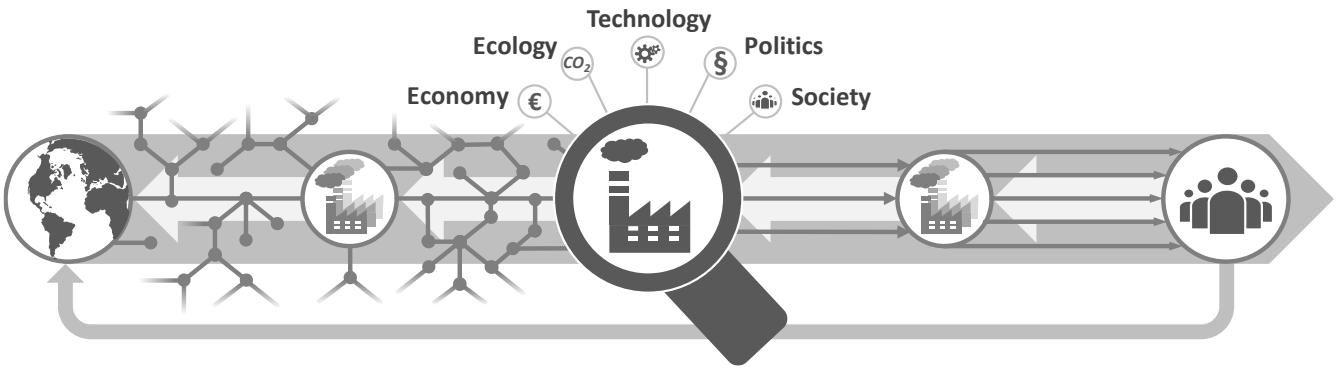
Karlsruher Institut für Technologie

Institute for Industrial Production (IIP)
Chair of Business Administration,
Production and Operations Management
Prof. Dr. Frank Schultmann

Seminar in Summer Semester 2025
Research Group "Sustainable Value Chains"



Building Sustainable Value Chains

Background and objectives

The bioeconomy refers to an economic system that utilizes renewable biological resources—such as plants, microorganisms, and organic waste—to produce food, energy, products, and services. It integrates principles of sustainability and innovation to transform how we produce and consume goods, aiming to reduce dependence on fossil fuels and minimize environmental impact.

The bioeconomy offers a pathway toward sustainable economic growth by integrating biological knowledge with engineering and business strategies. It presents numerous opportunities and challenges that require a multidisciplinary approach to create a more sustainable future.

Designing bioeconomic concepts involves creating sustainable economic models that utilize biological resources and processes to produce goods, energy, and services. While the bioeconomy presents significant opportunities for innovation and sustainability, several key challenges such as resource availability, economic viability as well as supply chain and logistics must be addressed to develop effective and viable bioeconomic strategies.


Source: The bioliq® process turns straw into biofuels.

Preparation and assessment

Designing bioeconomic concepts requires a multifaceted approach that addresses technical innovations, economic realities, environmental sustainability, and social dynamics. During the seminar the students work in groups on assigned scientific topics. Some literature will be provided, but should be supplemented by the students' own research. Participation in the seminar includes the preparation of case studies and exercises, which are summarized in a seminar thesis as a research paper and presented at the end of the semester. The assessment of the work is based on both the written seminar paper and the presentations given, which must be in English.

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Topic A
Bioeconomy in the Rhine-Neckar Metropolitan Region
BioCyclesRN

Be part of the BioCyclesRN research project and explore how biogenic resources can be systematically identified and integrated into new value chains to foster a circular bioeconomy in the Rhine-Neckar Metropolitan Region (MRN). The goal is to reduce environmental impacts while simultaneously creating economic opportunities for regional businesses and agricultural enterprises. A particular focus is on networking relevant stakeholders from industry, agriculture, and science to foster synergies and identify sustainable utilization concepts. Innovative approaches for circular use and cascading utilization of biogenic residues are being explored. To develop practical solutions, a thorough potential analysis of available resources and a stakeholder analysis of relevant actors are essential. These analyses will help determine promising material flows and viable value chains for regional implementations towards a sustainable future.

Tasks:

- Conduct a thorough literature review to identify the status quo of fossil resource consumption, especially in the chemical industry sector.
- Further review the key biomass resource potentials in the metropolitan region, utilize existing data, e.g., project report KommBÖ4MRN (Municipal and Urban Bioeconomy Strategy for the Rhine-Neckar Metropolitan Region), state strategy "Sustainable bioeconomy for Baden-Württemberg“, and data from the research project ReBioBW.
- Compile a technology overview, identifying suitable methods for converting residues into valuable products.
- Analyze the business network in the region and identify key players in the MRN.
- Reflect the report of the company VCG.ai, which is commissioned with an AI-aided analysis of the potential for a circular bioeconomy in the MRN.

Within the framework of this seminar topic, up to three students will collaborate on developing a comprehensive analysis. This seminar provides participants with the opportunity to engage in interdisciplinary research at the intersection of circular economy, bioeconomy, and industrial transformation. By integrating theoretical analysis with practical case studies, you will gain valuable insights into technological developments, sustainable business models, and regional innovation networks at practical level.

Supervisor

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Dr. Andreas Rudi; E-Mail: andreas.rudi@kit.edu, Tel.: 0721 628-44568

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Topic B
From Catalyst to Product

The development and application of catalysts are fundamental to the advancement of chemical industries, playing a pivotal role in enhancing reaction rates, selectivity, and energy efficiency. The journey from designing a catalyst to delivering a final product encompasses a multidisciplinary approach involving chemistry, materials science, process engineering, and economic analysis. Understanding this journey is essential for driving innovation and sustainability in sectors such as pharmaceuticals, petrochemicals, and renewable energy.

In this seminar, you will delve into the comprehensive process of transforming catalyst concepts into marketable products. Specifically, you will investigate the question: How does the progression from catalyst development to product manufacturing contribute to sustainable industrial practices?

- **Catalyst Design and Development:** Investigate various types of catalysts, including homogeneous, heterogeneous, and biocatalysts. Explore methods of catalyst synthesis, characterization, and performance evaluation. Understand the role of catalysts in influencing reaction mechanisms and kinetics.
- **Process Integration and Scale-Up:** Examine the challenges of integrating catalysts into industrial processes. Evaluate scale-up strategies from laboratory to pilot and full-scale production.
- **Economic and Environmental Assessment:** Review techno-economic analyses (TEA) and life-cycle assessment (LCA) to assess the viability of catalytic processes. Explore regulatory factors and sustainability standards influencing catalyst deployment.
- **Case Study Application:** Focus on a specific catalytic process (e.g., biomass conversion to biofuels, or Power-to-X concepts). Identify key challenges and innovations at each stage from catalyst to product. Propose optimization strategies for improving efficiency and sustainability.

Seminar structure: Within the framework of this seminar topic, up to three students will collaborate on developing a comprehensive review of a catalytic process from inception to product delivery. The seminar will involve: literature review, technical analysis, economic and environmental evaluation and the preparation of a scientific keynote.

Presentation and Discussion: By participating in this seminar, you will gain a holistic understanding of how catalysts drive product development in the chemical industry. You will develop skills in interdisciplinary research, critical analysis, and strategic thinking, which are essential for addressing complex challenges in modern engineering and business contexts.

Supervisor

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Topic C
Agri-PV for Biorefineries

The green transition in Europe is characterized by the trend towards increasing investments in renewable energies and sustainable conversion concepts. The biorefinery is such a concept, which converts biogenic raw materials into valuable products. To ensure overall sustainability of biorefineries the energy supply must be renewable. Agri-PV and solar thermal energy may contribute to satisfy the energy demand of biorefineries. However, to match the requirements of different types of energy systems and the various biorefinery concepts with suitable biomass cultivation options a techno-economic assessment is necessary. Because especially for agricultural businesses, installing a large-scale solar system represents a big investment decision. The agricultural business will have to decide, whether an energy system can be compatible with their farming and biorefiney concept, which fits best, and at what scale.

In this topic you will work on the concept of an integrated biorefinery that uses energy from its own PV/solar thermal park. In particular, you will study the question: What contribution can PV/solar thermal energy make to biorefineries?

In a first step, you will review existing literature to match energy with biorefinery with farming systems. In a second step, the relevant business models for the selected system designs are evaluated from technical and economic perspectives. How can the solar system be integrated with the biorefinery and farming decisions? How many m² are needed depending on the energy production to satisfy the energy demand? Finally, the analysis should conclude with a cost-benefit analysis on the viability of energy installations for biorefinery businesses and beyond.

Key aspects are:

- Agri-PV/thermal system differences and compatibility with agricultural management or building elements such as barns, greenhouses or biorefineries.

- Business models for Agri-PV/thermal systems in agriculture: Estimate the energy production of the solar plant in the region of the biorefinery to select the size requirements of the system.

- Investigate competition of solar energy systems in terms of land-use: food, feed, fuel, etc.

Within the framework of the seminar topic a maximum of three students will elaborate on the case study of a medium-sized lignocellulosic biorefinery, which faces the challenge to use renewable energy for producing sustainable products. The plant is located in a rural area next to biomass supply locations.

Supervisor

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Topic D
Bibliometric Analysis of Modeling Biobased Value Chains

The transition towards a sustainable bioeconomy requires the development of efficient and resilient biobased value chains that integrate renewable resources, conversion technologies, and market dynamics. To design and optimize these value chains, various modeling approaches have been applied in scientific research, ranging from techno-economic analyses and GIS models to optimization. However, the diversity of methods and the growing complexity of sustainability challenges call for a systematic analysis of the existing literature to identify key trends, methodological advancements, and research gaps.

In this topic, you will conduct a Structural Bibliometric Analysis to map the landscape of modeling approaches for biobased value chains. Using bibliometric tools, you will explore how different methodologies have evolved over time, which research communities contribute to this field, and what the dominant themes and emerging trends are.

In a first step, you will review existing literature and collect bibliometric data from databases such as Web of Science or Scopus. In a second step, you will apply bibliometric techniques such as co-citation analysis, bibliographic coupling, and keyword co-occurrence analysis to identify the intellectual structure of the field. What are the most influential papers and authors? How have modeling approaches for biobased value chains developed over time? Finally, the analysis should conclude with a discussion on research gaps and future directions, highlighting opportunities for advancing modeling frameworks.

Key aspects are:

- Identification of key research themes and trends in modeling biobased value chains.
- Analysis of methodological developments in system modeling, including optimization, simulation, and life cycle assessment approaches.
- Mapping of research networks to understand interdisciplinary connections and collaboration patterns.
- Evaluation of knowledge gaps and potential future research directions in sustainable value chain modeling.

Within the framework of the seminar topic, a maximum of three students will collaborate to perform the bibliometric analysis, interpret the results, and elaborate on the implications for future research and decision-making in the bioeconomy. The study will be supported by bibliometric tools for data visualization and network analysis.

Supervisor

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Topic E
Life Cycle Assessment (LCA) – Method for sustainability analyses

The consideration of ecological aspects is not only part of scientific studies but is increasingly being applied in all economic areas. When designing new products and processes, the use of methods to determine environmental impacts is an essential component. In this context, the methodology of life cycle assessment (LCA) represents a standardized approach to identify and quantify the environmental impacts along the whole value chain of a product. The LCA methodology is anchored in DIN ISO 14044 and constitutes an integral component of environmental management certification (DIN ISO 14001) for companies. As a standard tool, fundamental LCA knowledge is becoming increasingly requisite, thus making it a valuable asset for any engineer.

In this topic, you will learn the base knowledge of the LCA methodology and how to apply it on the case study of passenger cars (diesel vs. petrol vs. electric driven car). The aim of the case study is to compare the production and operation of the different types of drivetrain technologies regarding impact categories like Global Warming Potential (GWP), Resource Scarcity etc. Based on the theoretical aspects and practical examples, you will prepare education material, which serves as a descriptive introduction in the LCA methodology and procedure.

Key aspects of this topic are:

1. **Learn and summarize the fundamentals of LCA methodology**
2. **Conduct and analyse a comparative LCA case study**
3. **Merge the gained LCA-knowledge to prepare education material**

Within the framework of the seminar topic, a maximum of **three students** will focus on the theory and procedure of LCA methodology to extract the gained knowledge to prepare education material. Complementing the theoretical perspective, a case study will be conducted to illustrate and facilitate the understanding of the different aspects of a LCA.

Supervisor

M.Sc. Alexander Schneider, E-Mail: alexander.schneider@kit.edu, Tel.: 0721 608 44587

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Design of Industrial Plants and Processes

Grading

The grading takes several parts into consideration. Both the active participation in the events and the presentation are included in the grade. However, the main part is the written seminar paper, which, like the presentation, is prepared in groups of up to 3 people. The total workload corresponds to 3 ECTS points.

Application

Please apply with a CV, a short letter of motivation and a current transcript of records. Master's students must enclose the final grade transcript from their Bachelor's degree. Please briefly answer the following questions in your letter of motivation:

- Why should you be a participant in this seminar?
- Do you already have previous knowledge?
- What is your favorite topic?
- What do you expect to learn?

If you wish, you can also specify the group members you would like to join in your letter of motivation. However, admission to the seminar is on an individual basis.

Dates

- Kick-Off event: April 2025 at the IIP (Westcampus, Geb. 06.33) in Room 103
- The day of final presentations will be agreed with the seminar participants at the Kick-Off event. The presentations are expected to take place at the end of July or beginning of August.
- Students are required to be present on all days of the event.

Contact for organizational questions:

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