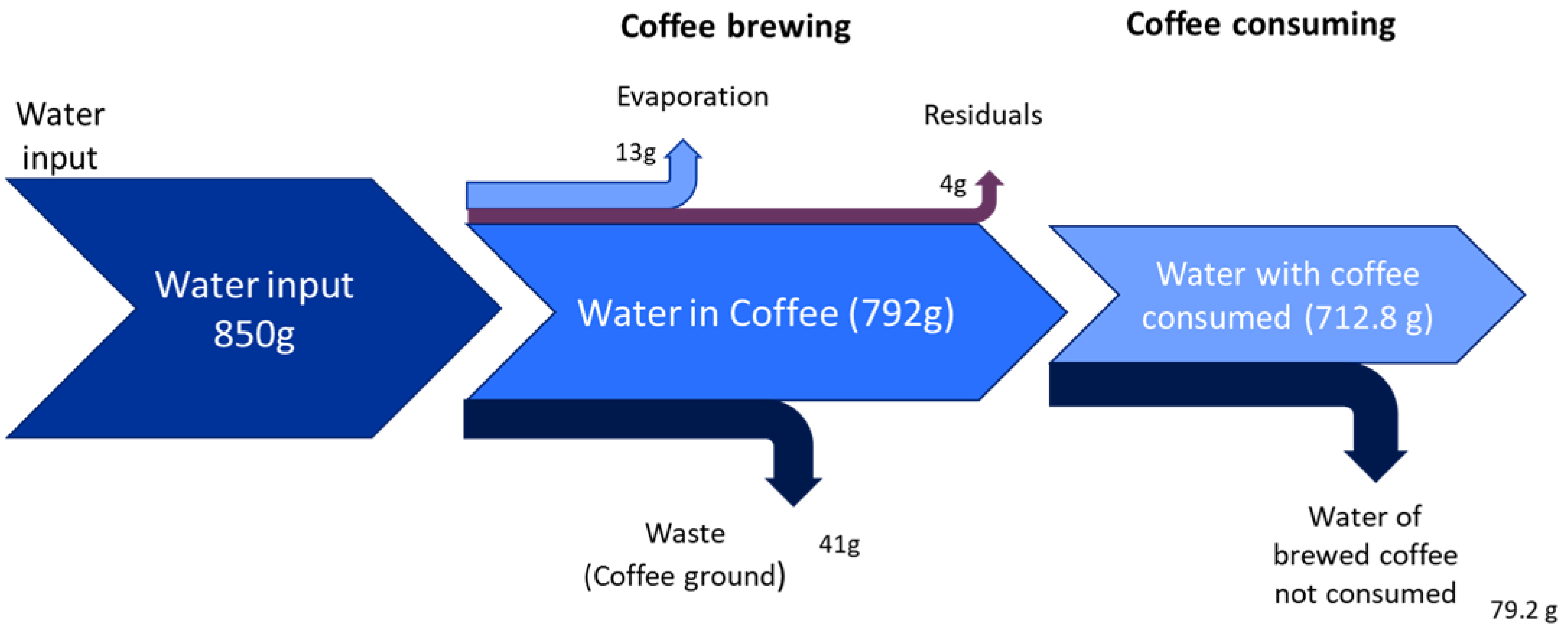


Template Chart B: overview (trainer notes)


Roasted coffee beans (90g)
Energy
Coffee grinding
Residual ground coffee (2g)
Ground coffee (88g)
Energy
Water (850g)
Filter (2g)
Coffee brewing
Residual water (4g)
Evaporation (13g, incl. energy)
Wet filter (3g incl. 1g water)
Wet coffee ground (121g incl. 40g water)
Hot coffee ready to drink (800g)

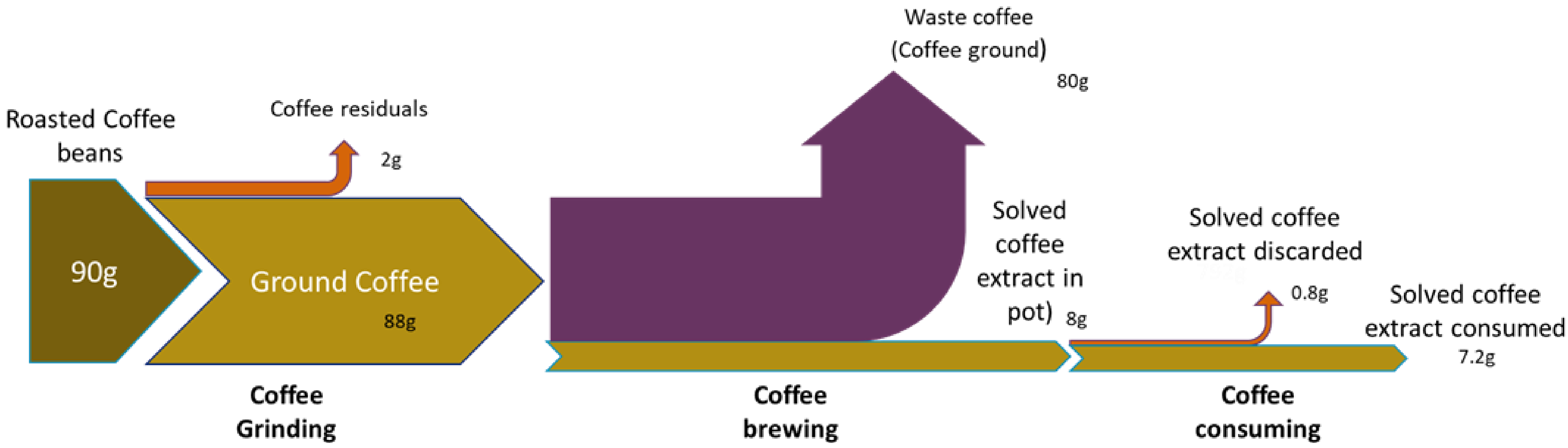
Process flow – Sankey diagram

Template chart C: Water efficiency (trainer notes)



Process flow – Sankey diagram

Template chart D: Material efficiency for coffee (trainer notes)



Measures for process optimization and impacts on lifecycle

Table 20: Exercise template (trainer notes)

Measures	Impacts in lifecycle
Good housekeeping • Improved material utilization; • Grinding of larger quantities; • Define recipes; • Define indicators; • Train operators; • Provide quality control.	Drinking remaining coffee may reduce overall consumption (impact on nervousness/coffee addiction may increase)
Technology modifications • Use a new (closed) coffee machine to reduce losses due to evaporation and waste heat; • Grinder producing less residues (complete emptying); • Finer grinding; • Use bigger filters; • Use espresso machine as completely different technology. • Buy ground coffee	New coffee machine may reduce energy consumption, however, energy required for production of new machine may exceed savings depending on operational life of the same
Substitution of raw and process materials • No paper filter (gold filter); • Possibility of using pre-ground coffee; • Soluble coffee	Using soluble coffee can eliminate energy consumption at the office almost entirely (only kettle needed) but outsources the same to the production process (i.e. extraction, drying and processing at unknown efficiencies)
Reduce, reuse, recycle • Composting of ground coffee and filters; • Reuse coffee grounds for a low-quality cup of coffee; • Reuse coffee grounds as pesticide (e.g. against potato beetle).	Reuse spent coffee grounds for low-grade coffee can increase overall energy and water consumption as demand for high quality is not fulfilled and additional coffee with fresh grounds will be brewed
Product modifications • Turkish coffee; • Stronger, weaker coffee; • Coffee sweets, coffee pills; • Instant coffee; • Caffeine pills	Turkish coffee may increase private use of toothpaste to remove coffee grounds stuck between teeth
Other organisational measures • Time-travel diagram to optimize coffee quantities.	Can provide indications as to when coffee is consumed (“coffee-rush-hour”) and inform type of technology modifications require (e.g. automatic kill-switch of coffee machine to reduce energy consumption)

Module 4b

Exercise 4b.1: Defining basic steps in a lifecycle assessment

Step 1: Goal definition and scoping

- „targetting two new high-end smartphones by Sony (models Z3 and Z5) with accessories but without network usage“
- „funtctional unit is set to life time usage (3 years) for a representative usage scenario“
- „All life cycle stages and processes are included in […] except reconoditioning mobile phone for reuse“
- „the environemtal life cycle assessment indicators are chosen as presented in Table 1“

ELCIA indicators as recommended by ILCD	Unit
Global Warming Potential **(GWP)**	CO_2-eq.
Ozone Depletion Potential **(ODP)**	CFC-11-eq.
Human Toxicity Cancer potential effects **(HumToxCan)**	CTUh
Human Toxicity non-Cancer potential effects **(HumTox)**	CTUh
Particulate Matter (2.5 µm) **(PM)**	G
Photo-Oxidant Creation Potential **(POCP)**	NMVOC-eq.

Step 2: Lifecycle inventory analysis

Raw materials acquisition:

- Primary materials, packaging materials for parts and final delivery, virgin and recycled inputs

Production:

- Parts production, packaging and transportation, assembly, ICT manufacturer support abilities, distribution

Use:

- Smartphone energy consumption based on Sony Data, associated use of networks

End of life:

- Open to explore different scenarios in this section (e.g. 90 % recycled, 10% virgin materials, or 20% recycled materials and 80% virgin materials)

Based on another study: Liebmann, A., 2015 ICT Waste Handling: Regional and Global End-of-Life Treatment Scenarios for ICT Equipment

Step 3: Lifecycle impact assessment

Results of impact category „global warming potential (GWP)“:

- Total GWP of the device based on functional unit (3 years) for model Z5 is 57 kg CO_2-eq and for model Z3 is 50 kg CO_2-eq
- Production stage of dominates GWP
- End of life stage can be carbon-negative if contents are recycled or plastic is incinerated and substitutes fossil fuels

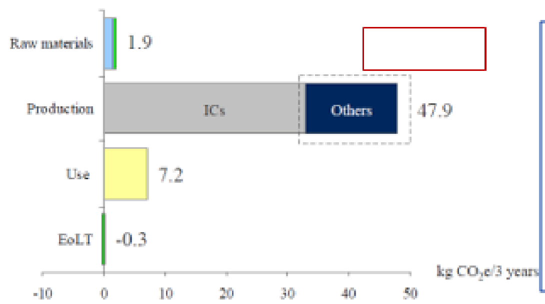
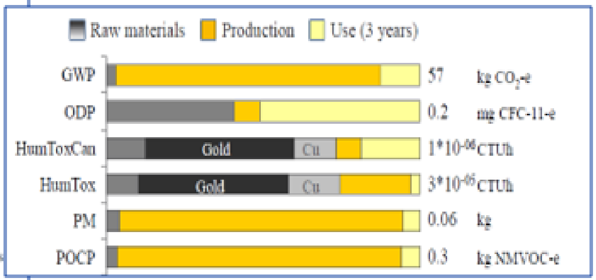


Fig.2 GWP for smartphone Z5 during its life time (3 years), including accessories but excluding network usage



Exercise 4b.2: Lifecycle Assessment of insulation materials (1/2)

Table 21: Life cycle impacts for the three material to fulfill the same functional unit

Impact category	Unit	Stone wool	Flax	Paper wool
Global warming potential	g CO_2-equivalent	1449	2357	819
Acidification	g SO_2-equivalent	12.3	17	5.5
Nutrient enrichment	g NO_3^- equivalent	12.0	12.6	5.5
Generation of solid waste	g non-hazardous waste	53	122	30
Generation of hazardous waste	g hazardous waste	0.5	0.4	1.7
Energy consumption				
Fossil fuels (incl. Feedstock)	MJ	14.61	27.84	6.75
Renewable fuels (incl. Feedstock)	MJ	1.07	15.31	15.35
Electricity	MJ	3.07	6.58	4.14
Total energy consumption	MJ	20.75	49.73	26.24
Water consumption	g water	3907	5771	822
Health aspects				
Carcinogenicity	Animal evidence	Yes	Not tested	Yes

Lung disease (non-malignant)	Human evidence	No	Yes	Not tested

Worksheet 1

Task 1: Compare the insulation material based on their ***functionality*** (according to the actual amounts of material that must be installed to achieve the thermal resistance of $1m^2K/W$).

4. Best functionality: ……………………………………… (Stone wool)
5. Medium functionality: ……………………………………… (Flax)
6. Lowest functionality: ……………………………………… (Paper wool)

Note: only very small differences. All materials perform well with respect to their insulation properties.

Task 2: Rank the different product systems with respect to their different impacts levels (whereby 1=best, 2=medium, 3=worst, n/a= no information available). Use the information provided in table 2 and note your findings in the table below:

Table 22: Ranking of the three insulation materials with respect to different impacts

Impact category	Unit	Stone wool	Flax	Paper wool
Global warming potential	g CO_2-equivalent	**2**	**3**	**1**
Acidification	g SO_2-equivalent	**2**	**3**	**1**
Nutrient enrichment	g NO_3^-equivalent	**2**	**3**	**1**
Generation of solid waste	g non-hazardous waste	**2**	**3**	**1**
Generation of hazardous waste	g hazardous waste	**2**	**1**	**3**
Energy consumption				
Fossil fuels (incl. Feedstock)	MJ	**2**	**3**	**1**
Renewable fuels (incl. Feedstock)	MJ	**1**	**2**	**3**
Electricity	MJ	**1**	**3**	**2**
Total energy consumption	MJ	**1**	**3**	**2**
Water consumption	g water	**2**	**3**	**1**
Health aspects				
Carcinogenicity	Animal evidence	**1**	**n/a**	**3**
Lung fibrosis (inhalation)	Animal evidence	**1**	**3**	**3**
Lung disease (non-malignant)	Human evidence	**1**	**3**	**n/a**
Cancer (IARC)	Human evidence	**3**	**n/a**	**n/a**

Advantages of ranking system:

- provides good overview
- easy to read
- no professional knowledge needed

Disadvantages aspects of ranking system:

- provides only general picture
- differences between materials might be marginal and therefore insignificant
- impact categories might be of varying relevance depending on your intention and the scope of your study/product

Worksheet 2

Task 3: Identify which materials have the largest and which the smallest global warming potential. Indicate your findings by labelling the x-axis on the figure below:

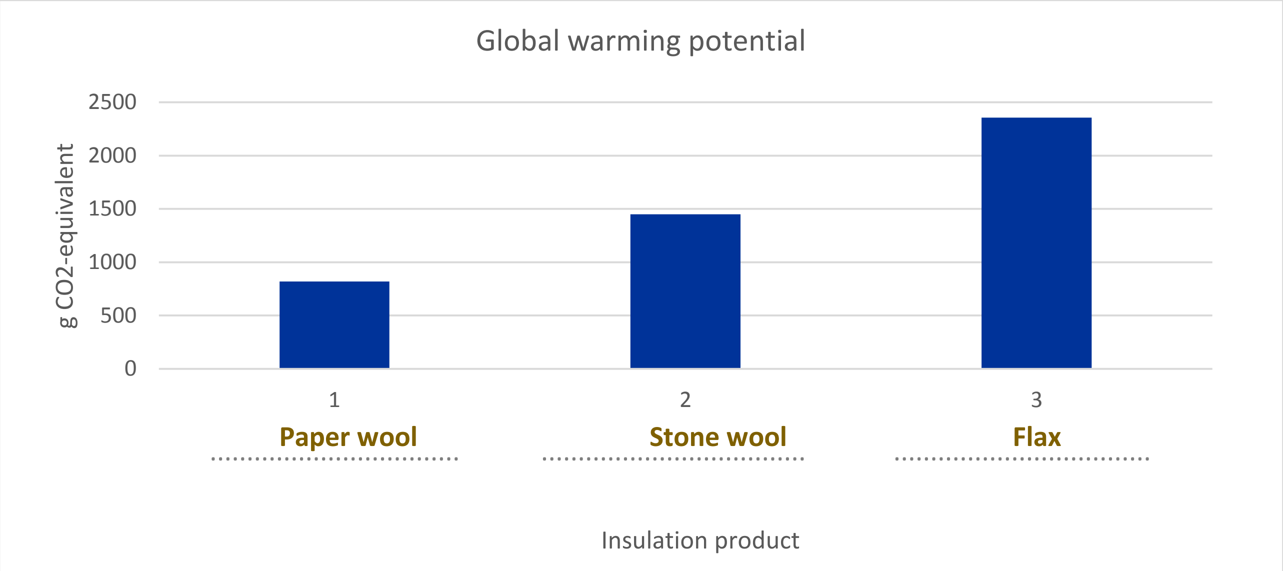


Figure 45: Global warming potential of the individual insulation products

Exercise 4b.2: Lifecycle Assessment of insulation materials (2/2)

Estimated time requirement: 20 minutes

Figure 46: Simplified overview of the life cycle of flax insulation products (Source: Schmidt et al. 2003)

Table 23: Inventory results for emissions to air for the three insulation materials

Emission to air	Unit	Stone wool	Flax	Paper wool
CO_2 (fossil)	g	1421	2142	805
CO	g	105	2.0	1.0
SO_x	g	6.08	11.57	2.88
No_x	g	2.47	7.44	3.74
N_2O	g	0.02	0.41	0.01
CH_4	g	1.04	4.19	0.57
HCl	g	0.06	0.04	0
H_2S	g	0.03	0	0
Ammonia	g	2.37	0.02	0
Hydrocarbons (except CH_4)	g	0.21	2.2	1.22
VOC	g	0.7	0.85	0.39
Particulates	g	1.19	1.54	5.08

Worksheet 3

Task 4: Analyse the provided information and discuss possible reasons for the high impact potential of flax. Identify lifecycle stages that have particular high impact.

- The global warming potential differs by almost factor 3 between the least contributing material (paper wool) and the most contributing (flax).
- It may be somewhat surprising that flax insulation, which in principle is based on a renewable resource, has the largest contribution.
- A number of reasons for this:
    - Large-scale agricultural production of flax requires artificial fertilizer; whose production is relatively energy intensive (causing emissions of carbon dioxide)
    - Production of fertilizer further emissions occur: dinitrogen oxide (N_2O) (a strong greenhouse gas)
        - Evaporation of N_2O of the fields
    - Binder and flame retarding materials added use relatively large amounts of fossil fuels for their production
    - Production process itself also contributes through emissions from its energy consumption. The energy is used to melt the binder materials before mixing with the flax raw material.
- Contribution to global warming potential of stone wool:
    - main contribution for stone wool insulation comes from the production process where fossil fuels are used for production of energy.
    - Production of stone raw materials is not very demanding in terms of energy consumption and there are no other emissions during their production that have a global warming potential.
    - Binder materials are only used in very small amounts and besides emissions from energy consumption there are no other known emissions that contribute to global warming in significant amounts.
- Contribution to global warming potential of paper wool:
    - Although the raw material for paper wool, old newsprint, primarily is based on renewable resources, its production still demands an input of fossil fuels and causes accordingly also emissions of carbon dioxide, which is the main contributor (more than 55%) in this system.
    - Other significant sources are production of aluminium hydroxide and the final production, each contributing with 10-15%.

Module 4c

Exercise 4c.1: Discussing Standards

Estimated time requirement: 20 minutes

Advantages	Disadvantages
• Standardised production enables economies of scale, thus bringing down the cost per product • Standards can ensure high quality of products and services, thereby creating added value for customers • Standards allow companies to sell uniform products on the global market place and capture global market segments • Since standards are developed by experts and practitioners, they capture knowledge and lessons learnt by them • Standards are integral to protecting consumers by ensuring product safety • Standards fulfil an important gateway function by indicating compliance and good practice	• Standards can compromise the uniqueness of products and services • Standards can create market barriers and inhibit free trade of goods and services • Standards can create additional costs by potentially over-regulating technical aspects in the production or product development process • Setting up verification processes for testing the compliance with standards requires a functioning eco-system and requires monetary resources • Standards can be difficult to understand for laymen due to their often technical nature and bulky language

How are standards relevant to RE and CE? Please provide a brief written answer.

Standards can help increase resource efficiency in the production process by minimising waste and providing guidance on manufacturing techniques. In a broader sense, standards can ensure product interoperability of products or services, for example by requiring power supplies to be standardised so that they work with a number of electrical appliances. In addition, standards can facilitate innovation towards RE and CE in the market place, e.g. by driving the need for more recyclable materials, lightweight constructions and repairable goods.

Exercise 4c.2: Environmental checklist

Table 24: EU Environmental Checklist

Technical working group: RECE-2025	Title of standard: CEN - EN 771-1: Specification for masonry units - Part 1: Clay bricks	Date of last modification of the environmental checklist: Date of training

Environmental Issue	Stages of the lifecycle										All stages
	Acquisition		Production		Use			End-of-Life			
	Raw materials and energy	Pre-manu-factured materials & components	Production	Packaging	Use	Maintenance and repair	Use of additional products	Reuse/ Material and Energy Recovery	Incineration without energy recovery	Final disposal	Transportation
Inputs											
Materials	0.15 m³										
Water	0.38 l		0.08 l + 0.026 l								
Energy	0.01 kWh	0.01 kWh	0.015 kWh + 0.012 kWh					1.45 kWh		14.88 kWh	0.002 kWh + 4.03 kWh
Land					0.05 m²			0.0007 m²		0.0717 m²	
Outputs											
Emissions to air	0.06 kg $CO_{2\text{-eq}}$	0.02 kg $CO_{2\text{-eq}}$	0.03 kg $CO_{2\text{-eq}}$ + 0.16 kg $CO_{2\text{-eq}}$					0.34 kg $CO_{2\text{-eq}}$		2.34 kg $CO_{2\text{-eq}}$	0.004 kg $CO_{2\text{-eq}}$ + 0.84 kg $CO_{2\text{-eq}}$
Discharges to water											
Discharges to soil											
Waste											
Noise, vibration, radiation, heat											
Other relevant aspects											
Risk to the environ-ment from accidents or unintended use	Health and safety during mining operations		Health and safety during milling and drying operations		Structural stability			Health and safety during demolition			
Customer information			Recycled content		Insulation factor						

Comments: Based on LCA results of clay bricks, the following clauses could be included in standard CEN - EN 771-1: 1) use of secondary raw materials during production; 2) lightweight construction to reduce required amount of material during production; 3) consumer information on thermal insulation value for reference during use phase.

NOTE 1 The stage of packaging refers to the primary packaging of the manufactured product. Secondary or tertiary packaging for transportation, occurring at some or all stages of the lifecycle, is included in the stage of transportation.

NOTE 2 Transportation can be dealt with as being a part of all stages (see checklist) or as separate sub-stage. To accommodate specific issues relating to product transportation and packaging, new columns can be included and/or comments can be added.

Module 4d

Exercise 4d.1: Assigning macro-level resource use indicators

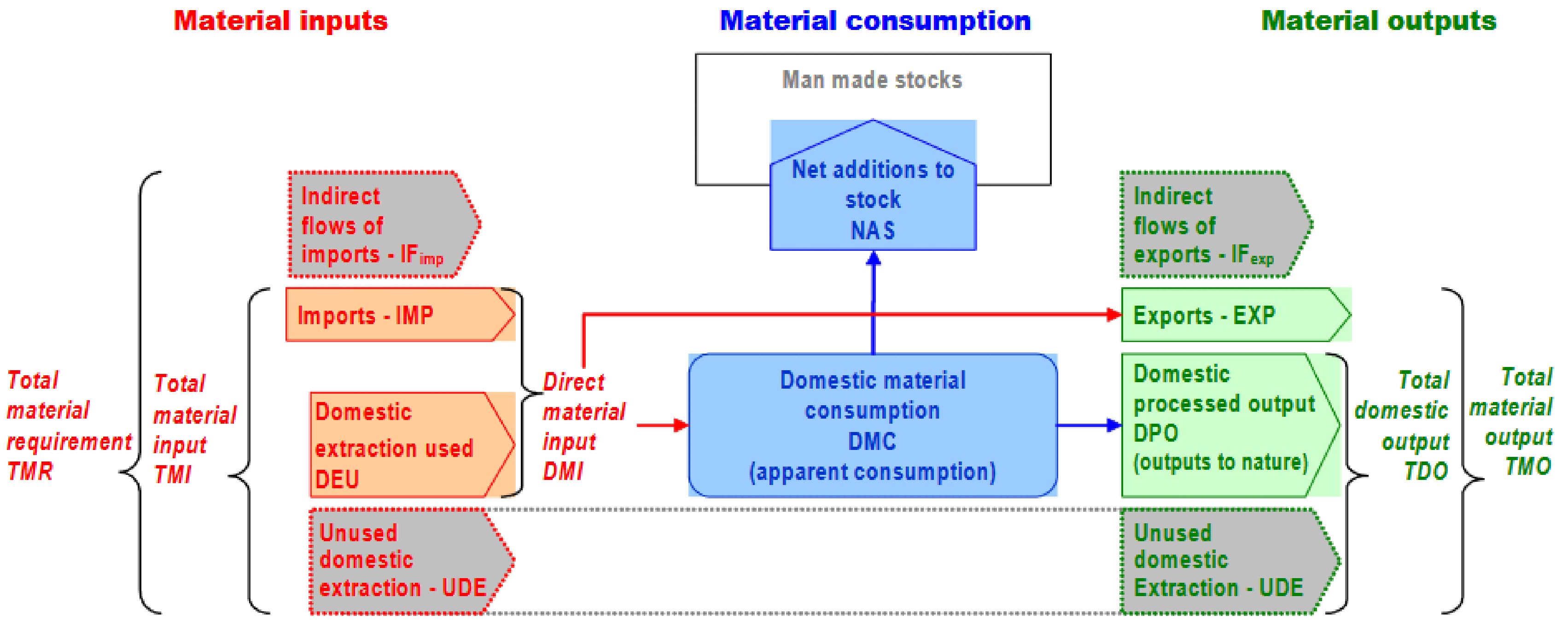


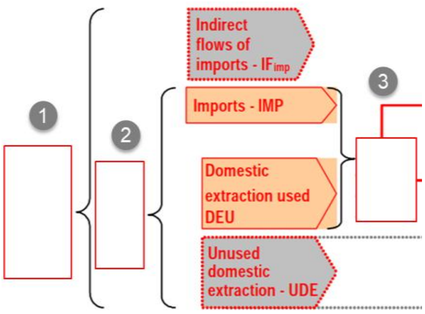
Figure 47: Exercise template for allocation of resource use indicators (source: https://www.oecd.org/environment/indicators-modelling-outlooks/MFA-Guide.pdf (adapted))

- See also https://www.oecd.org/environment/indicators-modelling-outlooks/MFA-Guide.pdf, p. 19

Data Sources

Agricultural statistics (cereals, vegetables etc. produced)	Environmental accounts for air emissions	Energy statistics and balances (extraction of fuels)
Energy statistics (emission inventories)	Forestry statistics (timber harvested)	Agricultural statistics for fertilizer use

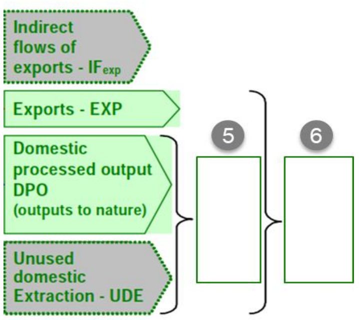
Material inputs



Data Sources for Material Input:

1. Forestry statistics (timber harvested)
2. Energy statistics and balances (extraction of fuels)
3. Agricultural statistics (cereals, vegetables etc. produced)
4. Statistics for foreign trade (imports)
5. Statistics for foreign trade (imports)

Material outputs



Data Sources for Material Output:

1. Environmental accounts for air emissions
2. Agricultural statistics for fertilizer use
3. Energy statistics (emission inventories)
4. Statistics for foreign trade (exports)
5. Environmental statistics for waste water and solid waste disposal

- See also https://ec.europa.eu/eurostat/documents/1798247/6191533/3-Economy-wide-material-flow-accounts...-A-methodological-guide-2001-edition.pdf/ p. 47

Exercise 4d.2: Applying a Circularity Calculator

Table 25: Comparison between “Chug’n’Chuck” and “KeepCap” capsules

	“Chug’n’Chuck” capsules	**“KeepCap” capsules**
		
Design	The disposable capsules are made from 100% virgin multi-layer plastics. Coloured coatings are used to distinguish and market different types of coffee (e.g. Cappuccino, Espresso). Marudhar Caffeinated Caps approached their suppliers of coatings agents to identify the types of substances used in the production of different colours. After two years of consultations and discussions, the suppliers submitted a bill of substances, however, without specifications about the exact formula.	The outer shell accounts for 35% of the total product weight and is made entirely from recycled stainless steel. The sieve-cap and inner shell are made from virgin stainless steel. The rubber sealing is directly sourced from an organic farm in Tamil Nadu. A complete bill of materials used can be found on the company’s website.
Production	The capsules are formed by thermoforming multiple layers of plastics to 1.25 mm thickness. Solid waste production and energy consumption is monitored on a company level. A material flow analysis indicated that material losses of 5% (waste) occur during the manufacturing process, mainly owing to offcuts and occasional quality rejects.	The capsules are formed by applying hydraulic pressure to sheets of stainless steel of 0.75 mm thickness for sieve-cap, outer and inner shells. Since the KeepCap was launched only two months ago, estimations for the generation of solid waste and energy usage in the production process do not yet exist.
Commercialization	Capsules are sorted by colour, stacked in hundreds, bailed in single-use plastics (foil) and delivered to customers where they are filled and sealed. Capsules are packaged in printed cardboard boxes (100% virgin fibres) of ten and sold to end-consumers via online channels and stores. No warranty is given due to the products’ single-use character.	The components of the capsules (sieve-cap, inner shell, outer shell) are individually wrapped in single-use plastics (LDPE, non-recycled) and subsequently boxed in small carton boxes (100% recycled materials). The product is directly marketed via Marudhar Caffeinated Caps’ online shop and retail outlets. A warranty of one year on heat-induced deformations to the outer and inner shell is provided.
In use	Marudhar Caffeinated Caps are made for singular use and replace previous coffee making practises such as filter coffee. The company has no further information about the use phase of the product.	The product is designed to be long-lasting and reusable, serving at least 2,500 individual coffee servings throughout its lifetime. Marudhar Caffeinated Caps has no further information about the use phase of the KeepCap. However, contact details of customers ordering via the company’s online shop are available. In case of damage, the products individual components (outer and inner shell, sieve-cap and rubber sealing) can be replaced.

End of life	Since Chug'n'Chuck capsules are entirely made of plastic, they are subject to Extended Producer Responsibility (EPR) systems across most of the core markets (e.g. through the Packaging and Packaging Waste Directive in the EU). This includes the obligation of collection and, in some parts, recycling rates (e.g. 70% by 2030 in the EU). After using, the spent coffee ground stays in the capsule and needs to be scooped out manually by the consumer to ensure separation at source.	Marudhar Caffeinated Caps has evaluated the introduction of a take-back scheme but found it too uneconomical due to low volumes and long latency periods in the rate of return. Consumers are not expected to remove the rubber sealing prior to disposal. Most of the KeepCaps core markets are characterised by comparatively well developed collection infrastructure combined with automated separation into metallic and non-metallic fraction. In addition, steel recycling rates in many markets have recently met an all-time high (e.g. 79.5% in the EU).

Worksheet 1

Table 26: Exercise template

Lifecycle stage	#	Max score	Score of "Chug'n'Chuck" capsules	Score of "KeepCap" capsules
Design	1	20	0	15
	2	2	2	0
	3	5	3	5
Production	4	10	5	0
	5	15	7	0
Commercialization	6	5	0	3
	7	10	0	7
	8	10	0	0
In use	9	15	0	5
	10	5	0	5
	11	10	0	10
	12	5	0	5
End of life	13	15	15	0
	14	10	5	10
	15	10	5	7
SUM			42/152	72/152

Group discussion: Strengths and limitations of the circularity calculator

Strengths and Limitations of the Circularity Indicator:

- *Does the methodology capture all necessary circularity aspects and if not, which aspects are missing?*
- Several possible answers
- Example for missing aspect: transport of products
- Efficiency of methodology heavily depending on data availability

- *Are the weightings (max scores) adequate or how should they be changed?*
- Several possible answers
- For example:
  - #2: relative parameter, max. score should be higher for products that require long- distance transport
  - #14: End- of life management more relevant for products with hazardous components. Max. score should be increased for such products

- *Which of the criteria did you find most difficult to assess and why?*
- Several possible answers
- For example #3: assessment of criteria depending on cooperation of producer

Module 4e

Exercise 4e.1: The greenest workshop

Table 27: Exercise template

Part 1: Products/services	Part 2: Criteria	Part 3: Classification
Flipcharts	- made from recycled paper	- CPP
Text markers	- water soluble - low content of volatile organic compounds (VOCs)	- GPP - GPP
Projector	- energy-saving - made from conflict-free minerals	- GPP - SPP
Snacks	- fair trade - organic	- SPP - GPP
Print-outs	- made from recycled paper - duplex print	- CPP - GPP/CPP

Exercise 4e.2: Greening tenders

Table 2: Exercise template part 1

Products	Services
- Construction material - Insulation material - Cables, wiring - Elevator - Doors, windows, light bulbs, etc. - …	- Planning of design, architecture, energy concept, etc. - Prepare construction site - Construction of the building - Lighting concept - Electricity and water supply - Maintenance of the building - …

Table 3: Exercise template part 2

	Tender specification	Sustainability improvements in tender specification
Definition of the contract tender (object of the contract)	Scope of work**:** Planning & construction of New Girls Hostel (G+8) by replacing rear wing of Sarayu Hostel at IIT Madras Tenderer: IIT Madras Engineering Unit Validity of the tender: Three months Time Period for completion: 12 months Date and time of submission of tender: 27.02.2020 at 3:00 PM Date of opening of the tender document: 28.02.2020 at 3:10 PM	Planning & construction of zero energy/energy efficient girls hostel at IIT Madras Planning & construction of green girls hostel at IIT Madras designed for deconstruction in 15 years from completion of building

Minimum requirements	- The building work shall be carried out complying in all respects with the requirements of relevant by-laws of the local body under the jurisdiction of which the work is to be executed or as directed by the Engineer-in-Charge and nothing extra will be paid on this account. - The contractor shall comply with all legal orders and directions of the local or public authority or municipality and abide by them. - Sample of all materials, fixtures etc., shall be approved in advance from the Engineer-in-Charge before taking up the respective work. - The contractor shall produce all the materials in advance so that there is sufficient time for testing and approving the materials and clearance of the same before their use in work.	Building must comply with criteria the Indian Green Building Council (IGBC) silver/gold/platinum/etc. rating Building must comply with criteria of highest Green Rating for Integrated Habitat Assessment (GRIHA) rating
Selection and exclusion criteria	- The applications will be evaluated for conformity to the eligibility criteria. - Misleading or false representation or deliberately suppressed the information in the forms, statements and enclosures required in the application for eligibility. - Record of poor performance such as, slow progress of work, abandoning of work, not properly completing the contract, or financial failures/weaknesses etc.	Present sustainable architecture & design concept under consideration of passive architecture, site preservation, etc. Present impact assessment of site selection and planning under consideration of soil erosion, preservation of plants & trees, proximity to local transport, etc. Present water conservation & energy efficiency Present building materials and resources concept under consideration of sustainable building materials, handling of waste materials during construction, etc. Present indoor environment concept under consideration of fresh air ventilation, daylighting, low-emitting materials, etc.

Estimated costs	- Up to Rs. 78.00 Lakhs	The offer with the lowest emissions/most energy efficient/resource efficient concept is allocated up to 10% of total points, while the others are allocated points proportionally. Allow for estimation of lifecycle costs
Other contractual provisions and approaches	- Child labour is strictly prohibited. - Movement of labour should be restricted to the areas where work is carried out. Workers should be made to confine themselves to the work areas and should not wander into nearby areas/buildings/forests. - The work should be executed during day time only. If the work is required to be carried out in the night, necessary permission of the Engineer-in-Charge shall be obtained. The contractor will make his own arrangement for lighting the area and no extra amount for carrying out the work during night is payable. To the extent possible engaging women labour in the night shift should be avoided. - Water for construction shall be arranged by the contractor. The contractor will not be allowed to use any of the water resources available within the campus nor will be permitted to dig any bore well inside the campus.	Contractor is responsible for any unforeseen maintenance cost (e.g. replacement of materials. etc.) in the first 20 years after construction of the building.

Module 4f

Exercise 4f.1: Freshwatching

Table 1: Tomato business model canvas

Offer	
Value proposition	• Online ordering, payment and table booking service • Deliver food from the restaurant of your choice to your home or any other place • Subscription/premium programme in selected cities offering promotions and complimentary food • Information about restaurants, menus, ratings, etc. • Promotions for restaurants, etc.
Customer segments	• Users who look for restaurants of various cuisines and who like to try new restaurants • Users who prefer home delivery or eating out • Restaurants who want to advertise their services • Restaurants who do not have their own delivery service
Relationships customers/partners	• Partnerships and close network of restaurants • Customers • (Delivery) staff
Value creation & delivery	
Key activities	• Creating and managing technology infrastructure • Coordination, order and payment platform for food • Managing logistics to process orders • Delivery
Key resources/capabilities	• Interactive technology platform

	• Big network & and good partnerships with restaurants • Large database of users • Subscription customers • Delivery personnel
Key partners	• Restaurants • Drivers
Channels	• Mobile application • Website
Value capture	
Costs	• Technology setup & maintenance • Fixed costs (e.g. salaries, office rent, etc.) • Fuel expenditure • Vehicle fleet (bicycles & motorised vehicles) • Advertising/promotions
Revenue flows	• Restaurants pay commission • Customers pay premium • Advertising / marketing

Table 2: Exercise template

Offer		**Circular intervention possibilities**
Value proposition	• Online ordering, payment and table booking service • Deliver food from the restaurant of your choice to your home or any other place • Subscription/premium programme in selected cities offering promotions and complimentary food • Information about restaurants, menus, ratings, etc. • Promotions for restaurants, etc.	• Sell recyclable / biodegradable / reusable packaging to partner restaurants • Provide pick-up service for used packaging either for recycling or reuse • Provide more information about serving sizes of individual restaurants to reduce food waste • Add a section where restaurants can offer food that is about to expire at a cheaper price, e.g. fresh baked bread (similar to too good to go app) • Offer to restaurants to promote more about the way how they do business, e.g. sourcing of organic food, measures against food waste, etc.
Customer segments	• Users who look for restaurants of various cuisines and who like to try new restaurants • Users who prefer home delivery or eating out • Restaurants who want to advertise their services • Restaurants who do not have their own delivery service	• Target environmentally aware consumers that do not order food frequently because of waste it produces • Offer preferential treatment to restaurants using organic food, use biodegradable packaging, etc.
Relationships customers/partners	• Partnerships and close network of restaurants • Customers • (Delivery) staff	• Partner with packaging providers • Use close connection to customers (e.g. subscription customers) to offer take-back/reuse scheme of packaging
Value creation & delivery		
Key activities	• Creating and managing technology infrastructure • Coordination, order and payment platform for food • Managing logistics to process orders • Delivery	• Take over packaging of food • Offer own “Zomato” food that comes in reusable food containers

Key resources/capabilities	• Interactive technology platform • Big network & and good partnerships with restaurants • Large database of users • Subscription customers • Delivery personnel	• Change entire vehicle fleet to bicycles or electric motorized vehicles • Offer take-back service of packaging of subscription/all customers
Key partners	• Restaurants • Drivers	• Recycling companies • Packaging industries • Partner with organic food suppliers and promote use to restaurants • Partnership with organisations that provide leftover food to the poor
Channels	• Mobile application • Website	• Infrastructure to reuse food packaging • Build up packaging recycling infrastructure
Value capture		
Costs	• Technology setup & maintenance • Fixed costs (e.g. salaries, office rent, etc.) • Fuel expenditure • Vehicle fleet (bicycles & motorised vehicles) • Advertising/promotions	• Cost for new infrastructures
Revenue flows	• Restaurants pay commission • Customers pay premium • Advertising / marketing	• Offer discounts to customers who use their own cutlery, napkins, condiments, etc. • Offer discounts to restaurants that use biodegradable packaging • Increased premiums from restaurants that now save on packaging material

Task 4f.2: Circular Business Model Canvas

Estimated time requirement: 30 minutes

Introduction

Circular business models aim to create product systems that keep resources at maximum utility for as long as possible. In a CE, companies need to develop offers and value propositions with the idea of increasing resource efficiency, product life extension and closing material loops in mind. Further, companies need to adjust the elements of their business model to facilitate circular strategies, such as repair, refurbishment, remanufacturing, and recycling. These strategies can be operated in their own business models or enabled through partner networks and extended value chains. The value proposition includes products that are more durable, easy to repair, reuse and remanufacture, as well as services that enable collection of products. This way, companies can maintain and capitalize on the embedded value in products and materials beyond a single life. The three key elements of circular business models address i) the company's value proposition, ii) the approach to value creation and delivery as well as iii) the modes of capturing value (see figure 1 below).

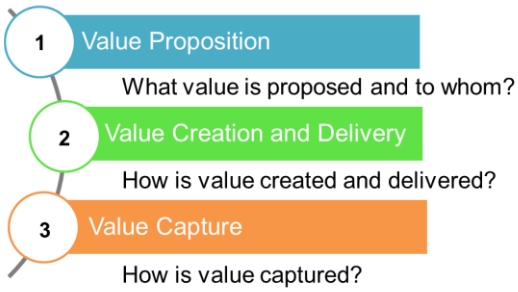


Figure 48: Three key elements of circular business models

Structure of exercise

Please read the tasks below and use the templates on the next pages in order to capture your results.

Part	Task	Time
1	Form groups of two to three people and analyse the case study of Bharat Earth Moving Equipment Pvt. Ltd. with regard to opportunities for adapting a circular business model by using the circular business model canvas template below. Focus on the three marked up cells.	20 min
2	Put the case study in policy Indian context by discussing the following aspects (use template in table 2): • Which policies and legislations are relevant for which aspect of the circular business model? • What policies and legislations exist in India today? • What policies and legislations are needed in the future to support circular business models?	10 min

Caste study: Bharat Earth Moving Equipment Pvt. Ltd.

BHARAT EARTH MOVING EQUIPMENT

Bharat Earth Moving Equipment's remanufacturing activity began in 1973, and has since grown to encompass twelve locations around the world, employing over 3,600 people in a business model with an emphasis on component recovery.

The CE framework places emphasis on the importance of designing effective products and systems rather than aiming solely for efficiency. Bharat Earth Moving Equipment has employed this strategy in their own product design, and rather than aiming to use less and less material, increasing amounts of consideration goes into creating a product that is intended to be remanufactured a number of times. In addition, the company estimates that 35% of their costs lie in overheads, while the majority – 65% – are materials costs. So salvaging materials gives a greater business advantage for the company over their competitors, where goals are often focused on driving down overhead costs.

Bharat Earth Moving Equipment has a number of examples of this in their product portfolio. One of the most well-known involves an engine block with a removable sleeve in the cylinder bore. When the component is recovered, this material can be removed and replaced to return the engine to as-new performance. Previous techniques for remanufacturing engine blocks have involved re-boring the engine cylinder and using a larger piston, but this can only be done up to three times before the quality of the product is affected. Additive manufacturing is also another option in use – cylinder bores can be resprayed with metal to return them to as-new condition.

In order to intercept products before they break, it is crucial to have consistent knowledge of the condition of the key components. Typically, this is monitored through regular and simplified maintenance process between the dealer and the customer, but Bharat Earth Moving Equipment are now beginning to make use of digital technology to add a 'Product Link' service to units in the field. This enables the manufacturer to monitor a number of criteria related to the general status of the item, such as fuel levels and potential risks, allowing closer and more detailed tracking of the customer's assets adding value and lowering owning and operating costs while creating a more effective reverse cycle.

In terms of pricing, Bharat Earth Moving Equipment is able to offer customers significantly lower prices on remanufactured parts when compared to their new products. However, an important part of the pricing structure of remanufactured components is a core deposit, approximately equal to that of the unit itself. Increasing core recovery rates is a challenge for any manufacturer engaging in remanufacturing activity, so offering an economic incentive to return the component keeps the embodied energy and materials within the company's network. This in turn enables it to salvage parts from returned cores, driving down remanufacturing costs. True to the definition of remanufacturing, the company's remanufactured products are rebuilt and tested to the same standards – and sometimes higher – as new products, and are sold with the same warranty.

Other than increasing recovery rates for cores, which is a continual opportunity for improvement, one of the key obstacles with the practice of remanufacturing is in the customer understanding and perception of the process and term. This issue exists outside of the heavy machinery industry, and can affect sales due to the misconception that remanufacturing results in inferior quality or performance, or the even safety risks. Bharat Earth Moving Equipment's brand reputation and offer of a warranty with the product goes some way to overcoming this issue, but there is still widespread misunderstanding and misuse of the term.

Part 1: Circular business models canvas – the case of Bharat Earth Moving Equipment

Circular Business Model Canvas BHARAT EARTH MOVING EQUIPMENT

Value Proposition	Collect & reintegrate (reduce primary materials)	First sale (with prolonged use)	Collect & reintegrate (organize take-back)	Additional sale of product or parts	Enable material recovery
Offer		Machines and services to develop infrastructure	Return of 'core'	Remanufactured machine	
Value Proposition		Low life-cycle costs, repair, and upgrade services	deposit in exchange of core	"like new machine" warranty	
Customer segments		Construction industries	Machine owners	After market	
Relationships customer/ partners		Close, e.g. maintenance and performance optimization	Close, e.g. performance optimization	Close	
Value Creation & Delivery					
Key activities		Material acquisition, manufacturing	on-site disassembling service	Quality checks, remanufacturing	
Key resources/ capabilities		Manufacturing technology, design for remanufacturing	Transport	Remanufacturing technology	
Key partners		Suppliers and dealers	Dealers for return	Remanufacturing tech. developers	
Channels		Dealers	Dealers	Dealers	
Value Capture					
Costs		Material costs, fix costs	Deposit, reverse logistics	Remanufacturing (tech. and labour)	
Revenue flows		Sale machines and services	None	Sales of machines and services	

Part 2: Policies supporting circular business models

Table 28: Policies supporting circular business models

Question	Notes
Which policies and legislations are relevant for which aspect of the circular business model?	Extended Producer Responsibility for End of Life Vehicles promote collection and recycling Tax reductions for repair/remanufacturing services create favourable conditions for prolonging lifetime
What policies and legislations exist in India today?	RE strategy on steel (provisions yet to be transposed into legislations) RE strategy on aluminium (provisions yet to be transposed into legislations)
What policies and legislations are needed in the future to support circular business models?	Tax on raw materials Tax breaks on repair/remanufacturing services

Module 4g

Exercise 4g.3: Calculation of Financing Factor of RE investments

Case study 1:

Option 1:

Investment sum:	Rs.	150,000	
Usage of water before:	kl per year	1,188	
Usage of water after:	kl per year	950.4	
Price of water:	Rs. per kl	635	
Lifetime of measure:	yrs	3	
Annual savings:	Rs.	**150,876**	(1,188 – 950.4) x 635
Simple payback period	yrs	**0,99**	150,000 / 150,876
Return on investment (ROI)	%	**201.75**	((150,876 x 3) - 150,000) / 150,000) x 100

Option 2:

Investment sum:	Rs.	3,000,000	30 x Rs 100,000
Usage of water before:	kl per year	30,000	2,500 kl x 12
Usage of water after:	kl per year	28,000	
Price of water:	Rs. per kl	635	
Lifetime of measure:	yrs	4	
Annual savings:	Rs.	**1,270,000**	(30,000 – 28,000) x 635
Simple payback period:	yrs	**2.36**	3,000,000 / 1,270,000
Return on investment (ROI):	%	**69.3**	((1,270,000 x 4 - 3,000,000) / 3,000,000) x 100

Worksheet Case study 2:

Option 1:

Investment sum:	Rs.	100,000	
Usage of electricity before:	kWh per year	180,000	15,000 x 12
Usage of electricity after:	kWh per year	171,000	180,000 x 0,95
Price of electricity:	Rs per kWh	7.88	
Lifetime of the measure:	yrs	5	
Discount rate:	%	9	

NPV:

Year	Yearly savings (Rs.)	PVIF	Present value (Rs.)
1	(180,000 – 171,000) x 7.88 = 70,920	1/1,09^1=0.92	65,064.22
2	70,920	1/1,09^2=0.84	59,691.94
3	70,920	1/1,09^3=0.77	54,763.25
4	70,920	1/1,09^4 =0.71	50,241.52
5	70,920	1/1,09^5=0.65	46,093.13
Total	Rs. 354,600		Rs. 275,854.06
		Initial investment minus	- Rs. 100,000
NPV			**Rs. 175,854.06**

Option 2:

Investment sum:	Rs.	900,000	300,000 x 3
Usage of diesel before before:	ltr per year	60,000	5,000 x 12
Usage of diesel before after:	ltr per year	57,000	60,000 x 0,95
Price of diesel:	Rs per ltr	50	
Lifetime of the measure:	yrs	5	
Discount rate:	%	9	
		900,000	300,000 x 3

NPV:

Year	Annual savings	PVIF	Present value (Rs.)
1	(60,000 – 57,000) x 50 = Rs. 150,000	1/1,09^1=0.92	137,614.68
2	Rs. 150,000	1/1,09^2=0.84	126,251.99
3	Rs. 150,000	1/1,09^3=0.77	115,827.52
4	Rs. 150,000	1/1,09^4 =0.71	106,263.78
5	Rs. 150,000	1/1,09^5=0.65	97,489.7
Total	Rs. 750,000		Rs. 583,447.67
		Initial investment minus	Rs. 900,000
NPV			**Rs. - 316,552.33**

Case study 3:

Investment sum:	Rs.	550,000	
Usage of acid before:	ltr per year	70,000	
Usage of acid after:	ltr per year	58,100	70,000 x 0,83
Price of acid:	Rs. per litre	10	
Lifetime of the measure:	yrs	6	
Discount rate:	%	12	
Annual savings:	Rs	**119,000**	(70,000 – 58,100) x 10
Simple payback period:	yrs	**4.62**	550,000 / 119,000
Return on Investment (ROI):	%	**29.82**	(((119,000 x 6) - 550,000) / 550,000) x 100

NPV:

Year	Annual savings (Rs.)	PVIF	Present value (Rs.)
	(70,000 – 58,100) x 10 = Rs. 119,000	1/1,12^1	106,250.00
	Rs. 119,000	1/1,12^2	94,866.07
	Rs. 119,000	1/1,12^3	84,701.85
	Rs. 119,000	1/1,12^4	75,626.65
	Rs. 119,000	1/1,12^5	67,523.80
	Rs. 119,000	1/1,12^6	60,289.10
Total			489,257.47
		Initial investment minus	Rs. 550,000
NPV			**Rs. – 60,742.53**

Glossary

Term/Abbreviation	Definition/Full-form	Module
BIS	Bureau of Indian Standards	4c
BSI	Federal Office for Information Security, Germany (Deutsches Bundesamt für Sicherheit in der Informationstechnik)	4c
Carbon Footprint[6]	A products carbon footprint is a measure to of the direct and indirect greenhouse gas (GHG) emissions associated with all activities in the product's life cycle. Products are both goods and services. Such a Carbon Footprint can be calculated by performing (according to international standards) an LCA that concentrates on GHG emissions that have an effect on climate change.	3
CE	Circular Economy	2-4
CEN	European Committee for Standardization	4c
CENELEC	European Committee for Electrotechnical Standardization	4c
CPP	Circular Public Procurement Sets a special focus on goods and services, which contribute to slowing, narrowing or closing loops within supply chains whilst minimizing environmental impacts and waste.	4e
C&D	Construction and Demolition	3
CO2	Carbon dioxide	2
DMC	Domestic material consumption (DMC) Macro indicator: Direct material input - exports	4d
DMI[7]	Direct material input Macro indicator: Total material input - unused domestic extraction measures the input of used materials into the economy, i.e. all materials which are of	4d

[6] https://www.lifecycleinitiative.org/resources/life-cycle-terminology-2/

[7] https://www.oecd.org/env/indicators-modelling-outlooks/4425421.pdf

	economic value and are used in production and consumption activities.	
DPO[8]	Domestic Processed Output Macro Indicator: represents the total mass of materials which have been used in the domestic economy, before flowing into the environment.	4d
EEE	Electrical and Electronic Equipment	3, 4c
EIB	European Investment Bank	4h
EPR[9]	Extended Producer Responsibility Environmental policy approach in which a producer's responsibility for a product is extended to the waste stage of that product's life-cycle. In practice, EPR involves producers taking responsibility for the management of products after becoming waste, including: collection; pre-treatment, e.g. sorting, dismantling or de-pollution; (preparation for) reuse; recovery (including recycling and energy recovery) or final disposal. EPR systems can allow producers to exercise their responsibility either by providing the financial resources required and/or by taking over the operational aspects of the process from municipalities. They assume the responsibility voluntarily or mandatorily; EPR systems can be implemented individually or collectively.	4g
EPR system/ scheme[10]	Any system set up by one or several producers to implement the EPR principle. It can be an individual system (or individual compliance system) where a producer organises its own system, or a collective system (collective compliance system) where several producers decide to collaborate and thus fulfil their responsibility in a collective way through a specific organisation.	4g
EU-REI	European Union - Resource Efficiency Initiative	2-4
ERP	Energy-related products	4c
Functional unit	Quantified measure of performance that serves as the basis for comparison when	4b

[8] https://www.oecd.org/env/indicators-modelling-outlooks/4425421.pdf

[9] http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-OEWG.11-INF-7.English.pdf

[10] http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-OEWG.11-INF-7.English.pdf

	considering the environmental impacts of multiple product systems.[11]	
GDP	Gross Domestic Product	4d
GPP	Green Public Procurement Public authorities seek to procure goods and services with a reduced environmental impact throughout their entire lifecycle.	4e
GWP	Global Warming Potential In kg CO_2-eq	4b
G20	Group of Twenty (international forum for the governments and central bank governors)	2
Impact category[12]	Impact Categories are logical groupings of Life Cycle Assessment results of interest to stakeholders and decision makers.	4b
IPR[13]	Individual Producer Responsibility Each individual producer is responsible for the collection and disposal of waste originating from his own products.	4g
IPCC	Intergovernmental Panel on Climate Change	2
ISO	International Standards Organization	4c
Life cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal.[14]	4b
LCA Lifecycle Assessment	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.[15]	4b
Life cycle impact assessment	Phase of Life Cycle Assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product.[16]	4b
Life cycle thinking	Life Cycle Thinking is a mostly qualitative discussion to identify stages of the life cycle	4a, 4b, 4c,

[11] https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_LED_Lifecycle_Report.pdf
[12] https://www.lifecycleinitiative.org/resources/life-cycle-terminology-2/
[13] http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-OEWG.11-INF-7.English.pdf
[14] ISO 2006
[15] ISO 2006
[16] ISO 2006

	and/or the potential environmental impacts of greatest significance e.g. for use in a design brief or in an introductory discussion of policy measures. The greatest benefit is that it helps focus consideration of the full life cycle of the product or system; data are typically qualitative (statements) or very general and available-by-heart quantitative data.[17]	
MCI	Material Circularity Indicator developed by the Ellen MacArthur Foundations and measures circularity of materials flows on the business and product level The MCI consists of three variables • the mass of virgin raw material inputs (V); • the mass of waste going to landfill or energy recovery (W); and • the product's longevity and use intensity, reflected by a utility factor (X).	4d
MFA	Material Flow Analysis a systematic assessment of the flows and stocks of materials within a system defined in space and time.	4a, 4b
MEAT	Most Economically Advantageous Tender	4e
MOEF&CC	Ministry of Environment, Forest and Climate Chang	
Mo/Steel	Ministry of Steel	
Mo/Mines	Ministry of Mines	
MoHUA	Ministry of Housing and Urban Affairs	
MEITY	Ministry of Electronics and Information Technology	
NDCs	Nationally Determined Contributions	
Orphan products[18]	Products that are on the market and for which a producer can no longer be identified	4g
Producer[19]	The entity whose brand name appears on the	

[17] https://www.lifecycleinitiative.org/resources/life-cycle-terminology-2/

[18] http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-OEWG.11-INF-7.English.pdf

	product itself or the importer. In the case of packaging, the filler of the packaging is considered the producer.	
PRO[20]	Producer Responsibility Organisation Collective entity set up by producers or through legislation, which becomes responsible for meeting the waste collection- and disposal obligations of the individual producers.	
Product system	Complete set of steps that are involved in the production, use, and disposal of a product or service throughout its life cycle. The LCA of a product system evaluates the resource consumption and by-product or waste emissions incurred by each process or phase of the life cycle.[21]	
Resource efficiency		2-4
SARSO	South Asian Regional Standards Organization	4c
SCP Sustainable consumption and production	The use of goods and services that responds to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardize the needs of future generations. It is increasingly recognized that efficiency gains and technological advances in products and their associated production processes alone will not be sufficient to bring global impacts to a sustainable level; changes will also be required to consumer lifestyles, including the ways in which consumers choose and use products and services.[22]	
SDG	Sustainable Development Goals	2,3
SIDBI	Small Industries Development Bank of India	4h
SPP	Sustainable Public Procurement Public authorities seek to find an appropriate balance between the three pillars of sustainability – economic, social and environmental – when procuring goods and services.	4e
Stakeholders[23]	All actors involved in the life-cycle of a product	4g,…

[19] http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-OEWG.11-INF-7.English.pdf

[20] http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-OEWG.11-INF-7.English.pdf

[21] https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_LED_Lifecycle_Report.pdf

[22] https://www.lifecycleinitiative.org/resources/life-cycle-terminology-2/

[23] http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-OEWG.11-INF-7.English.pdf

	including: producers, retailers, consumer-citizens, local authorities, public and private waste management operators.	
System boundary	Set of criteria specifying which unit processes are part of a product system. [24]	4b
TADF	Technology Acquisition and Development Fund	3
TDO	Total domestic input Macro indicator: Domestic material consumption + unused domestic extraction	4d
TMI[25]	Total material input Macro indicator: Total material requirement - indirect flows of imports represents the total quantity of material outputs to the environment released on the domestic territory by economic activity	4d
TMO[26]	Total domestic output Macro indicator: Total domestic output + exports includes also exports and therefore measures the total of material that leaves the economy	4d
TMR[27]	Total material requirement Macro Indicator: Indirect flows of imports + imports + used domestic extraction + unused domestic extraction includes, in addition to TMI, the upstream hidden material flows which are associated with imports and predominantly burden the environment in other countries.	4d
UNFCCC	United Nations Framework Convention on Climate Change	2
Value Chain	A value chain is a high-level model describing the activities that a firm operating in a specific industry conducts to receive raw materials as input, add value to the raw materials through	2-4

[24] ISO 2006

[25] https://www.oecd.org/env/indicators-modelling-outlooks/4425421.pdf

[26] https://www.oecd.org/env/indicators-modelling-outlooks/4425421.pdf

[27] https://www.oecd.org/env/indicators-modelling-outlooks/4425421.pdf

	various processes, and deliver finished products to customers. Michael Porter popularized the concept in his 1985 best seller, Competitive Advantage: Creating and Sustaining Superior Performance. He suggested that the activities of a business could be grouped under two headings: (1) Primary Activities – those that are directly concerned with creating and delivering a product; and (2) Support Activities – those not directly involved in production, but may increase effectiveness or efficiency (e.g. human resource management).[28]	
WEEE	Waste Electrical and Electronic Equipment	4c

[28] https://www.lifecycleinitiative.org/resources/life-cycle-terminology-2/