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Chapter 12. Sustainability in Building and Operating Real Estate

12.1. COURSE SUMMARY

Table 12–1

Audience and level of studies	Students (Bachelor)	
Group size	26–50	
Course duration	12 weeks	
Credits	5 ECTS	
Workload	Presence: 70h Self-study: 80h	Total: 150h
Contents/primary topics	• Sustainability in building and operating real estate	
Main course objectives	• Create an increased understanding over the complexities of sustainability in building and operating real estate • Application in projects	
Main teaching approaches	• Lecture-based learning • Experiential learning • Collaborative learning	
Main teaching methods	• Lecture • Sustainability-related research project • Group discussion	
Learning environment	Classroom (face-to-face learning) Beyond classroom (field trip to a sustainable building)	
Link to Sustainable Development Goals	SDG 6 | Clean Water and Sanitation | Ensure availability and sustainable management of water and sanitation for all SDG 7 | Affordable and Clean Energy | Ensure access to affordable, reliable, sustainable and clean energy for all SDG 11 | Sustainable Cities and Communities | Make cities and human settlements inclusive, safe, resilient and sustainable SDG 12 | Responsible Consumption and Production | Ensure sustainable consumption and production patterns SDG 13 | Climate Action | Take urgent action to combat climate change and its impacts	

Table 12–2

Impact assessment:	(None) Low/Medium/High	Explanation
1. Degree of student participation / activeness	High	Students are practicing exercises, participating in discussions, and working on an own project.
2. Degree of student collaboration / group work	High	Students are participating in a team project throughout the module.
3. Degree of student emotional involvement	Medium	In class, students get the opportunity to articulate their emotional stands on sustainability-related issues.
4. Degree of inter-/trans-disciplinarity	Medium	The operation of a building is an interdisciplinary task (in the sense of facility management). Furthermore, guest lectures are integrated.
5. Degree of student (self-) reflection	Medium	Students are reflecting on personal experiences relating to sustainability and on a scientific paper on the topic of sustainability in real estate.
6. Degree of experience of real-life situations	Medium	Students conduct a field trip.
7. Degree of nature-related experiences	(None)	
8. Degree of stakeholder integration	Medium	Students represent different stakeholders as they are members of companies that own buildings or provide facility services, they are also users of buildings in their professional and private roles.
9. Degree of integration between theory and practice	Low	Case studies and practical examples are included throughout the course.

12.2. COURSE INTRODUCTION

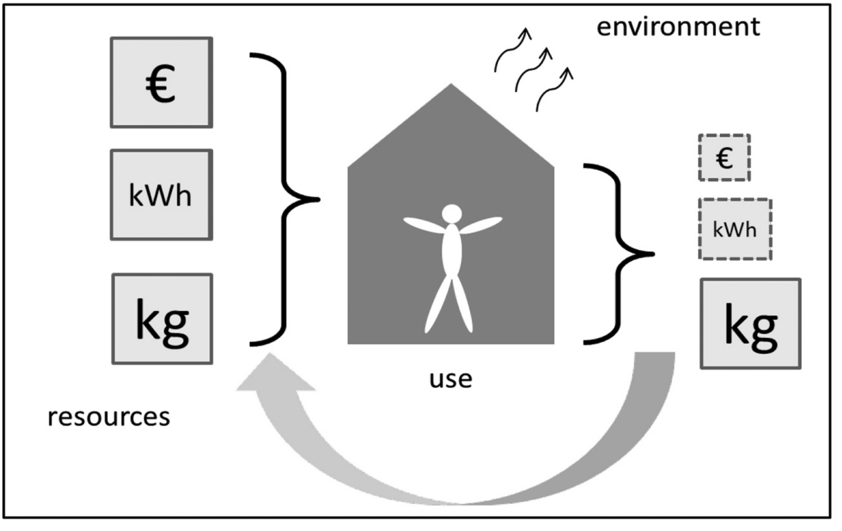
This module is offered within the study programme "Technical Facility Management" and is aimed at students who are employed in companies in the real estate industry and who deal with building operations there. In all modules of this degree programme, resource conservation is addressed as a key issue. In particular, the modules on construction and energy technology prepare students for the implementation of ecological sustainability.

Sustainability is introduced in the context of the Sustainable Development Goals (SDGs) and its applicability is then considered in detail in the fields of building construction and operation. The aim is to get to know the possible target and evaluation systems for sustainability in a respective country. The German Sustainable Building Certification DGNB (DGNB GmbH, 2021) and

SustainFM according to the guideline from GEFMA German Facility Management Association, GEFMA 160 – "Sustainability in Facility Management" (Pelzeter et al., 2020) are used as examples in Germany. These topics are framed by questions of how sustainability can be implemented in mobility, in urban development, in companies and in the private environment. By elaborating and discussing potentials and future developments, a "critical reflection on goals and values" is encouraged (Balsiger et al., 2017, p. 378).

Life cycle management and circular economy are fundamental principles for the sustainable construction and operation of buildings. As shown in Figure 12–1, the cycle of materials (in kg), energy (in kWh) and financing (in €) serve as inputs for the construction and use of a building. This ideally becomes recycled material (right, in kg) and a financial residual value (e.g., for the reuse of building elements, in €) at the end of the use phase. The further use of thermal energy (in kWh) is technically challenging, hence the dotted representation.

Figure 12–1



(Pelzeter, 2016, p. 6)

Because combatting climate change is currently a pressing SDG (Edenhofer, 2014), special emphasis is placed on creating awareness of the emissions of climate-impacting gases. For this purpose, the basics of life cycle assessment (Finkbeiner, 2014; Frischknecht, 2020) are taught, key figures are researched (e.g. CO_2 emissions for the production of one ton of steel-reinforced concrete or for one passenger kilometre in public transport), as well as determined by means of eLCA tools (Bundesinstitut für Bau-. Stadt- und Raumfoschung, 2021) and carbonFM (German Facility Management Association e.V., 2021; Krämer et al., 2021).

12.3. LEARNING OBJECTIVES

After completing the module, students should be able to develop concepts of sustainable construction and operation and implement them in their professional areas of activity in Facility Management (FM). In doing so, they can use the methods and benchmarks utilised in the module and further develop them according to the situation.

The learning objectives of the module can be assigned to the learning objectives and their categories as formulated by the UNESCO (2017) (see first and second column of Table 12–3 below). In the third column of the table, these learning objectives are assigned to competences that Wei et al. (2020) have identified as target-oriented for teaching in socio-environmental problem-solving.

Table 12–3

Learning objective dimension (UNESCO, 2017)	**Learning objective according to UNESCO (2017)**	**Competency referred to framework of Wei et al. (2020)**
Cognitive	"The learner understands the concept of 'virtual water'." (SDG 6) (p. 22)	systems thinking, integrative research
	"The learner understands the concept of energy efficiency and sufficiency and knows socio-technical strategies and policies to achieve efficiency and sufficiency." (SDG 7) (p. 24)	
	"The learner knows the basic principles of sustainable planning and building, and can identify opportunities for making their own area more sustainable and inclusive." (SDG 11) (p. 32)	
	"The learner knows about strategies and practices of sustainable production and consumption." (SDG 12) (p. 34)	
	"The learner knows which human activities – on a global, national, local and individual level – contribute most to climate change." (SDG 13) (p. 36)	

Learning objective dimension (UNESCO, 2017)	Learning objective according to UNESCO (2017)	Competency referred to framework of Wei et al. (2020)
Socio-emotional	"The learner is able to feel responsible for their water use." (SDG 6) (p. 22)	sociocultural awareness
	"The learner is able to clarify personal norms and values related to energy production and usage as well as to reflect and evaluate their own energy usage in terms of efficiency and sufficiency." (SDG 7) (p. 24)	
	"The learner is able to contextualize their needs within the needs of the greater surrounding ecosystems, both locally and globally, for more sustainable human settlements." (SDG 11) (p. 32)	
	"The learner is able to feel responsible for the environmental and social impacts of their own individual behaviour as a producer or consumer." (SDG 12) (p. 34)	
	"The learner is able to recognize that the protection of the global climate is an essential task for everyone and that we all need to completely re-evaluate our worldview and everyday behaviours in light of this." (SDG 13) (p. 36)	
Behavioural	"The learner is able to reduce their individual water footprint and to save water practicing their daily habits." (SDG 6) (p. 22)	boundary crossing, sociocultural awareness
	"The learner is able to apply basic principles to determine the most appropriate renewable energy strategy in a given situation." (SDG 7) (p. 24)	
	"The learner is able to promote low carbon approaches at the local level." (SDG 11) (p. 32)	
	"The learner is able take on critically on their role as an active stakeholder in the market." (SDG 12) (p. 34)	
	"The learner is able to evaluate whether their private and job activities are climate friendly and – where not – to revise [or amend] them." (SDG 13) (p. 36)	

12.4. COURSE OUTLINE

Table 12–4

Structure		Session focus	Activity in presence
Session	Subject		
The module described is taught over a period of 12 weeks. Each session lasts 180 minutes.			
1	Introduction, Projects	SDGs, political goals in the target country, status quo	Brainstorm on SDGs and FM; discussion

Structure		Session focus	Activity in presence
Session	**Subject**		
2	Concepts for optimising sustainability in the construction and operation of buildings	Substitution, efficiency, sufficiency; Life Cycle Management: usability, energy, costs, material, environment, information	Match, find examples
3	Assessment systems 1 - Sustainable construction	BNB, DGNB, LEED, BREEAM	Apply to building example (case study)
4	Assessment systems 2 - Sustainable operation	GEFMA 160, criteria procurement, water management, catering	Exercise on GEFMA 160
5	Key figures 1 - CO_2	Carbon footprint, GEFMA 162, evaluation concept, examples, optimisation, innovations	Apply carbonFM, research innovations on low carbon facility services
6	Questions about the project, support		
7	Key figures 2 - LCA	Procedure, impact categories, eLCA	Apply and evaluate different building materials in case study
8	Guest speaker from the business sector	Key figures on the life cycle of real estate	Hold a discussion round
9	Key figures 3 - Maintenance	Lifetimes, maintenance strategies, guidelines, calculation concept, optimisation of maintenance	Research and group lifetimes, calculate costs for case study
10	Key figures 4 - LCC	Life Cycle Costs, GEFMA 220, calculation concept, case study	Apply GEFMA 220 to case study
11	Evaluation systems 3 - Sustainability report	GRI Global Reporting Initiative, guest with his company´s sustainability report	Compare reports from facility management service providers
12	Innovative building materials, C2C	Demountable constructions, wood plastics, etc.	Discuss provocative questions on innovations
13	Questions about the project, support		
14	City of the future	Smart Grid, reintegration of production processes, case study	Draft own vision
15	Mobility	Visions of the mobility of the future	Read from a book on mobility stories from the future
16	Private consumption	Carbon calculations, water footprint, social sustainability in the supply chain	Use calculation tools, discuss findings and consequences
17	CO_2-optimised services	Presentation of the students' projects	Give feedback to fellow students
18	Conclusion	Review and feedback	Reflect on what has been learned

Abbreviations:

BNB – Bewertungssystem Nachhaltiges Bauen des Bundes (Sustainable Building Rating System of the Federal Government in Germany)

BREEAM – Building Research Establishment Environmental Assessment Method

C2C – Cradle to Cradle

DGNB – Deutsches Gütesiegel Nachhaltiges Bauen (German Sustainable Building Certification)

eLCA – electronic Life Cycle Assessment

GEFMA 160 – German Facility Management Association, Guideline 160 – SustainFM: Sustainability in Facility Management

GEFMA 162 – Guideline: Carbon Management for Facility Services

GEFMA 220 – Guideline: Life Cycle Costs in Facility Management

LCC – Life Cycle Costs

LEED – Leadership in Energy and Environmental Design

12.5. TEACHING APPROACHES AND METHODS

This course is embedded within the framework of a company-linked (dual) study programme, in which students work for three months each semester in a company that cooperates with the institution throughout the period of study. In this study programme, a seminar-based teaching concept is applied, by combining lecture-based, experiential and collaborative learning.

The lecturer gives a broad overview of the diverse topics of sustainability in the construction and operation of real estate in short lectures. Lectures are well suited to present broad knowledge in a compact way so that later case studies can be well classified (Schneider & Mustafić, 2015) (Ulrich, 2020). The active construction of the overview knowledge is guided by a variety of transfer exercises (Pinheiro & Simões, 2012). These exercises support active learning and consist of various tasks, such as researching application examples (inquiry-based learning) (Felder, 2016), discussing implementation concepts or applying assessment tools to a given building example. The practical application of the attained knowledge on sustainability can materialise in future projects carried out by the cooperating company to improve the sustainability of the building operations.

The assessment systems for sustainable building from DGNB (DGNB GmbH, 2021) and for sustainable operation from German Facility Management Association (German Facility Management Association e.V., 2015) are applied by the students (excerpt-wise) to the building example already used several times during the course. A consistent application example supports multidisciplinary learning throughout a study programme, but especially in the interdisciplinary field of sustainability. The analysis tools eLCA (Bundesinstitut für Bau-. Stadt- und Raumfoschung, 2021) and carbonFM (Krämer et al., 2021) are tested under the teacher's guidance. In the process, the students learn about possible data sources for environmental key figures of products. In Germany, key figures by Ökobaudat (Bundesministerium des Innern, für Bau und Heimat, 2021) and Probas (Umweltbundesamt, 2021) are freely available. Other methods such as group discussions on questions arising from the lecturers' presentations or from current events also come into play. A field trip to a particularly sustainable building provides the opportunity to talk to experts on site. Further, the opportunity to listen to a guest speaker from the industry highlights the practical significance of the presented indicators, in different disciplines (Pech et al., 2021). The application of a tool on CO_2 in everyday life then leads to self-reflection on personal CO_2 drivers and acceptable concepts for reducing them in personal lifestyles.

Overall, this teaching concept relies on the ability to analyse and derive conclusions in professional as well as private practice. The background to this is the fact that while individuals know the price of everything, they usually do not know the potential environmental impact of using a product (Lin & Huang, 2012). In the same way as the price has been used to classify and assess alternative courses of action, the environmental impact should also be considered in the future.

The students' self-learning is enhanced by preparing and presenting revisions of the contents of the previous session (Lou, 2021). Furthermore, they prepare a summary of the contents of a research paper they have researched themselves (Schneider & Mustafić, 2015). For these presentations, the topics and dates are coordinated in advance so that the student contributions fit the thematic sequence of the sessions. However, the main task of the students in this module is project work carried out in small groups (two to three persons), around the topic of innovations in facility management for the reduction of CO_2 emissions. Project-based learning leads to a particularly intensive acquisition of knowledge and methods (Pech et al., 2021; Yazici, 2020). After researching innovative devices or processes under development, calculations are carried out using carbonFM, among other tools. The results of the completed project work are presented at the end of the module. The topics are also coordinated for the alignment of the projects so that no duplications in the presentations occur.

The approaches and methods listed here are a mix of already tried and tested ones and are therefore not fundamentally new. However, innovation is at the centre of the module: Innovative building concepts are shown or researched and innovative concepts for the provision of facility services are the subject of the students' project work.

12.6. EXERCISES

Assessment of Sustainable Building

Time:
After the introduction to the system for assessing sustainable building.

Task, objectives:
A comparison of two pre-set construction or design alternatives on the example building based on two (self-selected) criteria from DGNB. The aim is to recognise which criteria are used to measure sustainable building. A secondary objective is to become familiar with the different criteria in DGNB and to understand the assessment procedure.

After an introduction to the task, the teacher serves as a contact person for individual queries, assists in closing information gaps on the building example for carrying out the assessment, if necessary, etc. Finally, the results of some of the groups are presented and compared with those of the others. A discussion on possibly unexpected measurement criteria in DGNB can ensue and contribute to a critical reflection of assessment systems.

Duration:
Approximately 90 minutes

Group work:
Teams of two persons

Design of a Low-CO2 Facility Service

Time:
After introduction of the Carbon Footprint

Task, objectives:
Comparison of a given standard service with a to be designed low-CO_2 service using carbonFM according to GEFMA 162. The aim is to recognise CO_2 drivers in the service and to identify possible alternatives in the service design. A secondary objective is to learn about / learn to use the carbonFM tool and the principles that GEFMA 162 recommends for CO_2 assessment.

After an introduction to the task, the teacher is the contact person for individual queries and provides support, if necessary, in estimating missing data for the newly designed service and possible devices/products that are used for it, etc. Finally, the groups present their results and compare the possible differences. A discussion on the identified CO_2 drivers deepens the problem awareness for climate protection in facility services.

Duration:
90 minutes, depending on the complexity of the standard service also longer

Group work:
Teams of two to three persons

Life Cycle Costing

Time:
After introduction to life cycle costing

Task, objectives:
Manipulation of a given life cycle cost calculation for the example building on Excel with regard to energy prices, calculation interest rate, etc.

After an introduction to the task, the teacher is the contact person for individual queries. The aim is to recognise influencing factors in life cycle costing. By working with the table, the participants get to know the procedure of a life cycle cost calculation. A final comparison of the results provides another opportunity to clarify questions about the correct procedure.

Duration:
30 minutes

Group work:
No

12.7. ASSESSMENT

For each student a portfolio is assessed, which can be awarded with a maximum of 100 points and consists of three parts:

- *Summary of a teaching unit (individual work), max. 10 points*:
  Students are asked to describe the essential contents of one session (1–2 pages). They should include a visualisation that can be used as a reminder in the following course. For example, the visualisation can be a short video film, diagram or graph not previously used in the course.

- *Summary of a technical essay (individual work), max. 10 points*:
  Students have to summarise the contents of an essay (minimum four pages long) in own words and conclude with a short statement (one to two pages).
- *Project work on the topic "Innovations to optimise CO_2 emissions in facility services in hospitals" (group task), max. 80 points:*
  Although the providers of facility services do not produce any products themselves, they do use products for their processes, which are associated with specific CO_2 emissions. A first approach to reducing CO_2 emissions is to choose the lowest-emission operating resources possible (e.g., vacuum cleaner). However, this project is about identifying and assessing innovative products or methods for service delivery. The project work includes a calculation, which is carried out according to GEFMA Guideline 162 Carbon Management in FM or with the tool carbonFM. The tool also provides benchmarks for various operating resources and materials — if already available. However, the challenge is primarily to identify suitable key figures or comparative values and define a scenario for the comparison between conventional and innovative service provision. Students have to submit a written documentation of the project (six to ten pages in length) and give a verbal presentation to the class (20 minutes duration).

12.8. PREREQUISITES

- Required prior knowledge from students: This course requires prior knowledge in the field of construction, facility management and energy technology.
- Required instructors and their core competencies: Teachers should have prior knowledge and methodological skills in the field of sustainable construction and operation of real estate. In particular, they should know the assessment concepts of sustainability of buildings, services and. companies.
- Other requirements:
  - Internet access and a PC, laptop, tablet, or smartphone are required so that students can conduct their own research and use online digital tools.
  - With eLCA, the teacher can be given access for the entire course in advance.
  - A building example with a floor plan, floor area figures and information on the building construction is the basis for testing the evaluation systems for sustainable construction and operation of real estate. Ideally, the students already know this example. A building at the university would be well suited for this.

12.9. RECOMMENDED RESOURCES

Recommended course literature:

- Sustainability in building construction and operation:

DGNB GmbH (2021). *The DGNB System*. https://www.dgnb-system.de/en/system/

- Life Cycle Assessment:

Jolliet, O., Shaked, S., Jolliet, A., Crettaz, P., & Saadé-Sbeih, M. (2016). *Environmental life cycle assessment*. CRC Press. https://openresearchlibrary.org/content/f4a6383f-2809-4d8c-abbd-9e206568513c

- Climate Change:

Rockström, J., & Gaffney, O. (2021). *Breaking Boundaries*. Dorling Kindersley UK.

- Individual carbon footprint:

World Wildlife Fund (2022). *Footprint Calculator*. https://footprint.wwf.org.uk/#/

- Virtual water:

Water Footprint Network (2022). *Resources.* https://www.waterfootprint.org/en/resources/

12.10. GENERAL TIPS FOR TEACHERS

- An important success factor lies in making the students' existing knowledge and experience on the topic of sustainability tangible. Therefore, classroom teaching that is spontaneously transformed into a group discussion can be advantageous.
- In the case of group work, self-selected groups of about three people have proven successful. These are usually homogeneous in terms of performance, so that friction losses due to free-riding are not to be expected.
- To ensure that the students' projects have a quality that enriches the module, it is worth investing some time in supervising the projects. The supervision appointments are obligatory for the students. In this way, it is possible to reach those who are particularly in need of assistance.

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