Circular Economy Transition – Minor Module

Motivation:

Unsustainable development continues to endanger and threaten our future, while resource, water, and energy scarcity give a red alarm for the linear (take-make-use-dispose) economy. One-third of the entire food produced in the world is wasted [1] with a global loss of 750 billion dollars annually [2]. 90% of the electronic and electric equipment waste (mobile phones, computers, headphones, etc.) are dumped in landfills [3] summing up to 54 million tons worldwide in 2019[1]. Greenhouse gas emissions and energy requirements increase the pressure on businesses and society. Sectors like construction and (animal-)farming face serious sustainability risks due to millions of tons of nitrogen and methane emissions produced. In energy production, considerable energy losses occur due to energy supply-demand mismatch and carbon emissions continue to increase while researchers inspired from Circular Economy develop energy storage, carbon capture, and conversion technologies. More examples can be explicitly named in this respect, but the only solution lays in *our common future*: a Sustainable Circular Economy. Hence, our *common mission* in this minor module is to have a direct impact on the development of the circular economy by implementing real-life problems, getting professionals involved, and strengthen relationships between business, government, and research organizations.

Timeliness:

The transition to a Circular Economy requires an acceleration as our global challenges increasingly demand more attention. The traditional take-make-use-dispose understanding has been triggering these challenges which cause pressure on local and global supply chains, governments, and consumers. Although the Sustainable Development Goals of the United Nations develop clear targets and a Circular Economy transition is recommended as a global priority by multiple actors such as the European Union, a large variety of barriers slow down this transition. These are associated with the non-circular product-development, operational problems through supply chains impacting on resource use, unsustainable consumer behavior, and governments' considerations in trade-offs among regulation scenarios.

Companies, consumers, and governments need to cooperatively take action for Circular Economy transition, which requires a multiple- and integrated-stakeholder understanding. Hence, from the educational perspective, the future Circular Economy awaits its implementors who speak different *languages* to achieve a common goal for *all*. To succeed it, the minor module of Circular Economy Transition offers a 15 EC package that takes companies, society, and governments in its core to achieve a groundbreaking impact for our *common future* in a cross-disciplinary education environment.

Main content:

Figure 1 summarizes the content of the module where a problem-solving oriented approach is proposed implementing learning goals on multiple stakeholder engagement and involvement. Main attention is given to the following priorities in the value chains from the business perspective: 'prevent waste if possible', 'create value from waste if waste is unavoidable', and 'recover value from end-of-life products'. Next to the circular business models, the role of governance, strategic communication between stakeholders, public engagement via responsible citizenship and sustainable consumption, and the impact of public bodies on directing resource and employment policies within the Circular Economy are embedded in the module. The module aims to develop an interactive approach between students representing different stakeholders in an online serious game. The game is set-up in order to let the students experience to run a circular ecosystem trying to achieve their individual goals and

[1] https://theconversation.com/global-electronic-waste-up-21-in-five-years-and-recycling-isnt-keeping-up-141997

collective goals of the circular ecosystem. Therefore, we put the Circular Economy Transition Game in the heart of the module. The courses all contribute to the knowledge, skills and insights needed to be successful in the game. Technological innovations and energy transition are in the practical core of the module and embedded in the game set up.

It is evident that an understanding of consumer behavior is required for sustainable circular initiatives to be successful. Hence, responsible citizenship and psychological components of (un)sustainable consumption are integrated into the module to showcase how the society can take an interactive role in the transition to circular economy. This is a unique design of the Circular Economy Transition minor to strengthen the trans-disciplinarity and the development of complementary skills between students from specifically targeted programs. The assessment methods are synchronized with the module content to ensure the unity of module components and to keep students' collective intelligence active to realize circular economy transition via effective cooperation. The five pillars of the module composition are shown in Figure 2.

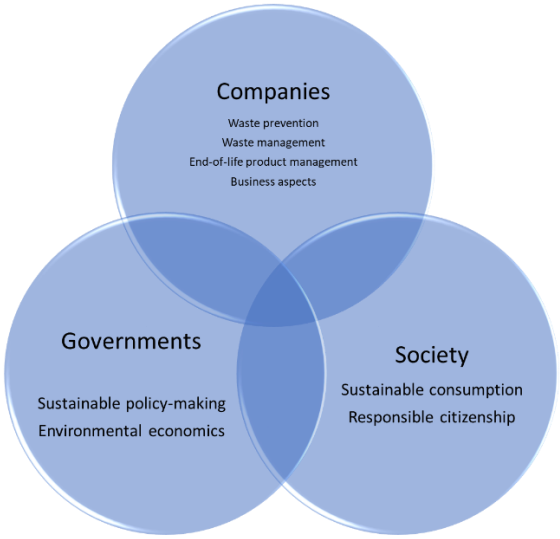

Figure 1. Module content from stakeholders perspective

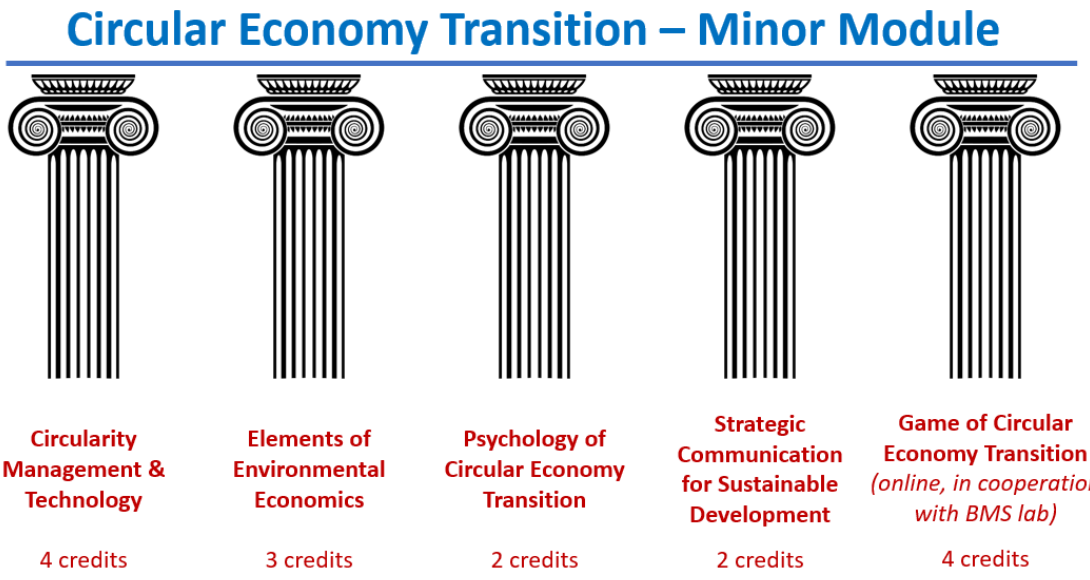

Figure 2. The five pillars of the Circular Economy Transition Minor Module

Learning goals:

At the end of the minor module, the students are expected:

- to recognize stakeholders involved in circular economy, their potential actions and interactions
- to develop (through the course) and apply (in the game play) multiple managerial and technical skills to implement circular economy networks
- to design solution concepts to implement a circular economic network over time (in the game play) recovering value-added from different types of resources, process wastes, and end-of-life products (given through courses)
- to technically and geographically identify the possibility of *loop-closing or loop-slowing* between minimum two entities (company-company, household-company, company-public entity, household-public entity, etc.)
- to match between the individual or collective sustainability needs of companies and the needs of consumers
- to develop and implement communication strategies to different stakeholders
- to distinguish the purchasing behavior of different types of consumers
- to develop and report solutions for shifting from unsustainable product development to circular product development
- to implement circular flows and promote evolutionary use of wastes both in form of upcycling and downcycling
- to measure sustainability indicators to assess own and network performance
- to link and convert their theory-based learnings (lectures) in circular economy practices (game)

<u>Course 1</u>

Circularity Management & Technology

Following the value hill of Achterberg et al. [4], we consider three phases of a product: pre-use, use, and post-use. Waste prevention and waste management are embedded in all scales aligned with the following practical goals. It is reasoned that the first goal is 'avoid waste in product/system/supply chain design phase', the second goal is 'close the loop and recover value from non-avoided process wastes', and the third goal is ''manage the end-of-life process of a product in the most sustainable way and extend its value". Conceptually, the main distinction is between products and wastes, i.e., products are the main goal of production activities while wastes are *undesired* secondary outputs, which vary from scrap materials to food packaging materials, construction and demolition waste, GHG emissions, wastewater, loss energy, etc. How to develop business from an undesired output? Waste prevention is mainly based on products, end-of-life product management is based both on products and wastes, and waste management is mainly based on technical and biological cycles aligned with the concept of symbiosis. Composition of the course:

- Waste Prevention
- Waste Management
- End-of-life Product Recovery
- Business aspects

ECTS: 4 (25% weight on average grade)

Short description:

Waste Prevention

In this part of the course, students will learn how to develop green product ideas [10] and use elements of green marketing to promote their sustainable products [5]. Specifically, we will have a look on the role of production processes in reducing raw materials and primary input (including energy and water) consumption in the economic system. In particular, we will focus on two main topics: (1) green products, i.e., products designed and produced to have a lower environmental impact during their entire life cycle [6,7], and (2) environmental innovation, i.e., innovation practices aimed at reducing the input consumption of production processes [8,9]. Students will learn circular economy practices such as the design for disassembly and remanufacturing [10,11] and also develop strategies to minimize the wastes(to be emitted in the product use phase) early in the initial product development phase.

Waste Management

When waste prevention is not possible or not effective, practical solutions are needed to tackle with waste streams. This challenge requires cooperative actions by multiple actors and leads to non-traditional but sustainable businesses. Industrial Symbiosis plays a critical role to construct this cooperation via offering the exchange of wastes between companies as substitutes of primary resources or sharing common services among each other [12]. As a *loop-closing* activity, industrial symbiosis associates with multiple aspects of dealing with *wastes* and converting them into *resources.* These are technological [13], operational [14], logistical [15], environmental [16], and social aspects [17] which are provided to enrich students' vision on the transdisciplinary characteristic of waste management. From a structural perspective, water-based, energy-based, service-based, and material-based symbiosis types are discussed at multiple geographical contexts, i.e., rural symbiosis, urban symbiosis, and industrial symbiosis, to provide a large variety of application levels

End-of-life Product Recovery

This part concerns the role of the products at the end of their life cycle in the circular economy context. In particular, the course will be focusing on reverse logistics and closed-loop supply chains, i.e., the circular economy practices allowing to recover products at the end of their life cycle, thus avoiding their disposal in landfills [18,19]. We will deal with product recovery options [20].

Students will learn the main differences between closed-loop supply chains and traditional supply chains, i.e., that processes do not end at the customer, as well as the basic principles of reverse logistics, e.g., how to design a closed-loop supply chain considering several perspectives (e.g., structural, operational, etc.) or how to set-up the relationships among the members of the supply chains to enable reverse product flows [21–24].

Business aspects

Society plays a key role in the transition towards the circular economy because their demand for goods and services affects the business strategies of companies. To support the transition towards the circular economy, consumers should switch from traditional products to green products. But what draws the attention of a consumer to a sustainable and circular product? How a company should promote its circular product or service to people? Students will become aware of the main factors able to affect the consumer purchases concerning green and sustainable products, in particular impacting

on the purchase intention, willingness to pay a premium price, or attitude towards green products (e.g., products remanufactured, refurbished, recycled, or produced from scraps) [25–27].

Learning goals

- to distinguish between the individual and sectorial needs of companies from different sectors to foster cooperation for circular economy transition
- to understand the role of reverse logistics and closed-loop supply chains in circular economy
- to identify where and how in a supply chain process a product can be made more sustainable
- to tackle with process waste streams and valorize them in a circular way
- to recognize green products and distinguish them from conventional products;
- to suggest strategies to people to make sustainable purchasing
- to identify the right circular business models for the right transition scenarios

Testing methods

- Group assessment: Challenge-based essay-writing (40% of individual course grade)
- Individual assessment: written exam (40 questions multi-choice, 60% of individual course grade)

Course 2

Elements of Environmental Economics

ECTS: 3 (20% weight on average grade)

Short description:

Environment and economics are strongly interrelated. In order to achieve the environmental goals at the international level, it is now fundamental to decouple the economic activity from environmental pollution [28]. This course aims to shed light on the relationship between environment and economics. Students will become aware of the main tools that governments, at both local and global levels, can adopt to promote sustainable industrial activities, such as environmental taxes and subsidies, as well as flexibility instruments developed at the international level. Furthermore, governments' interaction with the society to foster sustainable consumption practices (e.g., citizen-business-nonprofit cooperations) is also discussed.

Learning goals

- to understand the relationships between environment and economics
- to learn how to promote the sustainable policy instruments
- to help society change unsustainable consumption behavior via societal or political means

Testing methods

- Group assessment: Challenge-based essay-writing (40% of individual course grade)
- Individual assessment: written exam (30 questions multi-choice, 60% of individual course grade)

Course 3

Psychology of Circular Economy Transition

ECTS: 2 (15% weight on average grade)

Short description:

It is evident that an understanding of consumer behaviors is required for sustainable circular initiatives to be successful. This course, therefore, focuses on the perceptions and behaviors of consumers as stakeholders and actors in a sustainable circular society, how these are influenced by sustainable technology and automation, and how perceptions, behaviors, and interaction can be optimized to decrease household energy use.

The transition to a sustainable circular economy requires the consumer to change from a mere user to an active participator. In a sustainable-energy context, for instance, energy conservation may be brought about not only by influencing individual behavior, but also that of groups, such as neighborhoods, in which energy production, energy storage, and energy consumption – e.g. relating to e- mobility and in-home consumption - need to be balanced. The decision to use one's car or to do the laundry will no longer be an individual one, but, rather, one that needs to be coordinated with other users in order to prevent spikes in consumption.

This transition presupposes a number of factors on an individual as well as a group level; these will be expanded upon in this part of the course. E.g., users will need a certain degree of environmental concern to be motivated enough to participate and continue to do so, have knowledge and understanding of the energy system in relation to mobility in order to agree to the restrictions of shared use, have sufficient trust in the technology and governing institutions, their fellow network members, etc.

In addition, it is also important to focus on technology and technology design. On the one hand, if designed right, design features such as product-integrated feedback mechanisms can be effective tools in facilitating and guiding user behaviour [29,30] On the other hand, innovations often also lead to suboptimal behaviours. For instance, various studies have pointed to the so-called rebound effect (Midden et al., 2007): e.g., households with energy-efficient lighting tend to leave the lights on longer than those without, and people who have bought a more economical car use it to drive more miles than before. Various other mechanisms can be brought to bear to explain inefficient or wasteful behavior. For instance, the belief that one is already living a sustainable lifestyle, may be used to "excuse" inefficient behaviors ("moral licensing"). In addition, people may be ignorant of the negative consequences of various everyday-life behavior for circularity. Depending on the antecedents of inefficient behavior, various potential solutions may be brought to bear to counteract them. In summary, this course looks for a solution in pro-active participation of the society in order to achieve both sustainable circular economy and a *circular society*.

Learning goals:

- Identify behaviors that contribute to / are detrimental to a sustainable circular economy from a consumer (or user) perspective
- Identify possible antecedents of these behaviors
- Use this knowledge to design a strategy to facilitate desirable behavior and prevent undesirable behavior relating to sustainable circularity.

Testing methods

- Group assessment: Challenge-based essay-writing (40% of individual course grade)
- Individual assessment: written exam (20 questions multi-choice, 60% of individual course grade)

Course 4

Strategic Communication for Sustainable Development

ECTS: 2 (15% weight on average grade)

Short description:

Various stakeholder groups, including businesses, governments, and society, play a key role in the transition towards the circular economy. However, these stakeholders all have their own interests and stakes that affect their perceptions of the desirability of sustainable technological change [31]. Communication has a significant impact on achieving sustainable development. This course focuses on how strategic communication with and between stakeholders can contribute to sustainable change. Students learn about various communication processes that are relevant for sustainable development, including message framing, forming and influencing perceptions, public engagement, and stakeholder collaborations.

Learning goals

- to recognize different stakeholder perspectives in sustainable circular economy
- to understand the role of communication in sustainable development
- to develop strategic communication strategies towards different stakeholders for fostering sustainable development

Testing methods

- Group assessment: Challenge-based essay-writing (40% of individual course grade)
- Individual assessment: written exam (20 questions multi-choice, 60% of individual course grade)

Game of Circular Economy Transition

ECTS: 4 (25% weight on average grade)

Short description:

The game will run in the newly designed multi-disciplinary minor module “Sustainable Circular Economy”. Thus, the students have the chance of exchanging diversified knowledge with each other. This is supported by accompanying courses given to enlarge the stakeholder-oriented view of students and provide them with the necessary fundamentals and concepts. Thus, cross-cutting points such as socio-spatial, socio-economic, or techno-economic dimensions of the sustainable circular economy are transmitted to students. This set of cross-cutting points is fundamental for the development of circular economy, which is a holistic concept and requires different perspectives to be successfully implemented. As future managers, engineers, or policy-makers, establishing an inclusive and cooperative attitude of students in a highly sensitive societal matter is the prior goal of the game. Thus,

students gain competitive knowledge about dynamics of an interdisciplinary problem: the challenge of circular economy transition.

The game is planned to be online and suitable for hybrid teaching (can be run independently from the number and location of attendants), which is an advantage for the resilience of the minor module. In addition, it is planned to be developed as a flexible game to which several diverse game modules can be added and integrated. From an institutional perspective, the minor module and the game will contribute to BMS' engagement to the Sustainable Development Goals of the United Nations – with particular attention to Goals #17 (partnerships to achieve the goal), #4 (quality education), #7 (affordable and clean energy), #9 (industry, innovation, and infrastructure), #11 (sustainable cities and communities), #12 (responsible consumption and production) and #13 (climate action). Consequently, we contribute to the development of globally responsible citizens.

Learning goals:

- to practice the learned content from courses of the module in an online game set up
- to execute loop-slowing and loop-closing activities as companies
- to implement a network of sustainable relationships in the circular ecosystem
- to efficiently use IT technologies as circularity facilitators

Testing methods

- Group assessment: online serious game performance (50% of individual game grade),
- Individual assessment: (i) short essay based on the learning outcomes from the game (3 pages) (30% of individual game grade), (ii) presentation based on serious game (20% of individual game grade)

Table 1 shows synoptically the grading matrix according to which students will be assessed.

Table 1. Grading criteria for the Minor Module

Course	**Credits (component weight)**	**Assessment weights**				
		Individual effort			**Group effort**	
		Written exam	**Presentation**	**Short essay**	**Challenge-based Essay**	**Performance**
Circularity Management & Technology	4 (25%)	60%	0%	0%	40%	0%
Elements of Environmental Economics	3 (20%)	60%	0%	0%	40%	0%
Psychology of Circular Economy Transition	2 (15%)	60%	0%	0%	40%	0%
Strategic Communication for Sustainable Development	2 (15%)	60%	0%	0%	40%	0%
Game of Circular Economy Transition	4 (25%)	0%	20%	30%	0%	50%
		58%			42%	

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