



Work package n°3 - Course content development

Module 2 Circular economy and symbiosis

(Work package 3 - Course content development: outline for the theoretical part)

Table of Contents

1 Introduction.....	3
2 Background and Motivation.....	3
3 Theoretical Framework	4
3.1 Key Concepts and Definitions	4
3.2 Detailed Explanation	4
3.3 Case Studies and Examples	5
4 Practical Applications	5
5 Summary and Take-home learning messages.....	6
6 Further Reading and Resources	6
7 Assignments and Assessments Strategy	7



1 Introduction

The topic's importance and relevance are quite clear. The linear way of production and consumption has led to mountains of waste, polluted soil, air and fresh water, loss of biodiversity and ocean acidification and of climate change.

We have one planet, but live as if we had five, ending the conditions for the life we live. Four limits of the nine planetary boundaries have already been exceeded, loss of biodiversity, altered land use, altered biogeochemical flows of nitrogen and phosphorus. The First and Second laws of Thermodynamics have been neglected for too long. Extraction from finite layers in the ground must stop and renewable sources should be used to the extent they grow to avoid over-extraction. This is the basis for circular economy as means to possibly mitigate the climate change and to achieve the sustainable development goals (SDG).

The aim of micromodule 2 is making students aware of the basis and the strategies for changing the linear direction to a circular one. Awareness of one's own carbon footprint is a first step. The second step is to be aware of the systemic hierarchy for circularity assessment. Case based learning with examples will be utilized and the mixed/interdisciplinary teams of students will cooperate in finding energy efficient circular solutions and maybe also company symbiosis where one industry's waste becomes another's raw material in the chosen cases.

2 Background and Motivation

In Europe, this existing building stock is responsible for 40% of total energy use and app. 36% of CO₂ emissions. Construction industry is therefore facing increased demands to contribute to a more sustainable future, as global challenges are growing. Awareness of the environmental impact in the construction sector has increased significantly, which has led to an interest in circular solutions, resource efficiency and choice of environmentally friendly materials. Conventional construction methods are being questioned more often, also by the big companies, and development is moving towards new ways of working with focus on sustainability.

Building new energy efficient nearly zero energy buildings (NZEB) is important, but 95% of the built environment we will have in 30 years from now is already built, and most of the building stock is not energy efficient. Hence the need for a holistic view of energy efficient circular solutions in the whole construction sector.



3 Theoretical Framework

3.1 Key Concepts and Definitions

Decreasing our carbon footprint is something we all have to deal with and beginning with our own personal footprint is a first start.

Defining projects using the systemic hierarchy for circularity assessment is the first key concept in micromodule 2.

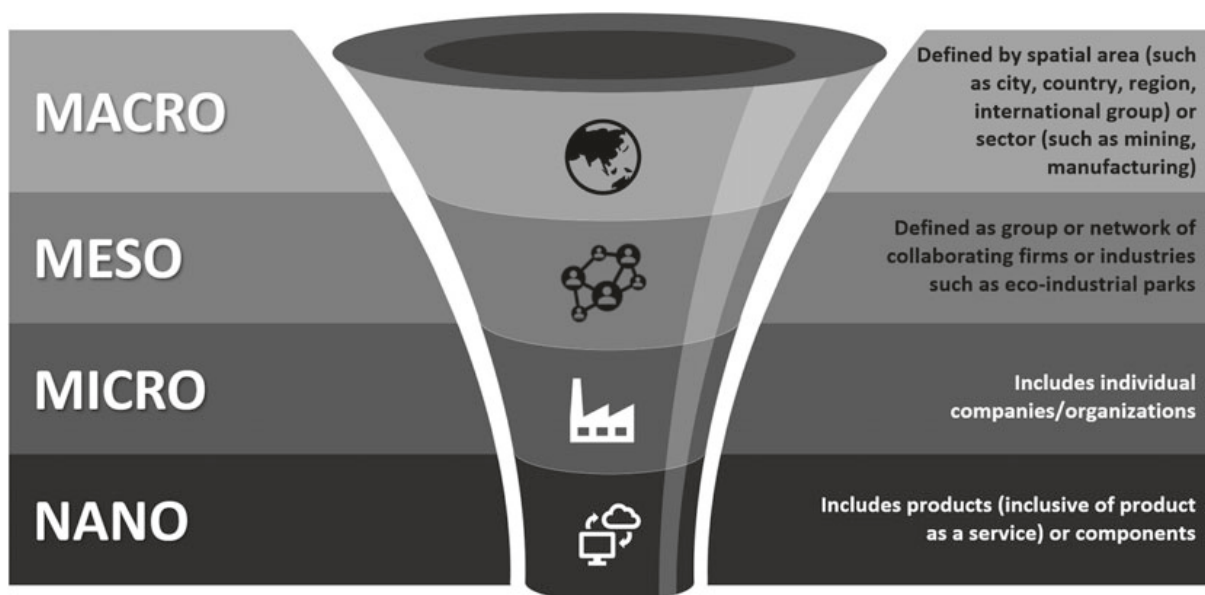
Using the ten Rs within circular economy when working with the existing building stock as well as with new buildings is the second key concept.

Combining circular economy and energy efficiency for every kind of building projects is the third key concept.

Making use of symbiosis with companies in e.g. regenerating construction and indoor building materials is the fourth key concepts.

3.2 Detailed Explanation

Circular economy is implemented on four levels; macro, meso, micro and nano levels.



Schematic representation of the four levels of systemic hierarchy considered for circularity assessment—(top-down) macro, meso, micro, and nano. (Right) The scope of each level of the systemic hierarchy is defined (Patil & Ramakrishna Eds. 2023).

The Rs are usually explained as being five or seven, but there are actually ten Rs used within circular economy.

1. Refuse – prevent raw materials' use
2. Reduce – decrease raw materials' use
3. Redesign – reshape product with a view to circularity principles
4. Reuse – use product again (as second hand)
5. Repair – maintain and repair products
6. Refurbish – Revive product
7. Remanufacture – make new from second-hand product
8. Re-purpose – reuse product but with other function
9. Recycle – salvage material streams with highest possible value
10. Recover – incinerate waste with energy recovery

A rough categorising of the Rs could be as follows. The first and second R is defined at a macro level, and at a meso level we have R number 2, 3, 4 and 9. R number 4, 5, 6, 7, 8 and 9 can be found on the micro level. R number 4 and 10 can be categorised as both macro and nano depending on how electricity and heat are defined and the size of the energy generating plant. Company symbiosis can be found on macro, meso as well as on micro levels within the systemic hierarchy. This rough categorising should be discussed by the interdisciplinary teams.

3.3 Case Studies and Examples

One of the cases from the real world is a study of a multi-family building in Gothenburg where circular economy and the Rs have been used by an architect. The aim for the housing company was to regenerate the building using as few new materials and components as possible. This exemplary study will form the basis for the interdisciplinary teams' understanding how circular economy can be used and on what level of the systemic hierarchy it was performed.

All lectures and literature studies digitally available in micromodule 2 is aimed at enhancing and deepen the understanding of the three subtopics; four levels of systemic hierarchy, the use of the Rs in circular economy, and companies' symbiosis.

4 Practical Applications

In the final case during the last week of the nZEBRA testing period the interdisciplinary teams will have a lecture and then, by themselves, design energy efficient and circular solutions. The exact case is not yet decided on. It can be analysing and suggesting energy efficient circular solutions for an office building, or it can be solutions for companies' symbiosis where one industry's waste becomes another's raw material.

(Discuss how the theoretical knowledge can be applied in practical situations. Provide examples of practical applications and explain how they relate to the theoretical concepts discussed earlier.)

5 Summary and Take-home learning messages

The students will be given the possibility to read and discuss the learning material by working in interdisciplinary teams forming an awareness of circular economy and company symbiosis and their necessary contribution to the SDGs.

Learning objectives

1. Understand the systemic hierarchy levels for assessment of circularity
2. Understand the basic concept of circular economy
3. Define the major components of circular economy and how they can be used
4. Understand the process of symbiosis

(Summarize the key points covered in the topic. Highlight the most important concepts and takeaways for the students.)

6 Further Reading and Resources

Books

- McDonough W. & Braungart M. (2002) *Cradle to cradle: Remaking the way we make things*. New York: North Point Press.
- Anoop Patil R. and Ramakrishna S. (2023) *Circularity assessment: Macro to Nano. Accountability towards sustainability*. Singapore: Springer Nature Singapore Pte Ltd. <https://doi.org/10.1007/978-981-19-9700-6>
- Jonansson G., Sundin E., Wiktorsson M. (2019) *Sustainable Manufacturing*. Lund: Studentlitteratur AB.

Thesis

- Kunic N. (2024) *Transforming a Building by Implementing Circular Economy Principles*. Master Thesis. Halmstad: Halmstad University.

Articles

- Dokter G., Thuvander L., and Rahe U. (2021) How circular is current design practice? Investigating perspectives across industrial design and architecture in the transition towards a circular economy. *Sustainable Production and consumption* 26 (2021) 692-708. <https://doi.org/10.1016/j.spc.2020.12.032>
- Nußholz J., Çetin S., Eberhardt L., De Wolf C., Bocken N. (2023) From circular strategies to actions: 65 European circular building cases and their decarbonisation potential. *Resources, Conservation & Recycling Advances*. 17 (2023) 200130. <https://doi.org/10.1016/j.rcradv.2023.200130>



- Nyström K. and Murata M. (2024) Regenerative businesses' role in industrial symbiosis realisation. *Sustainable Development*. 2024;1–14. DOI: 10.1002/sd.3246
- Cardoso Chrispima M., Mattsson M., Ulvenblad P. (2023) The underrepresented key elements of Circular Economy: A critical review of assessment tools and a guide for action. *Sustainable Production and Consumption*. 35 (2023) 539-558.
<https://doi.org/10.1016/j.spc.2022.11.019>

Websites

- www.ellenmacarthurfoundation.org
- https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

7 Assignments and Assessments Strategy

- o Each student should be able to do two digital tests based on the digital lectures and the literature in micromodule 2 on the Blackboard with 80% right answers.
This will equal 25 points.
- o Each interdisciplinary team will discuss the three subtopics; the four levels of systemic hierarchy, the use of the Rs in circular economy, and companies' symbiosis, and hand in a written assignment of minimum 3-pages.
This will equal 35 points.
- o Each interdisciplinary team will in an IRL workshop/seminar analyse, discuss and suggest energy efficient circular solutions for a case.
This will equal 40 points.

(Outline the assignments and assessments related to this topic. Describe the tasks, expectations, and criteria for evaluation.)

