Karlsruhe Institute of Technology

Institute for Industrial Production

Annual Report 2023

Chair of Business Administration, Production and Operations Management




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Preface

This annual report of the Chair of Business Administration, Production and Operations Management at the Institute for Industrial Production (IIP), Karlsruhe Institute of Technology (KIT) depicts our main activities during the year 2023. Our three research groups "Sustainable Value Chains", "Risk Management", and "Project and Resource Management in the Built Environment" have conducted numerous projects on a regional, national and international level covering a broad range of topics. The team of the Chair consists of about 25 researchers, 4 administrative staff and a several student assistants.

During 2023, we worked on 24 third party funded research projects. We published 16 peer-reviewed journal papers, numerous articles in conference proceedings and book chapters. 6 PhDs were completed. Teaching activities resulted in around 600 exams and about 43 bachelor and master theses were supervised. In addition to the various activities at KIT, we managed to continue and broaden our national and international networks.

We hope that this report inspires your interest in our activities. Any comments are welcomed. We look forward to future collaborations around our research and teaching activities.

Prof. Dr. Frank Schultmann

Research Groups

Sustainable Value Chains

Head of research group: Dr. Andreas Rudi

The research group Sustainable Value Chains develops strategies for a more sustainable design of value chains and production systems as well as the affiliated logistical, organisational and information related functions. In this context, sustainability is defined as the joint consideration of economic, ecological and social aspects. Major areas of research are related to circular economy concepts regarding both material or product cycles (closed-loop supply chains, reverse logistics) and the use of renewable, bio-based resources in industrial value chains (bioeconomy).

To cope with the related manifold problems, different approaches from economics, engineering as well as environmental and social sciences are implemented, adapted and enhanced. Interdisciplinary methods and models are developed based on the regarded problems and transferred to specific industrial applications.

A focus task is the development of multi-dimensional planning models that enable an integrated analysis, assessment and optimization of material streams, complex interconnected plants or complete production networks. Other aspects considered are empirical stakeholder and acceptance analyses and policy advisory.

A further aim of our work is the development of sustainable concepts for material flow management and for decision support at regional, national and global scale. The research focus is currently on industrial plants, products and networks of the chemical and energy industry (PtX), the automotive industry (EV-battery recycling) as well as on the utilization of biomass (in biorefineries).

Typical methods applied are:

- Process simulation and system analysis
- Investment and production cost estimation (techno-economic analysis)
- Empirical social studies (especially questionnaire-based surveys and statistics)
- Life Cycle Assessment (LCA) and environmental impact assessment
- Operations research based modelling (optimization and multi-criteria decision making)

Members of the research group (from l. to r.): Alexander Schneider, Raphael Heck, Diana Temnov, Paul Heinzmann, Nina Treml, Andreas Rudi, Sonja Rosenberg, Sandra Huster, Sonia Alikhah (missing on the photo).

Risk Management

Head of research group: Dr. Florian Kaiser

The Risk Management Research Group works on scientific research questions and practice-relevant problems in the area of Risk Management with a special focus on systemic risks, behavioral risks, critical infrastructure and supply chains. The applied methods comprise economic modelling, empirical approaches and data analytics as well as simulations.

Due to the increasing complexity and acceleration of decisions in a globally interconnected world risk management becomes an ever-important task for firms and governments. Recently, attention has been directed to the threat to Critical Infrastructure caused by climate catastrophes, business crime or terrorism. But also "minor" risks, such as weather extremes, power blackouts of short duration, IT-disruptions or disrupted suppliers can seriously impact the "ordinary run of things" and the way how we wish to (or even must) take it for granted.

The risk management research group is closely connected to the KASTEL Helmholtz Institute, which was found in 2021. The work with the other KASTEL partners continued and was extended by experimental research in the KASTEL-research group Human & Societal Factors as well as data analytical works within the research group engineering secure systems.

Furthermore, in 2023, a novel project started called LandWandel, focusing on the science-driven prioritization and standardization of measures for climate protection. In addition, the feasibility study "Municipal Climate Protection" started examining the possibility of creating an intelligent, dynamic database of climate protection measures relevant to municipalities.

In February, a digital workshop was conducted as an integral component of the ALANO project. The workshop explicitly assessed diverse alternative storage strategies within food emergency stockpiling. Participants engaged in discussions and evaluations to enhance and identify effective storage methods.

In April Markus Lüttenberg successfully completed his PhD with a thesis on "Strengthening Resilience of Supply with Essential Goods through Public-Private Emergency Collaborations: Challenges and Incentives". The Risk Management Research Group extends warm congratulations to Mr. Lüttenberg for his achievements.

In June 2023, a workshop on Boundaries & Resilience was co-hosted by the Risk Management Research Group. Supported by the Franco-German University, the workshop brought together experts and researchers from France, Italy, and Germany in Sophia Antipolis (France) at the Côte d'Azur to share their knowledge and experience in crisis and risk management and explore innovative ways of cross-border collaboration.

Later in the year, Markus Lüttenberg concluded his tenure at the IIP, and we express our deep gratitude for his contributions, wishing him all the best in his future endeavors.

Members of the research group (from l. to r.): Dilana Rauch, Amelie Schwärzel, Florian-Klaus Kaiser, Katharina Eberhardt, Markus Lüttenberg.

Project and Resource Management in the Built Environment

Head of research group: PD Dr. Rebekka Volk

The Project and Resource Management in the Built Environment (PRM) group carries out technical, economic and environmental model-based analysis of energy- and resource-efficient technologies and renewable/sustainable policies, as well as their potentials regarding the built environment. Especially we work in the fields of circular economy, decommissioning and dismantling of nuclear facilities, sustainable urban development, energy resource and emission/waste efficiency in industrial processes, buildings and urban districts and the use of renewable energies in buildings.

To offer decision support for different planning activities on consumer/user or producer perspective, building level, district, regional or national level, several optimization models have been developed and employed. Among others the AWOHM model for energetic retrofits of buildings, the namares model for sustainable urban development, the ECCO models for site-specific greenhouse gas quantification in value chains and the ResourceApp MogaMaR and NukPlaRStoR models for optimized (nuclear) decommissioning project planning. AWOHM is an agent-based simulation model for the German residential building stock, the building stock's energetic quality and technical equipment as well as its owners and residents to identify economically feasible retrofit options and the resulting national greenhouse gas emissions. The ResourceApp, MogaMaR and NukPlaRStoR models are optimization models for scheduling deconstruction projects taking into account resource constraints, uncertainties, and material flows. While the ResourceApp model is focusing on residential and non-residential buildings, MogaMaR and NukPlaStoR are address nuclear power plants and facilities. The MogaMaR/NukPlaRStoR model is licensed by our project partner RODIAS GmbH as a software product called OPTIRA since mid 2020. Furthermore, we work on the planning and decision support model namares for a sustainable urban development on district level. In 2022 a second funding phase (namares 2.0) has been successfully acquired.Key aspects are the sustainable and efficient resource usage and management with a focus on land use, water, ecosystems and materials. Other models that are currently developed include the detection and analysis of thermal bridges in buildings and leaks in district heating networks. As well, we analyse current and emerging recycling technologies and supply chains with respect to more resource efficient (recyclable and/or CO_2-reduced) building materials and products, ranging from biobased composites (research projects ReGrow, Willow Weave and ReSidence) to autoclaved aerated concrete (research project REPOST) and different types of plastics (research projects Kreislaufwirtschaft für Kunststoffe, Rückbau und Recyclingstandards für Rotorblätter). In these projects, we analyse processes and production methods, new production technologies and assess the whole supply chains and material flow systems for decision support. Furthermore, we perform location, capacity and logistics planning based on economic and ecological factors.

Typical methods used in the PRM group are:

- Agent-based modelling to identify cost-efficient renewable energies' potentials in residential building stocks and municipalities
- Model-based material stock/flow and life cycle analyses
- Automated image processing to identify potential cost savings of heat and cooling losses
- Techno-economic assessments and scenario analyses
- Project management optimization methods

Members of the research group (from l. to r.): Justus Steins, Elena Vollmer, Niklas Braun, Simon Steffl, Antonia Frank, Rebekka Volk, Rafael Bischof, Mihir Rambhia, Elias Naber .

Research Projects

AI4EOSC – Artificial Intelligence for the European Open Science Cloud

Elena Vollmer, PD Dr. Rebekka Volk

Partners: Agencia Estatal Consejo Superior De Investigaciones Científicas M.P. (CSIC), Steinbuch Centre for Computing at the Karlsruhe Institute of Technology (KIT), Ustav Informatiky, Slovenska Akademia Vied (IISAS), Universitat Politecnica De Valencia (UPV), Predictia Intelligent Data Solutions Sl, Laboratorio De Instrumentacao E Fisica Experimental De Particulas (LIP), Istituto Nazionale Di Fisica Nucleare (INFN), Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (PSNC), Microstep-Mis Spol Sro, Wielkopolski Osrodek Doradztwa Rolniczego W Poznaniu (WODR)

Funding: European Union (EU)

Duration: 2022 – 2025

The AI4EOSC project aims to deliver an enhanced set of services for the development of Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL) models and applications. These services will allow for advanced features such as distributed, federated and split learning; provenance metadata; event-driven data processing services or provisioning of services based on serverless computing.

The project will focus on tools to provide AI, ML and DL services by integrating real life use cases to aid in the design process and showcase the afore-mentioned functionalities. AI4EOSC bases its activities on the technological framework delivered by the DEEP-Hybrid-DataCloud H2020 project. The DEEP platform is a production-ready system that is being effectively used by researchers in the EU to train and develop ML and DL models.

The AI4EOSC consortium has been assembled to ensure a balanced and complementary set of partners with backgrounds in research, development, technology and innovation. The consortium comprises several of the most active institutions in terms of development, implementation, deployment and operation of distributed pan-European e-infrastructures as well as experienced and highly innovative SMEs with an untapped potential in the field of AI. It consists of 10 partners from academia (including the project coordinator CSIC, KIT, IISAS, UPV, LIP, INFN and PSNC) and industry (Predictia, MicroStep-MIS and WODR).

The IIP joins this endeavour by providing a use case on automated thermography, centered around thermal images of city infrastructure (such as buildings and the ground above district heating networks). These will form a basis to test the platform's functionality and proficiency in incorporating new AI-based models to - in this case - detect thermal bridges on buildings and common thermal anomalies. If possible, new platform services such as federated learning can be showcased using the provided data and AI-model(s).

The project kick-off took place in October 2022 at the coordinating university in Santander, Spain. During the course of the event, the project was introduced and planned procedure was discussed on how the current DEEP platform will be improved. The division of the workload into seven work packages was outlined, each work package presenting its key aims and current status. This included an overview of IIP's use case in automatic thermal image analysis as part of workpackage number 6. Since then, regular meetings have taken place and the development of user stories, epics and use case requirements for the first deliverable are well underway. Further work focused on setting up a pipeline for training the AI-model(s) that are to be provided as part of the use case as well as the

integration of the model(s) into the AI4EOSC platform.

The challenges of this integration, among other things, were discussed at a user workshop in November 2023, held in Bratislava, Slovakia. In addition to technical support, there were several talks about current and planned platform features, such as experiment tracking with MLFlow or using Flower or NVFlare for federated learning.

The first reporting period, which – thus far – included an extensive review meeting with the project's EU coordinator and financial reporting, marked the end of year one of the project. The full report for this project period is due in February 2024.

ALANO - An analysis of alternative storage strategies of public emergency food supply

Dr. Florian Kaiser, Katharina Eberhardt, Dr. Markus Lüttenberg

Funding: Federal Ministry of Food and Agriculture (BMEL), Federal Agency for Agriculture and Food (BLE)

Duration: 2022 - 2024

In light of past experience in emergency food preparedness and taking into account the lessons learned from the COVID-19 crisis, this research project will examine whether and how adjustments can be made to the design of public food storage and household food storage, in order to be well prepared for future crisis situations.

The aim of the project is to analyze existing and alternative strategies for public emergency food storage. This is done by a multi-stage investigation, in which first the status quo is identified and analyzed. For this purpose, a detailed cost-benefit analysis will be prepared. This is intended to show the current costs of public food stockpiling in peacetime and the benefits in the event of a supply crisis for the scenario's "pandemic", "blackout" and "defense case". In a next step, alternative supply strategies will be evaluated and compared to the status quo.

The findings of the research project are to be integrated into the future design of the state's emergency food preparedness system. The systematic cost-benefit analysis and the identification of alternative situation strategies as well as the consideration of private food storage provide a comprehensive assessment of potential measures.

On February 08, 2023, a digital expert workshop of the ALANO project took place. At this event, the project was presented as well as current results. The workshop's primary goal was to evaluate alternative storage strategies in the context of emergency food stockpiling. This process involved close collaboration with representatives from government authorities and industry specialists. Through extensive discussions, the workshop aimed to carefully identify and evaluate the most promising alternatives for effectively stockpiling food reserves. The collective insights and expertise of the participants played a crucial role in this thorough assessment process.

In addition to conducting additional expert interviews and refining optimization models, preparations have commenced for an upcoming expert workshop scheduled for March 2024. Furthermore, an empirical study on food stockpiling in private households was carried out in Berlin, Nordrhein-Westfalen, and Baden-Württemberg, involving 655 participants.

With support from

Federal Ministry of Food and Agriculture

by decision of the German Bundestag

Project manager

Federal Office for Agriculture and Food

CEDIM – Center for Disaster Management and Risk Reduction Technology

Risk Management group

Partner: Geodetic Institute (GIK), Geophysical Institute (GPI), Institute of Applied Geosciences, Institut für Finanzwirtschaft, Banken und Versicherungen (FBV), Institute for Hydromechanics (IfH), Institute for Industrial Production (IIP), Institute for Nuclear and Energy Technologies (IKET), Institute of Concrete Structures and Building Materials - Materials Testing and Research Institute (MPA Karlsruhe), Institute of Meteorology and Climate Research, Institute of Photogrammetry and Remote Sensing (IPF), Institute of Regional Science (IfR), Institute for Technology Assessment and Systems Analysis (ITAS), Institute of Technology and Management in Construction, Institute of Economics (ECON), Institut für Wasser und Gewässerentwicklung

Funding: Karlsruhe Institute of Technology

Duration: since 01/2006 (ongoing)

The Center for Disaster Management and Risk Reduction Technology (CEDIM) is an interdisciplinary research center of the Karlsruhe Institute of Technology (KIT) in the field of disaster management. The main goal of CEDIM is to advance our scientific understanding of natural and man-made hazards, and to develop disaster management solutions for the early detection and reduction of the related risks.

Facing the increasing probability of extreme events and their tremendous possible impacts on societies, it is inevitable to investigate their impacts on current and future energy, mobility and information systems. This is also more than valid, facing the aspect that through the network character of those systems, extreme events lead to cascading effects along its system parts. That is why, natural disasters can have also severe impacts far away from their place of origin. The current globalization and strong interconnectedness around the world is also increasing this aspect. To assess the indirect impacts of natural events, two subprojects were implemented, dealing with supply chain vulnerability under consideration of global interconnectedness (IIP) and changed consumer mobility requests in the aftermath of a disaster (ECON).

CARE-o-SENE – Katalysatorforschung für nachhaltige Flugzeugtreibstoffe

Work package 4 : Impact Assessment aus techno-ökonomischer und ökologischer Perspektive

Paul Heinzmann, Dr. Andreas Rudi

Partner: Sasol Germany GmbH; Helmholtz-Zentrum Berlin für Materialien und Energie (HZB); University of Cape Town, Department of Chemical Engineering (UCT); Fraunhofer Institute for Ceramic Technologies and Systems (IKTS); INERATEC GmbH; Karlsruher Institut für Technologie (KIT), Institute for Catalysis Research and Technology (IKFT)

Funding: Federal Ministry of Education and Research (BMBF)

Duration: 2022 - 2025

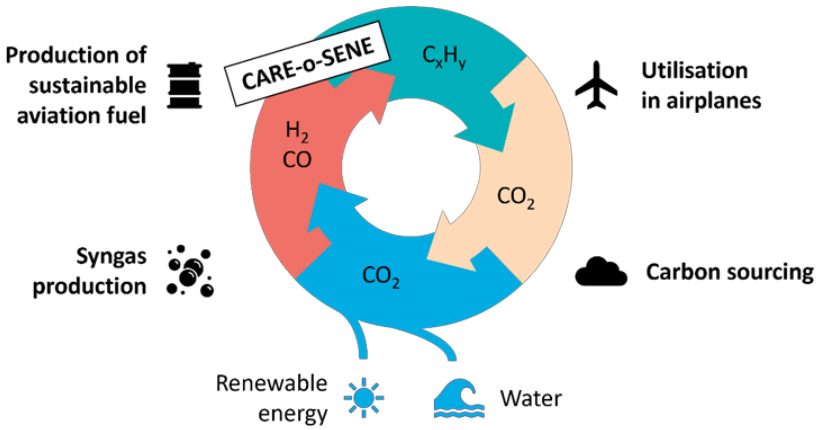
The energy transition requires the substitution of fossil fuels with carbon-neutral alternatives. Power-to-Liquid (PtL) processes might be the future key to a sustainable decarbonization of hard to abate sectors, such as the aviation sector. The CARE-o-SENE project focuses on the process of converting renewable hydrogen and CO_2 to sustainable aviation fuels (SAF) by utilizing Fischer-Tropsch (FT) processes. FT process derived synthetic paraffinic kerosene (FTSPK) show well demonstrated benefits and high greenhouse gas emissions reduction potential.

To achieve the expected rapidly growing medium to long term demand of SAF, a competitive, reliable FT catalyst with high conversion efficiencies and yields to the desired kerosene product fraction are key success factors.

Therefore, the goal of CARE-o-SENE is the accelerated and knowledge-based development of Fischer-Tropsch catalysts for the highly efficient and sustainable production of green SAFs in relevant volumes for the transformation of the aviation sector. The project aims at the scale-up of a promising catalyst (TRL 4) targeting a reduced usage of metals, a higher activity, selectivity and longer lifetime, leading to economic and environmental benefits. Additionally, new FT catalysts (TRL0/1) will be developed and analyzed, based on the combined knowledge and skills of the involved partners.

For future application, development and improvement, understanding and quantifying the overall benefits that the improved catalysts, could have on the production of Sustainable Aviation Fuels (SAF), will be analyzed in an impact analysis in work package 4. This will include life cycle assessment as well as techno-economic evaluations to assess the feasibility of the whole production, application and recycling.

The overall goal of the project strongly complements the German "Hydrogen Strategy". The project will have significant benefits in establishing new, long lasting strategic partnerships and foster existing ones between the various German and South African companies and institutes



ReBioBW – Potentials of agricultural residues for the bioeconomy in Baden-Wuerttemberg

Raphael Heck, Dr. Andreas Rudi

Partner: Universität Hohenheim, the Departments of Bioeconomy, Production Theory and Resource Economics, Biobased Resources in the Bioeconomy

Funding: State Ministry of Rural Affairs, Food and Consumer Protection (MLR)

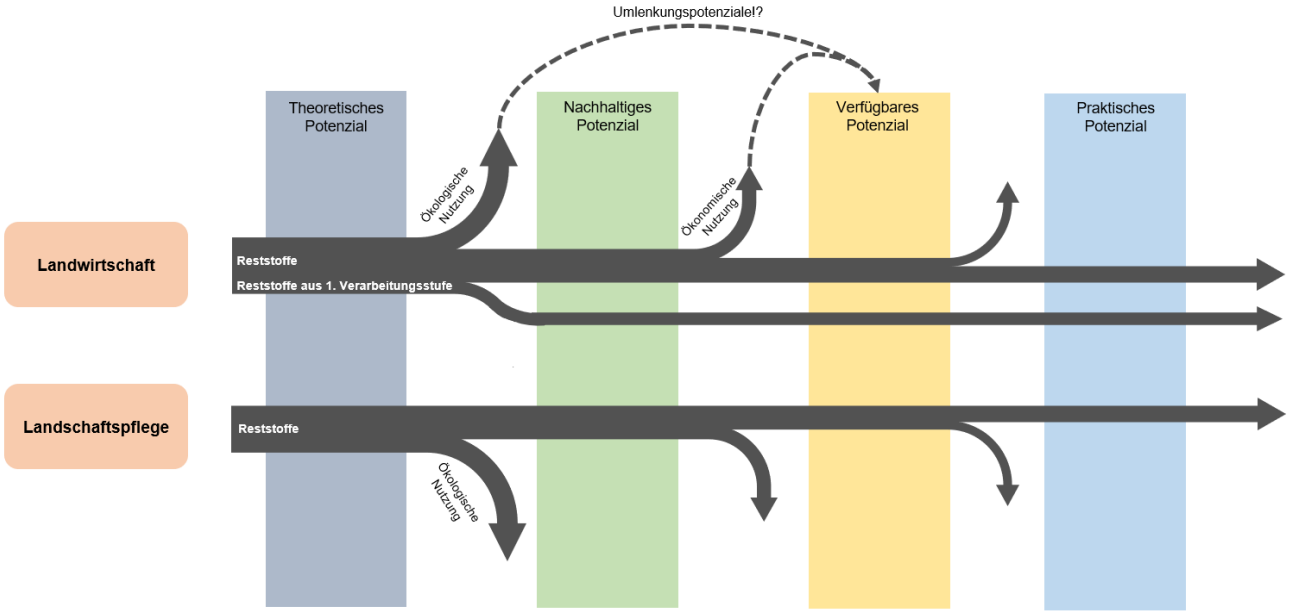
Duration: 2022 - 2025

By substituting fossil resources with renewable resources, the bioeconomy in Baden-Württemberg supports a climate-neutral economy. In order to avoid conflicting goals with food security, the focus is on agricultural residues. However, increased use of residues can cause conflicts of interest with existing use or climate protection if humus build-up and carbon storage in the soil are at risk. At the same time, the use of the residues offers opportunities for new regional value chains in rural areas. Realizing these opportunities and avoiding conflicting goals therefore requires a holistic evaluation of the residual material potential.

The aim of the ReBioBW project is to record the current and future potential of residues from agriculture and landscape conservation for the bioeconomy in Baden-Württemberg.

Using statistical data, the theoretical potential is calculated as the absolute volume of residues and minus the quantities for humus build-up, the sustainable potential. A representative survey among farmers is intended to provide information on the current use of the residues to determine the economically available potential. Qualitative surveys among companies and farmers show hurdles and framework conditions for calculating the practical potential. By developing a regional bioeconomy sector model and coupling it with an agricultural operating model, the knowledge gained is used to estimate the economic and ecological effects of residue use and future residue potential against the background of economic, social and political drivers. The surveys are accompanied by knowledge transfer along the value chain of agricultural residues aiming to close knowledge gaps regarding the nature, demand and supply of biomass and to increase the practical potential.

The project is being carried out in close coordination with the Baden-Württemberg Ministry of Food, Rural Areas and Consumer Protection and is based on the state strategy for sustainable bioeconomy.



DeMoBat – Industrielle Demontage von Batteriemodulen und E-Motoren zur Sicherung wirtschaftsstrategischer Rohstoffe für die E-Mobilität

Sandra Huster, Sonja Rosenberg

Partner: Fraunhofer Institut für Produktionstechnik und Automatisierung (IPA), Clausthal Research Center for Environmental Technologies (CUTEC), KIT Institut für Produktionstechnik (wbk), Hochschule Esslingen, BTU Cottbus – Fachgebiet Physikalische Chemie , Mercedes Benz AG, Siemens AG, Silberland Sondermaschinenbau GmbH, Greening GmbH & Co. KG, Erlos GmbH, acp systems AG, CTC battery technology GmbH

Funding: Ministry of the Environment, Climate Protection and Energy Sector Baden-Württemberg (MUKE)

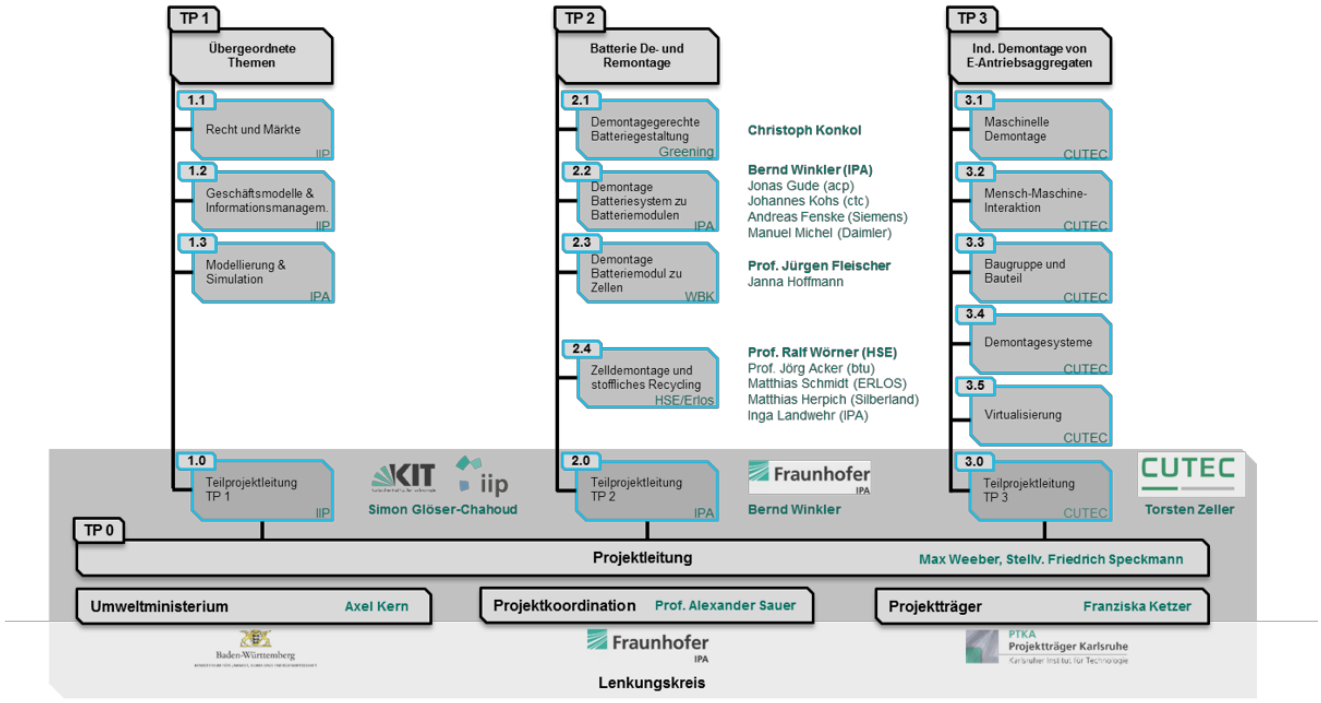
Duration: 12/2019 – 03/2023

The joint project DeMoBat aims to develop industrial disassembling processes for traction batteries and drive trains of electric vehicles. These processes are considered as a prerequisite for a resource-efficient and sustainable design of closed-loop supply chains for electro-mobility.

Traction batteries represent a key cost factor of electro-mobility and cause significant environmental impacts during production, which is why their most efficient and long-term use is a crucial element of the sustainable design of electro-mobility.

The targeted disassembly of battery packs into individual modules and subsequent cell level enables condition-specific uses of the battery modules or cells. A disassembling allows on the one side reassembling for second use applications, such as energy storages or automotive spare parts. On the other side, high-quality recycling of the electrode active material can be reached. The same applies to electric motors, where the rare-earth permanent magnets and copper coils are valuable components.

As the leader of sub-project 1 within the DeMoBat consortium, the IIP investigated raw material markets, business models, legal framework conditions, and logistics, as well as cost estimation of the disassembling processes. The outputs of sub-project 1 are documented in several research articles.



E-Akteur – Akteursbeziehungen in der kreislaufwirtschaftlichen Wertschöpfung von E-Fahrzeugbatterien

Sandra Huster, Dr. Andreas Rudi

Partner: Fraunhofer Institute for Manufacturing Engineering and Automation (IPA)

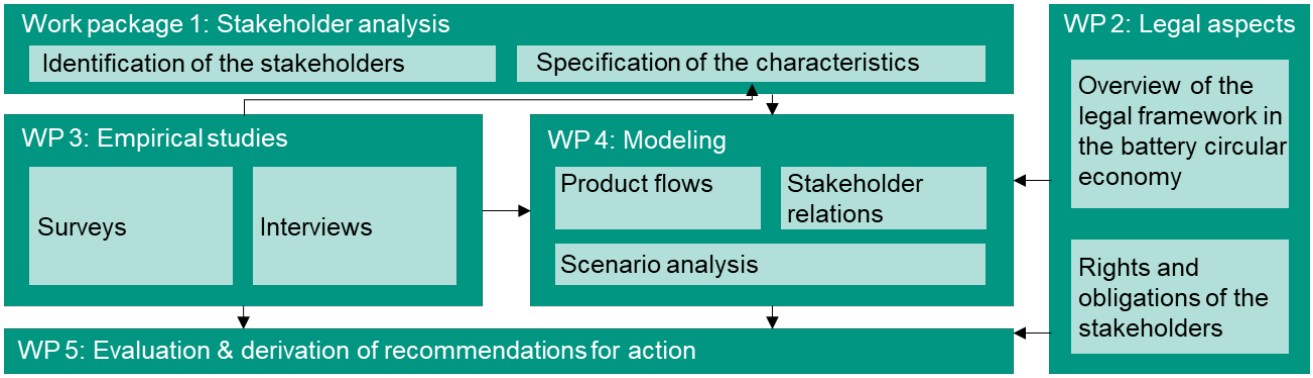
Funding: Ministerium für Wirtschaft, Arbeit und Tourismus Baden-Württemberg (MWAT)

Duration: 11/2022 - 12/2024

Due to the increasing spread of electric vehicles, it is foreseeable that many e-vehicle battery systems will reach the end of their first phase of use in vehicles soon. To meet the challenge of recycling these battery volumes in a resource- and environmentally-conscious manner, a wide variety of recycling solutions are being researched.

Industrial recycling capacities are also already being established. Other options for handling batteries in a recycling-friendly manner, such as repurposing them or remanufacturing them for reuse in the vehicle as a replacement battery before final recycling, are also being discussed, but to a much lesser extent. This also reflects in the public and scientific debate, which focuses primarily on recyclers and manufacturers of vehicles and batteries. Other players, such as logistics service providers, remanufacturers, core brokers, and customers, receive less attention, although presumably, all players influence how batteries will be recycled in the future. It is currently unknown how those above and other stakeholders for used traction batteries will interact with each other and what factors decide which recovery path a battery system will take after initial use. In order to build an efficient, collaborative, circular economy value network for future EoL battery streams in Baden-Württemberg, it is considered necessary to understand the interests and interactions of the stakeholders. This will help identify how incentives for collaboration can be set on the part of policymakers, and barriers can be reduced to create an environment in Baden-Württemberg that is attractive for battery circular economy companies.

The project will first identify and describe the relevant players. Empirical studies will help to understand the interests of the stakeholders. Thus, one goal of this research project is a transparent survey and description of the stakes, incentives, and barriers of the stakeholders involved in circular economy value creation. The findings on the stakes will then be used to parameterize innovative modeling approaches. In these models, the physical battery material flow is to be represented, but also behaviors of the stakeholders involved are to be mapped with the help of agent-based modeling. The models will be used to analyze, on a scenario basis, how different basic conditions affect the recovery pathways of traction batteries. The empirical studies and the scenario analysis will be used to derive options for steering battery flows toward different end-of-life paths.



Entwicklung von Rückbau- und Recyclingstandards für Rotorblätter

PD Dr. Rebekka Volk, Simon Steffl

Partner: THINKTANK Industrielle Ressourcen-strategien, Institut für Technische Chemie (ITC) am KIT, Fraunhofer-Institut für Chemische Technologie (ICT), Baumeister Rechtsanwälte, Composites United e.V.

Funding: Umweltbundesamt (UBA)/
Federal Environment Agency (UBA)

Duration: 2020 – 2022

Wind turbines are a decisive component in achieving the goals of the energy turnaround in Germany. The number of onshore wind turbines has more than tripled in the last 20 years. In addition to the numerical development, their continuous increase in size and, closely related to this, the increasing complexity of the material composition, is of great importance. The height of wind turbines and their rotor diameters influence the possibility of a uniform energy yield and allow the development of new areas for energy conversion. This leads to the expectation that, within the scope of technical possibilities, the height and especially the rotor diameter will continue to increase in the future.

Due to their operating life and the reduction in EEG payments, wind turbines are increasingly being dismantled due to decommissioning or repowering, and this trend is expected to continue. The possibility of rebuilding disused plants in emerging markets will be made more difficult in future by their increasing size. It can therefore be assumed that new generation turbines will have to be recycled mainly in Germany. The pressure and the necessity to develop conclusive dismantling and recycling concepts for Germany's wind power plants will therefore increase considerably.

In a previous study commissioned by the Federal Environment Agency (UBA) a first, conclusive and complete dismantling and recycling concept was developed. Conceptual proposals for high-quality and complete plant recycling were developed and organisational obligations were assigned to manufacturers, operators and owners.

Figure: Wind park

From the perspective of high-quality recycling, composite materials like carbon fibre reinforced (CFRP) or glass fibre reinforced (GFRP) plastics are a particular challenge. The composite materials are mainly found in the rotor blades, making them a key component in the dismantling of wind turbines. In the case of the rotor blades, it is often unclear which materials were used because of the large number of makes. Especially with longer rotor blades, one must always expect to find layers of CFRP. In the UBA study "Entwicklung von Rückbau- und Recyclingstandards für Rotorblätter", these composite materials play only a minor role. In the next few years, however, the increasing proportion of CFRP-containing waste will pose a particular challenge for health and environmental protection reasons during dismantling, shredding and processing, and as a disruptive factor for the established recycling of CFRP and due to the ultimate lack of safe disposal. Here, too, the organisational responsibility for the highest possible quality recycling plays an important role.

Use and management of finest particulate anthropogenic material flows in a sustainable circular economy ("FINEST")

PD Dr. Rebekka Volk, Rafael Bischof

Partner: Helmholtz-Zentrum Dresden-Rossendorf (HZDR), KIT-ITC Helmholtz Centre for Environmental Research (UFZ), Helmholtz-Zentrum Berlin für Materialien und Energie (HZB), TU Bergakademie Freiberg, Universität Greifswald

Funding: Helmholtz Association of German Research Centres under the "Helmholtz Sustainability Challenge"

Duration: 07/2022 – 07/2027

FINEST aims to develop a combined pyrolysis- and rotary-kiln based recycling process for creating high value products from the waste of external thermal insulation composite systems (ETICS) based on expanded polystyrene (EPS) and its mineral adhesions. Recycled cement clinker bricks and styrene are potential products of the FINEST project. These products are expected to partially replace their virgin counterparts, reducing construction and other sectors' environmental impact.

ETICS are multilayer insulation systems applied to building facades, walls, and roofs to reduce heat transmission and exchange, lowering energy demand and costs. They consist of a base coat, EPS insulation (such as EPS), anchors, a base coat, a reinforcement mesh, and a finishing coat. The layers are held together with adhesive. ETICS have been in use since the 1960s and have an approximate lifespan of 60 years. To improve buildings' energy efficiency, ETICS are being increasingly installed and the amount of waste from ETICS will increase.

One of the common insulating materials included in ETICS is EPS, a low-density fossil-fuel-based plastic. Its production has a large environmental footprint but, installed as an insulating material, it reduces energy consumption during building operation. Currently, waste EPS is typically burned for heat recovery and the material value is lost. The layers contain valuable minerals, metals and plastics bound together. The exact composition and quantity of each component varies from building to building. ETICS are difficult to separate mechanically and contain diverse, high-value materials that can be used in a circular economy.

The FINEST project is structured into three sub-projects which address plastic, mineral and metal fine particulates. In sub-project 1, UFZ, UG and HZB focus on developing processes for recovering microplastics whereas the focus of sub-project 3 (TU BAF) is on recovering metal fines. The mineral components of EPS-based ETICS are KIT's focus (sub-project 2). KIT IIP is responsible for the life cycle assessment and techno-economic assessment of the new recycling process with respect to minerals . Our emphasis is on demonstrating the potential for sustainability and avoiding risks to the environment. In addition, the optimum number and location of decentralised treatment facilities in Germany will be evaluated.

FINEST will establish and maintain a research school for training 28 postgraduate students. This includes the provision of internships to build connections with industry. PhDs will be prepared for leadership roles in industry and academia through a tailored doctoral programme. Knowledge will be transferred to industry through careers, which will be achieved through a central transfer desk at HZDR which is connected to industry clusters and organizations.

InnoFuels – Networking, further development and framework conditions for the scale-up of electricity-based fuels and advanced biofuels

Alexander Schneider, Paul Heinzmann, Dr. Andreas Rudi

Partner: Institut für Kolbenmaschinen (IFKM), Institut für Katalyseforschung und -technologie (IKFT) and numerous industry partners

Funding: Federal Ministry for Digital and Transport

Duration: 2022 - 2026

Currently, activities, advancements in technologies, and the framework for the synthesis of renewable fuels are being addressed in numerous research and development projects, each focusing on specific aspects of production, application, and evaluation of these fuels. However, a comprehensive networking and intensive exchange to leverage synergies at the federal and EU levels have not taken place so far, thereby impeding their further development, implementation, and scale-up.

The InnoFuels platform aims to bridge this gap by bringing together relevant activities into a consortium comprising industry, application, and research.

The existing information is intended to be consolidated, processed into guidelines and policy recommendations, and utilized in events such as innovation workshops to promote innovation. Within the framework of InnoFuels, partially "regional" or isolated approaches/solutions will be merged, creating a platform for the exchange of knowledge and experiences, as well as the conceptualization of comprehensive solutions.

The InnoFuels platform is divided into eight innovations focuses: *production*, *supply chain*, *application aviation*, *application maritime traffic*, *application road & rail*, *sustainability*, *market & regulation* and *subject matter experts*. The IIP supports the platform with system analyses applying environmental and economic methodologies to assess business cases and to show potentials and opportunities regarding the market launch of renewable fuels.

The project results provide detailed information regarding existing works and projects, further development and technical and regulative challenges in the field of renewable fuels. Therefore, the innovation platform serves as a knowledge tool to facilitate a more sustainable development of the mobility sector, ultimately contributing to the achievement of the stated climate goals.

IntWertL – Intelligente Wertschöpfungsnetzwerke für Leichtbaufahrzeuge geringer Stückzahl

Sonja Rosenberg, Sandra Huster, Nina Treml, Dr. Andreas Rudi

Partner: KIT-IMI, Fraunhofer IPA, DLR, bwcon, many small SME from BW, further associated partner (cities)

Funding: Federal Ministry for Economic Affairs and Climate Action (BMWK)

Duration: 2022-2026

The mobility sector is currently undergoing a transformation, which must be evaluated in terms of the economic, ecological and social dimensions of sustainability. Global competitive pressure is increasing sharply, and sustainability and climate protection are transforming from an additional benefit to an obligatory goal. Classic individual mobility is increasingly being questioned by society. Concept lightweight construction offers new forms of mobility. Vehicles can be optimized for a specific application (use case) and be resource-saving alternatives compared to the classic series-produced vehicle. While there are numerous prototypes of such use-case specific mobility, the introduction into the market often fails due to the high costs associated with pre-series and small series production.

The project therefore aims to build a digital engineering and production platform for small and medium-sized enterprises that enables manufacturing companies and engineering service providers in cooperative approaches to offer complex products in small quantities to increase their global competitiveness. Distributed engineering and production lowers barriers to launch such lightweight vehicles. Small companies can thus become integrators/OEMs themselves. The engineering and production platform is initially designed for specific use cases of lightweight vehicles. To ensure that the developed platform can withstand the challenges of practical use, the commitment of potential users is of particular interest. That is why the active participation of more than twenty SMEs from Baden-Württemberg is not only encouraging for the project work, but also shows that the industry sees strong economic potential in the development of the platform. Leichtbau BW GmbH and bwcon are responsible for the overall project coordination and lead the knowledge transfer. In addition to the industry partners, KIT, represented by IMI (Institute for Information Management in Engineering) and IIP, Fraunhofer IPA and DLR are involved in the project as scientific partners. The project is rounded off by associated municipalities, which contribute their knowledge about the future mobility behavior of end customers to the project.

The IIP will carry out the ecological evaluation within the project. Among other aspects, this includes the development of a concept to derive the ecological benefits of the developed lightweight engineering and production platform. Furthermore, it will be investigated how the platform can be extended in order to be able to take ecological aspects into account when using the platform.

LandWandel – Innovative Climate Parameters for Adaptation Measures in Rural Areas

Dilana Rauch, Dr. Florian Kaiser

Partner: Stadtwerke Freudenstadt GmbH & Co. KG, Institute of Meteorology and Climate Research Troposphere Research (IMKTRO), South German Climate Office

Funding: Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

Duration: 2023 - 2026

The aim of this transdisciplinary project is an integrative consideration of interests in the adaptation of rural areas to climate change. Together with selected partners from research and practice, innovative climate parameters are to be defined and transferred to the "AnLand" catalog.

Rural areas are of considerable importance for the economy and the entire population. They account for 93% of the area of the European Union. Although only 20% of the population live in rural areas, they generate 45% of gross value added. 53% of jobs are located in rural areas (http://www.laendlicher-raum.eu/). Many municipalities, especially in rural areas, are severely affected by the consequences of climate change. In order to do justice to the importance of rural areas, it is imperative to strategically promote climate change adaptation in these areas. To alleviate adverse climate change effects on the one hand and to benefit from advantageous climate developments on the other hand, climate adaptation measures aim to make rural areas more resilient, more climate-friendly and ultimately more economically and demographically attractive.

The project LandWandel combines the regional experience of Stadtwerke Freudenstadt with the expertise of two institutes at the KIT in the areas of regional climate change and its economic effects. Furthermore, the city of Freudenstadt and the VKU Baden-Württemberg (association of municipal companies) play an active advisory role as associated partners. In essence, the project LandWandel will result in quantitative climate indicators that take into account both the experience in the region and are based on high-resolution climate information. The IIP will primarily derive suitable climate adaptation measures based on the climate indicators and analyze the efficiency and effectiveness of those measures. The socio- and techno-economic evaluations carried out in the project are to be fed back into the region to support decision-making on the municipal level.

Namares 2.0 – Urban resource management on the district level

PD Dr. Rebekka Volk, Elias Naber

Partner: City of cologne, Environment and Energy Agency Karlsruhe County, Institute for Environmental Science and Geography at the University of Potsdam, Smart Geomatics GmbH. The project is coordinated by IIP.

Funding: BMBF - funding code: 033W111AN

Duration: 2022-2024

Namares 2.0 is the successor of NaMaRes (04/2019-06/2022) with a partly new project consortium. For our further research and development efforts in urban resource management, we successfully obtained funding from the German Federal Ministry of Education and Research (BMBF). The project supports the implementation of the flagship initiative Future City of the BMBF1 framework program "Research for Sustainable Development - FONA3" within the guideline "Resource Efficient Urban Neighborhoods for the Future" and on the topic of "Sustainable Urban Land Management".

The objectives of this second research phase are the continuation and further development of the namares software (from phase 1 NaMaRes) and the digital support of an integrated planning and transformation process on the district level for the transformation of existing districts into resource-efficient urban districts. The enhanced namares model will be used in the project in multiple urban areas in Cologne, Bruchsal and Bretten and it will integrated into municipal planning processes. Moreover, it is planned to make the academic model open-source for further scientific exchange and development and develop a commercial product (webtool with GUI) at the same time for easy user interaction. The role of the municipal partners in namares 2.0 is the use and test of the software. Moreover, the project partners will provide feedback on the development process in co-design workshops to further enhance the software. The academic partners will continue the academic development and plan to publish scientific publications. In 2023 several milestones were completed. A comprehensive set of planning guidelines was published. Notable public activities were presenting and publishing intermediate results at the "DFNS 2023 - Dresdner Flächennutzungssymposium" conference, presenting Namares at federal horticulture show in Mannheim (BuGa2023) and attending the urban development symposium "Practice areas for an open society - perspectives for a cooperative planning culture".

Ref4Fu – Refineries for Future: Erneuerbare Kraftstoffe aus Grünen Raffinerien der Zukunft

Work package 4: Techno-economic and ecological assessment of renewable fuels

Paul Heinzmann, Diana Temnov, Dr. Andreas Rudi

Partner: Institut für Kolbenmaschinen (IFKM), Institut für Katalyseforschung und -technologie (IKFT), Institut für Mikroverfahrenstechnik (IMVT), Engler-Bunte-Institut (EBI)

Funding: Förderprogramm Nachwachsende Rohstoffe (FNR), Federal Minsitry of Food and Agriculture (BMEL)

Duration: 2022 - 2025

The REF4FU project, in cooperation with 5 researchers and 6 industrial partners, aims to develop, validate, and evaluate sustainable refinery concepts with which the future demand for liquid fuels can be generated based on sustainable raw materials. From green methanol, Fischer-Tropsch hydrocarbons, and pyrolysis oil, the fuels that are customary in road, air, and ship traffic today and that are likely to be required in the future are to be produced, tested, and evaluated using scalable technologies. The technologies required for this should be verified in TRL 5 at least. The refinery concepts derived from this are evaluated concerning technical, ecological, and economic characteristics, and their flexibility for future fuel requirements and possible synergy and optimization potentials are determined. Finally, an overall assessment is made against the background of the regulatory framework and the feasibility of the refinery concepts developed.

The results of the analyzes and models shall demonstrate the potential of synthetic, green fuels. For this purpose, the system mentioned must first be implemented and tested on a pilot plant scale. Furthermore, the cost and profitability analysis results are used to support the decision-making process regarding the optimization of the system constellations, the usefulness of the planned synergies, and the profitability of the overall concept. The developed supply concepts and calculated GHG reduction potentials scientifically represent the possible contribution of synthetic fuels/biogenic fuels in sustainable road, air, and shipping traffic.

In Work Package 4, a techno-economic and ecological evaluation of the fuels is carried out. The work focuses on the flow chart simulation, the economic assessment, and the derivation of synergy and optimization potentials.

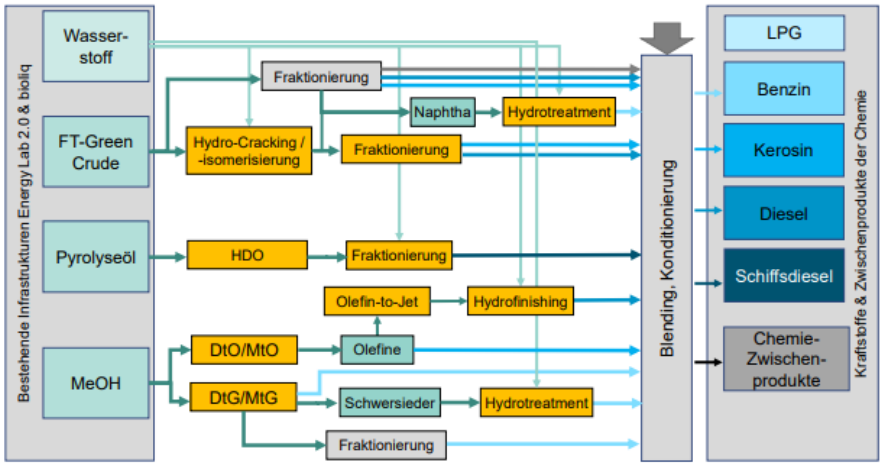


Figure: Diagram of the planned process network. Fuel fractions are produced from the input materials depicted on the left through the yellow-highlighted process stages, and these are further processed into various types of fuels.

reFuels Demo

Alexander Schneider, Paul Heinzmann, Dr. Andreas Rudi

Partner: Institut für Kolbenmaschinen (IFKM), Institut für Katalyseforschung und -technologie (IKFT), Institut für Mikroverfahrenstechnik (IMVT), Engler-Bunte-Institut (EBI), Institut für Technikfolgenabschätzung und Systemanalyse (ITAS) and numerous industry partners

Funding: Ministry of Transport Baden-Württemberg

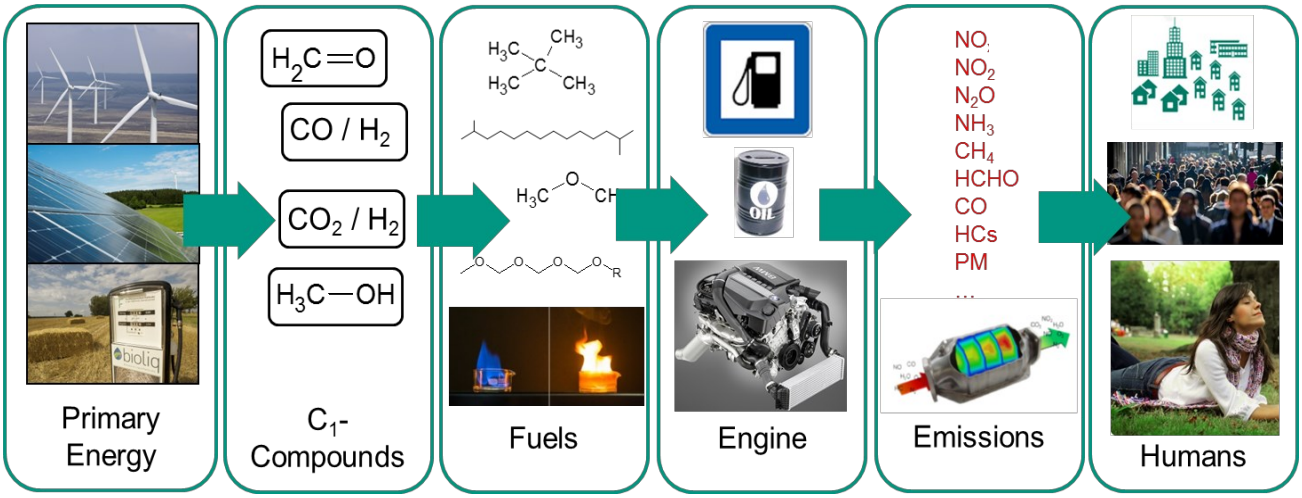
Duration: 2023 - 2025

The utilization of renewable produced fuels (reFuels) is one of the main actions beside electric mobility on the way to a CO_2 neutral transportation sector. These fuels use carbon-containing residues of agriculture and forestry, as well as industry and municipality waste in combination with hydrogen produced from the electrolysis process for chemical synthesis.

The project consortium comprises several institutes of the KIT and other partners from the industry. Compared to the preliminary project *"reFuels"*, *"reFuels Demo"* has a closer scope and sets the focus on production processes for reFuels based on methanol. The aim of the project is the further development of the technology and the assessment of the scalability of Methanol-to-X (MtX) processes on industrial scale. Therefore, a variable model of a pilot plant on the refinery site of the Mineralölraffinerie Oberrhein (MiRO) should be developed to enable flexible plant and operation configurations and the creation of optimal scenarios by applying economic and environmental assessment methods

The Institute for Industrial Production evaluates current developments, different business cases and cost scenarios by conducting a techno-economic analysis. This task aims to deliver deeper understanding of cost structure of different process constellations and to support decision making regarding the optimal configuration of the MtX processes.

The project results deliver insights on the feasibility of a MtX pilot plant, their integrability in an existing refinery site (MiRO), existing challenges and configuration potentials. These technical and scientific findings can serve as recommendation for the industry and the development of plants and new processes. This progress would help to reduce greenhouse gas emissions caused by the mobility sector and to achieve claimed climate goals.



ReGrow - Function-integrated lightweight structures for sustainable construction with local renewable raw materials

PD Dr. Rebekka Volk, Simon Steffl

Partner: KIT Professorships Digital Design and Fabrication, Building Physics and Technical Building Services, Design of Structures, Light Technology Institute, Institute of Microstructure Technology, FiBR GmbH

Funding: BIPL-Innovation Ministry for Nutrition, Rural Areas and Consumer Protection Baden-Württemberg

Duration: 2022 - 2023

The ReGrow project opens up new applications in the construction industry for rapidly and regionally growing renewable materials such as willow rods and flax fibres. The two robot-assisted 3D manufacturing processes specially adapted for renewable raw materials, willow braiding and free-form winding, are being used and assessed in this project. In addition to traditional timber construction, this expands and diversifies the range of locally available forestry and agricultural building materials, thus making an important contribution to the circular economy in the construction industry. This includes the development of a new type of construction and design repertoire and as well as the implementation of appropriate machine technology for the production of load-bearing components. Both technologies are combined in a complementary way to implement a modular concept for the production of functionally integrated building components with renewable raw materials. Within the framework of the project, a demonstrator will be implemented and shown at the "Bundesgartenschau 2023" in Mannheim. A central research building made of wound flax fibres will be used to create a shading and roofing structure that will provide a venue for lectures and exhibitions. In order to be able to evaluate this new approach to sustainable building technology in terms of its environmental effects, the project and corresponding manufacturing processes will be analysed within a life cycle assessment.


ReGrow
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REPOST - Autoclaved aerated concrete recycling cluster: Development of new options for circular economy

PD Dr. Rebekka Volk, Justus Steins

Partner: Xella Technologie- und Forschungsgesellschaft mbH, Otto Dörner GmbH, KIT - Institute for Technical Chemistry

Funding: BMBF - funding code: 033R249B

Duration: 06/2019 - 12/2022

"REPOST" has set itself the goal of creating the basis for a high-quality and economical recycling management of autoclaved aerated concrete (AAC). New and competitive products for masonry construction are to be created from post-demolition AAC. In addition to direct material recycling, alternative recycling methods - e.g., the production of clinker substitutes - are also being investigated. The project is funded within the framework of the funding measure "Resource-efficient recycling management - Innovative product cycles (ReziProK)" by the Federal Ministry of Education and Research (BMBF).

AAC is a building material that has been known and proven for almost 100 years. The recycling of fresh AAC, which occurs as cuttings or breakage during production, has been practiced for decades. In contrast to this, post-demolition AAC often contains accompanying materials that make high-quality recycling difficult, which is why AAC is usually disposed in landfill after use. Decreasing landfill capacities, legal obligations for the recyclability of products as well as the conservation of primary materials therefore make it essential to find recycling alternatives for this demolition material. REPOST aims at the reduction of primary raw materials in the production of AAC by recycling post-demoliton AAC at the same or comparable quality level. This concept differs from conventional building material recycling. In the statistics, around 90 % of mineral construction waste is recycled, but mostly as low-value and one-off downcycling in road construction.

Figure: Aereated concrete waste to be recycled

The REPOST work plan is based on the life cycle of a recycled AAC block and begins with the dismantling and sorting/preparation of AAC from the existing stock. The secondary raw material obtained is to be used directly as an additive for new masonry products. First, we quantified the expected AAC waste in Germany until 2050. The results show a sharp increase of waste volumes in the following decades which further motivates the establishment of recycling options.

AAC contains a large proportion of deacidified lime, which was produced using a high amount of energy and high CO_2 emissions. Where recycling within a closed cycle is not possible, a thermal conversion into dicalcium silicate, a main component of cement clinker, is investigated. The aim is to partially replace the primary raw materials cement or lime in the production of AAC with a recycled product that causes lower CO_2 emissions and energy consumption during its manufacture. With the involvement of demolition and processing companies, business models focusing on location, capacity and logistics are being developed for the new recycling options over the entire life cycle.

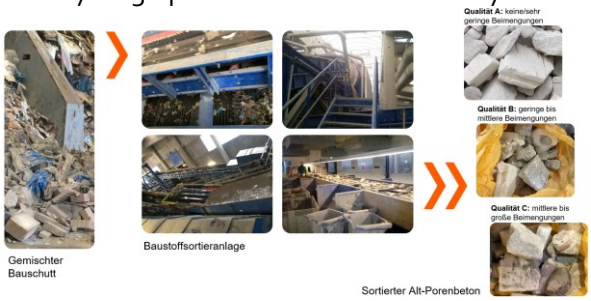


Figure: Provision of old aerated concrete in various grades of purity

ReSidence – Regionally Regrowing, Recyclable and Reconfigurable Modular Housing

PD Dr. Rebekka Volk, Simon Steffl,

Partner: KIT Professorships Digital Design and Fabrication, KIT Professorships Wood Engineering and Building Construction, Construction and Building Physics and Technical Building Services, Design of Structures, KIT Professorship Building Materials and Concrete Construction, FibR GmbH, Nature Conservation Foundation Pfrunger-Burgweiler Ried

Funding: BIPL-Innovation Ministry for Nutrition, Rural Areas and Consumer Protection Baden-Württemberg

Duration: 2023 - 2025

The ReSidence project is researching digital construction technologies for rapidly renewable resources and combining these into a modular construction method for temporary, completely recyclable and waste-free living space extensions. To this end, a construction method developed at FibR GmbH for load-bearing structures made of natural fiber composite is being further developed and research is being conducted into how this can be transferred to façade constructions. At the same time, research is being carried out into how a hybrid material system of willow/clay/wood composite developed jointly at KIT can be used for load-bearing wall and ceiling components. In a synergetic development of both construction methods, their interfaces are being researched and combined into a holistic, digitally prefabricated construction system made of natural building materials. The project maps the complete material cycle of the raw materials used and researches the extraction of natural raw materials, their combined use as hybrid components in the construction industry, their reusability and the recycling of such components. This requires coordinated innovations in the following areas: Agricultural management of wetlands, material characterization of natural hybrid material systems, digital process technology for processing inhomogeneous grown materials, integrative computer-based design processes, as well as the development of structural models and test procedures for the dimensioning and approval of such building systems. Following on from the ecological and climatic necessity of rewetting peatlands to bind Co2, agricultural methods are being tested to extract building materials from these peatlands and thus use them both ecologically and economically.

The modular reusability of the robotically prefabricated flax fiber facade structure and the willow-clay-wood wall and ceiling construction system will be tested in the overall system using the demonstrator construction at the Wangen State Garden Show. As part of the project, the IIP's Project and Resource Management in the Built Environment research team will holistically record the resulting material flows in order to carry out a comprehensive LCA analysis on this basis. In addition to ecological considerations, economic factors of the construction method are also recorded in order to evaluate its transfer and market potential.

SPECK – Systemic optimization of the meat value chain using the example of pig farming through the development and embedding of digital tools

Nina Treml, Dr. Andreas Rudi

Partner: KIT-aifb, University of Kassel, van Asten Tierzucht Neumarkt GmbH & Co. KG, Erzeugerschlachthof Kurhessen AG, Agri Syst GmbH, Service Team Alsfeld, Topigs – SNW GmbH

Funding: Federal Ministry of Agriculture and Food, Federal Agency for Agriculture and Food

Duration: 2021 - 2024

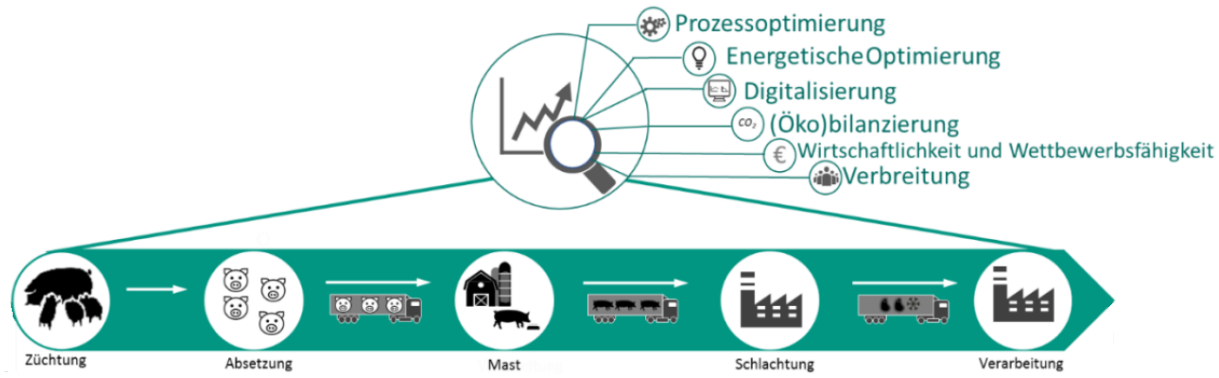
Agriculture and especially animal husbandry are currently facing major challenges, such as ensuring food quality and enabling sustainable value chains. To address these challenges, regional and global food security, animal welfare, efficient use of raw materials, climate and environmental protection and their interactions play a prominent role.

In order to address the challenges of product quality and sustainability, the digitalization of food value chains seems necessary so that relevant data can be generated and analyzed. Within the research project SPECK (Systemic optimization of the meat value chain using the example of pig farming by developing and embedding digital tools), the research group Sustainable Value Chains is working together with the University of Kassel, the research group critical information infrastrucures (cii) of the AIFB at the Karlsruhe Institute of Technology and partners from industry.

The aim of the research project is to optimize the meat value chain by developing and embedding digital tools as well as the process analysis of the technological status quo of market participants along the value chain and, based on this, the ecological assessment of the value chain using life cycle assessment methodology.

The scope of the IIP includes the preparation of Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) along the value chain. Further, the development of animal welfare and meat quality indicators based on the LCA methodology is aimed at. The approach of the IIP is based on the following sub-objectives:

- Identification of the value chain links of pork production and inventory analysis of the data necessary for LCA
- Balancing (LCA and LCC) of the value chain links in the context of the LCA methodology on the one hand considering the industry partners, on the other hand a "standard" case in Germany mapped through case studies
- Sensitivity analysis of different parameters within LCA/LCC
- Increasing the transparency of ecological burdens in the context of pig production in Germany
- Discuss possibilities of transparent and uniform presentation of meat quality and animal welfare aspects



TFTEI – Technical Secretariat of the Task Force on Techno-Economic Issues

Diana Temnov, Dr. Andreas Rudi

Partner: Interprofessional Technical Centre for Studies on Air Pollution (CITEPA), Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)

Funding: French Environment and Energy Management Agency (ADEME)

Duration: since 2002 (ongoing)

Since 2002, DFIU and CITEPA (France) form the Technical Secretariat of the former Expert Group on Techno-Economic Issues (EGTEI), now Task Force on Techno-Economic Issues (TFTEI). The work is primarily funded by the French environmental agency ADEME under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). Between 2002 and 2008 several sector specific background documents with techno-economic information about air emission abatement techniques have been developed and revised. This information is considered in the Integrated Assessment Models (IAM) RAINS and GAINS, developed by the International Institute for Applied Systems Analysis (IIASA) in Luxembourg, Austria. Both models have been applied for the derivation of emission abatement strategies on UNECE and EU level.

After EGTEI focused on technical background documents for the revision of the Gothenburg Protocol and investment and cost calculation for emission abatement in large combustion plants in recent years, the work has been honoured in December 2014 by promoting the former Expert Group into a Task Force that is a constant part of the Working Group on Strategies and Review (WGSR). The current work focuses on VOC abatement in order to support the revision of the BREF STS and on emission abatement in the aluminium and cement sector. Furthermore, an information platform (the so-called Clearing House on Abatement Techniques) is built up and hosted by TFTEI. The results of the TFTEI activities shall be of use for the convention and its members, but particularly for the EECCA-region, where mission abatement strategies are currently developed.

THINKTANK "Industrial Resource Strategies"

PD Dr. Rebekka Volk, Frank Schultmann

Partner: AUDI AG, Badische Stahlwerke GmbH, Carl Zeiss AG, Daimler AG, Robert Bosch GmbH, Scholz Recycling GmbH, SchwörerHaus KG, Umicore AG & Co. KG, German Chemical Industries Association (VCI) Baden Württemberg, Zeller+Gmelin GmbH & Co. KG.

Duration: 2018 - 2023

In February 2018 the THINKTANK "Industrial Resource Strategies" was set up at the Karlsruhe Institute of Technology (KIT). This THINKTANK is a pioneer institution between policy, industry, and science to develop ideas and answers on questions concerning resource and raw material efficiency. The efficient usage, as well as the recycling and reuse of (raw) materials, have a high priority, especially in a Federal State like Baden Württemberg that only has a few natural resources, but is at the other hand a well-developed production location. Therefore, ideas and concepts to reduce its dependency on raw material imports and geopolitical crises should be developed within the THINKTANK.

Four institutes of the KIT are involved in the THINKTANK, among others the Institute for Industrial Production (IIP). Within the THINKTANK, we will work on topics such as circular economy, resource efficiency alongside the entire supply chain. The circular economy framework will be applied holistically to achieve a more efficient material selection, to increase the collection and recycling rate, and to decrease the resource input. Furthermore, the impacts of important technical and social trends and transformation processes on resource demand and efficiency will be analysed.

Five pilot projects have been defined to set up the work of the THINKTANK. Those projects deal with questions in trending areas such as blockchains and digitalization, closed loops supply chains, circular economy and the 2nd life cycle of products.

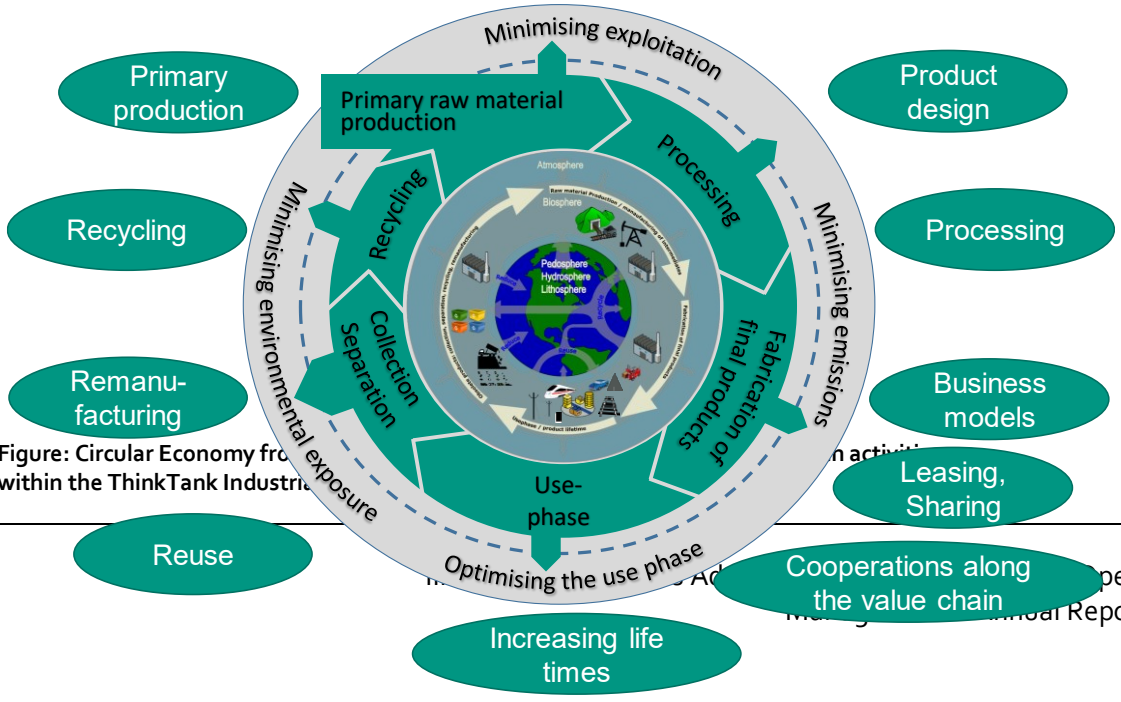


Figure: Circular Economy fro… within the ThinkTank Industri… …n activiti…

URBAN – CO2-reduced concrete by upcycling residues from concrete preparation and CCU

PD Dr. Rebekka Volk, Humberto Patarca, Antonia Frank

Partner: KIT - Institute for Technical Chemistry (ITC), KIT –Institute of Concrete Structures and Building Materials (IMB), Leibniz University Hannover (LUH) - Institute for building materials (IfB), Sika Deutschland GmbH, EHL AG, Holcim (Deutschland) GmbH

Funding: BMBF - funding code: 03EE5130C

Duration: 2023 - 2025

The aim of the project is to develop a highly CO2-reduced, high-quality and resource-efficient concrete cycle for old, post-demolition concrete. For this purpose, a belite-based Portland cement clinker (RC clinker) with a low CO2 footprint will be produced from concrete crushed sand for the first time. Released CO2 can be separated in a concentrated manner and used for the technical carbonation of either mechanically processed concrete crushed sand as a substitute in cement or for carbonation hardening of coarse RC rock formation (CCU) using a new process based on a pressure autoclave.

Recycled cements with a greatly reduced CO2 footprint are formulated from recycled bricks, Portland cement clinker and technically carbonated crushed sands as well as other substitutes. In order to enable its use in production, recipes for recycled concretes based on adapted superplasticizers and accelerator systems are developed from recycled cement and recycled aggregate (RC2). At the end of the project, plant tests will be carried out to demonstrate the high-quality concrete cycle using the example of concrete products and precast concrete elements.

The newly developed technical process is assessed and evaluated technically, economically and ecologically for different plant sizes and locations over the entire life cycle and compared with the state of the art. The aim is to reduce the cumulative CO2 emissions of RC2 concrete by at least 40% compared to conventional recycled concrete.

In addition, regulatory boundary conditions are examined (e.g. Recycling Building Materials Ordinance, DIN-EN 197-1, legal classification of a plant for clinker production) in order to identify obstacles in the implementation of centralized or decentralized concepts.

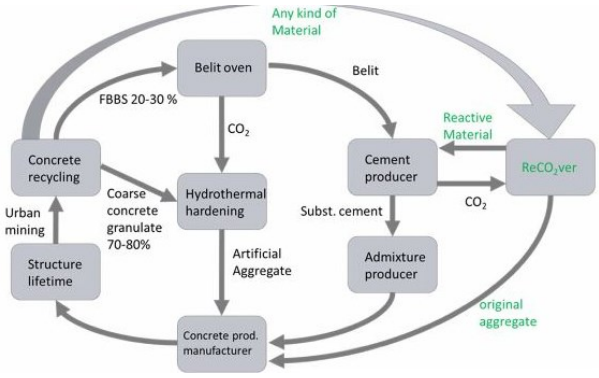


Figure: Circular flows (URBAN), supplemented with the material flows of the Sika project RECO2VER (green)

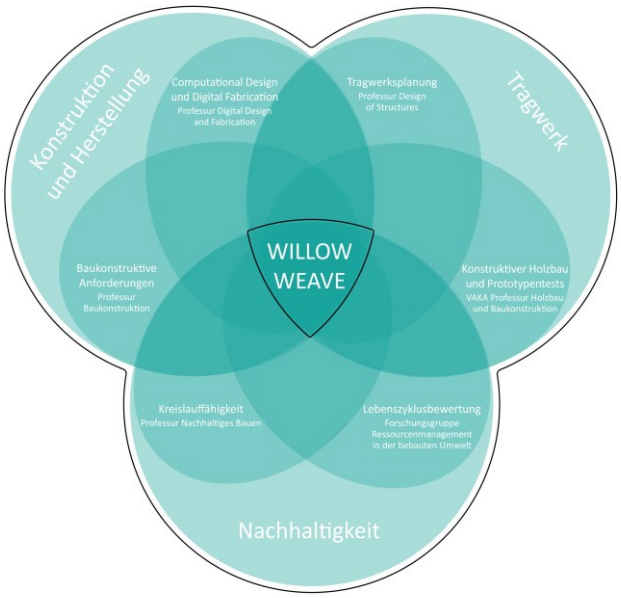
Willow Weave – Digital Circular Construction

PD Dr. Rebekka Volk, Simon Steffl

Partner: KIT Professorships: Digital Design and Fabrication, Design of Structures, Building Construction, Sustainable Building, VAKA Wood Construction and Building Design

Funding: BMBF - funding code: 03EE5130C

Duration: 2022 - 2023



The KIT Future Fields stage 2 project "Willow Weave" contributes to the strategic development of the promising and socially highly relevant research field Digital Circular Construction as a Future Field at KIT. The pilot project aims for the combination of preliminary work. This is done through the holistic experimental research of an exemplary structural building component made of willow-clay composite on a 1:1 scale and its production process assessment. It promotes coordinated innovations in the fields of digital construction, sustainable construction, construction design, structural engineering, component testing, and life cycle assessment within the framework of an integrative co-design process.

Innobeton – Innovative Technologien zur Entwiclung eines neuartigen reaktiven Betonzusatzstoffs aus feinem Betonabbruch (Brechsand) – Ressourceneffizienz im Baustoffrecycling

PD Dr. Rebekka Volk, Antonia Frank

Partner: KIT-IMB/MPA, TBS Transportbeton Rhein-Neckar GmbH & Co. KG, mbl Mineral- und Betonlabor GmbH, peterbeton Rudolf Peter GmbH & Co. KG, Heinrich Feess GmbH & Co. KG, Scherer + Kohl GmbH, Gebr. Pfeiffer SE

Funding: BMBF - funding code: 03EN2102A

Duration: 2023 - 2025

The research project is developing an innovative process for the production of a new type of concrete additive from recycled fine concrete rubble as a substitute for cement clinker, fly ash and granulated blast furnace slag as well as its overall characterization over the product life cycle (development, production, properties, application and recycling options). This initially includes the analysis of regional and supra-regional material flows in order to identify possible raw material sources for thermomechanical processing.

The figure shows the interactions and the overall structure of all the project partners in the project.

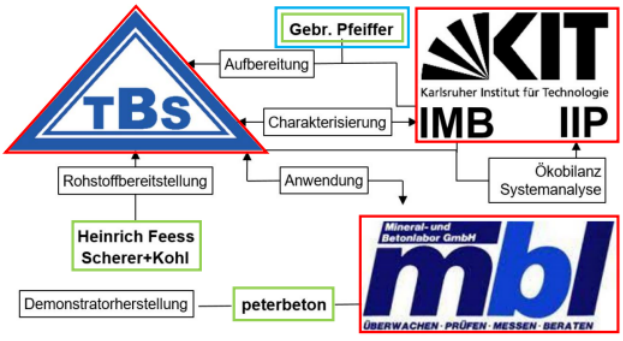


Figure: Composite structure of the project partners

The Karlsruhe Institute of Technology (IIP) will carry out the analyses of the material flows and the life cycle assessment of the new material (including a comparison with conventional concrete additives and substitution effects). In addition to the volume analysis, site and capacity planning as well as logistics optimization for the collection of the secondary raw material and transport to suitable processing and production plants for the new concrete additive will also be carried out. Closely linked to this is the profitability analysis of the new value chain.

For the first time, the project aims to pursue a holistic approach to evaluating the use of a new type of reactive concrete additive for concrete based on recycled concrete demolition material.

Due to the generally strong regional nature of concrete production, the focus of the research is on south-western Germany. As the basic composition of concrete - cement, water and aggregate - does not depend on local characteristics, the results can be applied throughout Germany and worldwide with little effort thanks to the cooperation of the applicant companies.

Completed PhD Dissertations and Habilitations

PhD Dissertation:

Entwicklung und Anwendung eines stoffstrombasierten Optimierungswerkzeugs zur Ablaufplanung von Rückbauprojekten

(Develpoment and Application of a Material Flow Based Optimization Tool for Scheduling Dismantling Projects)

Marco Gehring

To achieve the environmental policy goal of transitioning to a circular economy, selective dismantling is preferred in the construction sector instead of conventional demolition. That is, mixing of materials released during dismantling is avoided as much as possible. In addition, conditioning the materials is necessary to increase recycling rates. Conditioning and transporting (jointly referred to as processing) as well as storing materials at the construction site are subject to capacity restrictions. If these material flow-related capacity restrictions are exceeded during the execution of a dismantling project, the dismantling must be interrupted or rescheduled at short notice. To avoid this, an optimization tool is developed in this thesis, which allows for taking into account material flow-related capacity restrictions during the planning phase of a dismantling project. This should assist project managers with finding a realistic schedule that is compatible with capacities in material processing. In addition, the optimization tool aims at supporting decisions on procuring machines or sizing storage spaces. Dismantling nuclear facilities is a suitable application case due to the project complexity and the high safety requirements associated with the material flows.

The optimization tool is based on quantitative models and methods from the research field of project scheduling, a subdiscipline of Operations Research. First, a scheduling problem is formulated, which can be summarized as finding start times for (project) activities so that the project makespan is minimized. The constraints of the scheduling problem state that precedence relations between activities, capacities of renewable resources (e.g., staff, machines) as well as processing and storage capacities must be satisfied. Taking into account processing and storage capacities, which can delay the dismantling project, is a significant enhancement over existing models. In particular, due to the storage capacities, the computational effort to find a feasible solution can already increase exponentially. Therefore, four novel heuristic solution methods are developed, each suitable for specific types of problem instances. Constraint and linear programming are also used to solve the problem. Extensive computational experiments with test instances show that the novel solution methods and constraint programming are suitable for computing high-quality schedules for material flow-intensive projects within reasonable computation times. Recommendations are given regarding which specific method should be used under which circumstances.

PhD Dissertation:

Strengthening Resilience of Supply with Essential Goods through Public-Private Emergency Collaborations: Challenges and Incentives

Markus Lüttenberg

Private actors ensure the supply of essential goods such as food, drinking water, and medicine to the population. However, crises such as natural disasters, human-caused conflicts, or pandemics can cause disruptions of private supply chains and, subsequently, supply shortages in the market. In this case, public actors need to become active and responsible for supplying the population with essential goods. Nevertheless, the ability of public actors to provide essential goods in a crisis is constrained due to limited resources and a lack of knowledge about the relevant commercial supply chains.

Therefore, companies that produce, distribute, or sell essential goods can be valuable partners but must be adequately motivated to participate in crisis management. A promising form of collaboration to strengthen resilience lies in the concept of public-private emergency collaborations (PPECs), elaborated in different studies within the dissertation. The necessity of PPECs and their public acceptance depends on the attitude and preparation of the population, which is why the empirical investigation of these accompanying questions is another central part of the dissertation.

Four general recommendations for the stakeholders in crisis management, public actors, private actors, and the population, are derived: First, all stakeholders must adapt their behavior and improve current protection measures and strategies against global crises and supply chain disruptions. Second, humanitarian crisis management is a team effort involving many actors. Therefore, understanding synergies, mutual attitudes, and the incentive constellation of the actors involved is a crucial prerequisite for success. Third, crisis management also includes the right communication strategy. It is not only important to contribute but also to communicate it in a successful and convincing way. Fourth, collaborative approaches, as in PPECs, where each stakeholder brings his or her strengths into the collaboration, are beneficial for all parties involved, and increase society's overall resilience.

Consequently, the dissertation provides valuable insights into the status of humanitarian crisis management from the perspective of different stakeholders. It offers the potential to improve this field of research through collaborative approaches, as in PPECs, addressing the strengths and incentives of stakeholders accordingly.

PhD Dissertation:

Concepts and Tools to Improve the Thermal Energy Performance of Buildings and Urban Districts – Diagnosis, Assessment, Improvement Strategies and Cost-Benefit Analyses

Zoe Mayer

Retrofitting existing buildings to optimize their thermal energy performance is a key factor in achieving climate neutrality by 2045 in Germany. Analyzing buildings in their current condition is the first step toward preparing effective and efficient energy retrofit measures. A high-quality building analysis helps to evaluate whether a building or its components are suitable for retrofitting or replacement. Subsequently, appropriate combinations of retrofit measures that create financial and environmental synergies can be determined.

The dissertation is a cumulative work based on nine papers on the thermal analysis of existing buildings. The focus of this work and related papers is on thermography with drones for building audits, intelligent processing of thermographic images to detect and assess thermal weaknesses, and building modeling approaches to evaluate thermal retrofit options. While individual buildings are usually the focus of retrofit planning, this dissertation also examines the role of buildings in the urban context, particularly on a district level. Multiple adjacent buildings offer numerous possibilities for further improving retrofits, such as the economies of scale for planning services and material procurement, neighborhood dynamics, and exchange of experiences between familiar building owners.

The work reveals the opportunities and obstacles for panorama drone thermography for building audits. It shows that drones can contribute to a quick and structured data collection, particularly for large building stocks, and thus complement current approaches for district-scale analysis. However, the significant distance between the drone camera and building, which is necessary for automated flight routes, and varying recording angles limit the quantitative interpretability of thermographic images. Therefore, innovative approaches were developed to process image datasets generated using drones. A newly designed AI-based approach can automate the detection of thermal bridges on rooftops. Using generalizations about certain building classes as demonstrated by buildings from the 1950s and 1960s, a novel interpretation method for drone images is suggested. It enables decision-making regarding the need to retrofit thermal bridges of recorded buildings. A novel optimization model for German single-family houses was developed and applied in a case study to investigate the financial and ecological benefits of different thermal retrofit measures. The results showed that the retrofitting of building façades can significantly save energy. However, they also revealed that replacing the heating systems turns out to be more cost-effective for carbon dioxide savings.

Small datasets, limited availability of technical equipment, and the need for simplified assumptions for building characteristics without any information were the main challenges of the approaches in this dissertation.

PhD Dissertation:

Planning and Evaluation of Biomass-based Value Chains at the Example of Energy and Chemical Valorization of Lignocellulosic Biomass in Baden-Wuerttemberg

Andreas Rudi

The utilization of renewable resources has always been an essential part of humanity's practices. With the global increase in energy and resource demand, coupled with the depletion and exhaustion of fossil resources and their associated climatic impacts, the use of biomass as a renewable energy and carbon source is gaining increasing significance. The implementation of bioeconomic concepts for energetic and chemical valorization can reduce dependence on fossil resources, enhance sustainable resource efficiency, and decrease anthropogenic greenhouse gas emissions while also strengthening regional value creation. Establishing biomass-based value chains requires careful planning of environmental, social, technological, and economic aspects along the value chain, where systematic evaluation can help identify and minimize potential risks associated with different valorization purposes. To this end, the simultaneous assurance of both economic and ecological objectives is necessary across strategic, tactical, and operational decision levels. Current research on biomass-based value chains lacks an integrated approach to planning and assessment considering multiple objectives across various decision levels.

Against this background, the PhD dissertation develops a generic approach for multi-objective decision support, applied at the example of Baden-Württemberg. The integrated approach is subdivided into several components consisting of a GIS-supported potential estimation and multi-attribute site suitability analysis, a techno-economic-ecological evaluation, and three multi-objective optimization models. These models comprise mixed-integer linear problem formulations for strategic site, tactical network flow, and operational transportation planning, which are solved to pareto-optimality using a method of multi-objective problem-solving, and subsequently, the solutions are weighted and evaluated using a multi-attribute decision method to select a preferred outcome. In the case study, the bioenergy potential from the regionally available price-elastic raw material potential of forest residues, residual straw, and miscanthus, as well as candidate sites for biomass power plants, is determined, along with the product potential for lignocellulose biorefineries. In addition to determining suitable plant locations, technology and capacity choices are made by compensating negative scale effects of biomass provision with positive scale effects of biomass conversion.

While the combustion of residual straw and miscanthus shows advantages over gasification, the chemical valorization of forest residues presents a promising concept for decentralized production of platform and basic chemicals. The tactical configuration of plant supply in the face of fluctuating supply is managed through transportation, storage, and drying processes in a dynamic, two-stage stochastic program. Finally, the operational supply of plants via collection tours of an alternatively powered vehicle fleet is examined in a transportation planning model, and a comparison of propulsion systems is carried out. The integrated approach contributes to the research of bioeconomic concepts, and the findings from its application help in meeting climate and environmental policy goals.

PhD Dissertation:

Designing a Circular Economy for Plastics: The Role of Chemical Recycling in Germany

Christoph Stallkamp

Parties involved in the Paris Climate Agreement agreed to reduce greenhouse gas emissions to reduce the impacts of global warming on society. When focusing on reducing greenhouse gas emissions, the second largest emitter of CO_2 is the industrial production of goods. Here, the chemical industry, with the production of plastic, has a significant impact. Therefore, the present dissertation addresses designing a circular economy for plastics employing chemical recycling, contributing to the decarbonization and defossilization of the German chemical industry.

Five studies address substantial aspects of the chemical recycling of plastic waste and barriers to establishing it as a circular economy strategy. Study A assesses chemical recycling via pyrolysis for the lightweight packaging waste stream and shows that combining mechanical recycling with chemical recycling has economic and environmental ad-antages over employing these technologies individually. Study B conducts pyrolysis experiments for automotive plastic waste and includes the generated data in an economic and environmental assessment of a potential chemical recycling route. Different economic and environmentally preferable waste handling options are identified when comparing chemical recycling with waste incineration with energy recovery. Study C shows the importance of integrating the quality of secondary materials in assessing recycling routes. Study D examines the economics of the pyrolysis of automotive plastic waste and identifies the minimum input capacity at which the pyrolysis is economically feasible. Study E combines the collected findings in a facility location optimization model for pyrolysis plants treating lightweight packaging and automotive plastic waste in Germany's current waste treatment network. Political steering strategies are analyzed to support political decisionmakers in resolving the conflict between economic and environmentally favorable waste treatment options and to integrate chemical recycling into waste management.

In addition to the detailed results of the individual studies, implications for four cross-study research topics were derived: First, waste containing primarily polyolefins but also waste containing engineering plastics can be technically pyrolyzed and is, therefore, feedstock for chemical recycling. Second, chemical recycling is environmentally preferable over energy recovery for all waste streams, but mechanical recycling has a lower environmental impact than chemical recycling for lightweight packaging waste. Economically, chemical recycling is not preferable to energy recovery for automotive plastic waste. Third, the quality of the secondary materials must be considered when assessing waste recycling op- tions, as these strongly influence economic and environmental assessment. Fourth, political steering strategies like the extension of CO_2 certificate trading and introducing recycling rates for waste that is a feedstock for energy recovery can align economic and environmentally preferable waste treatment options.

PhD Dissertation:

Public-Private Perspectives on Supply Chains of Essential Goods in Crisis Management

Alexander Zienau

Public authorities are responsible to maintain the population's supply with essential goods like food or drugs at any time. Such goods are produced, transported and sold by companies in supply chains. Past supply crises all over the world have showcased numerous examples of spontaneous collaboration between public authorities and companies in supply chains. However, insights on formal collaboration which is agreed upon in the preparedness phase is rare in both practice and literature.

Therefore, this dissertation's first research objective is to identify under which circumstances companies are most willing to collaborate with public authorities. In this context, public authorities' and companies' characteristics, resources and roles in a collaboration are identified from literature research as well as real-life cases in Study A. Study B empirically determines companies' preferred preconditions for collaboration: Companies value the continuity of their business processes and expect to be compensated monetarily or by lifted restrictions. The second research objective is to develop collaborative supply chain concepts and evaluate them from public and private perspectives. Study C develops a collaboration concept in a real-time setting in which commercial trucks are jointly re-routed into crisis regions. In Study D, public authorities coordinate tactical use of commercial last-mile delivery vehicles for the home supply with food and drugs. In Study E, strategic collaboration in using dual-use warehouses is investigated with a focus on logistics networks. Study F determines the impact of demand shortfalls and payment term extensions on financial and physical flows in food supply chains. In Studies C-F, the main drivers for effectiveness and efficiency are investigated.

By examining collaboration between companies and public authorities in supply crises, this dissertation contributes to the research streams of supply chain risk management and so-called extreme supply chain management. The results provide public decision-makers with insights into companies' motivation to engage in public crisis management. The developed collaborative supply chain concepts serve public authorities as a basis for collaboration design and companies as starting points for integrating public-private collaboration into their endeavors to make supply chains more resilient.

Staff 2023

Head of the Chair of Business Administration, Production and Operations Management

Prof. Dr. Frank Schultmann

Administrative Staff

Liana Blecker (also working for the Chair of Energy Economics)

Corinna Feiler (also working for the Chair of Energy Economics)

Josiane Folk (also working for the Chair of Energy Economics)

Katrin Grauer

Heads of Research Groups

Dr. Andreas Rudi – Sustainable Value Chains

PD Dr. Rebekka Volk – Project and Resource Management in the Built Environment

Dr. Florian Kaiser – Risk Management

Research Associates and their PhD-topics

Sonia Alikhah: Optimal solutions for sustainable value chains, production and distribution systems in the food sector

Niklas Braun: Logistics optimization in nuclear decommissioning projects

Katharina Eberhardt: Analysis of alternative storage strategies of public emergency food supply

Antonia Frank: Concrete Recycling

Marco Gehring: A Material Flow Based Optimization Tool for Scheduling Dismantling Projects

Raphael Heck: Cooperation and Competition in Bioeconomy Value Networks – Analysing the Techno-Economic and Socio-Economic Potentials of Innovative Biorefinery Concepts

Paul Heinzmann: Techno-economic optimization of e-fuel and hydrocarbon production taking into account plant flexibility and storage systems

Sandra Huster: Forecasting core supply and demand for reconditioned products under consideration of stakeholder preferences

Markus Lüttenberg: Strengthening Resilience of Supply with Essential Goods through Public-Private Emergency Collaborations: Challenges and Incentives

Zoe Mayer: Energy retrofits of single buildings and identification of heat losses on district scale

Elias Naber: Socio-Technical Modeling and Agent-based Simulation of Deep Energy Retrofits in the German Building Stock - Mitigating Emissions Caused by Cooling and Heating of Buildings

Humberto Patarca: Concrete Recycling

Mihir Rambhia: Urban Green Management

Dilana Rauch: Utilizing Climate Parameters for Effective Climate Adaptation Measures

Sonja Rosenberg: Integrating End-of-Life Battery System Disassembly in Reverse Supply Chain Network Planning and Assessment

Alexander Schneider: Comparative environmental and economic assessment of Power-to-X value chains

Christoph Stallkamp: Economic and environmental assessment of chemical plastic recycling processes and their integration into the waste management system as a strategy for circular economy for plastics.

Simon Steffl: Assessment of end-of-life options of fibre-based composite materials

Justus Steins: Potentials and Design of a Circular Economy for Autoclaved Aerated Concrete

Diana Temnov: Superstructure Optimization of a newly developed green refinery concept

Nina Treml: Wholistic Sustainability Assessment of the Pig Value Chain in Germany

Elena Vollmer: Automation and software development for district heating system monitoring: Analysing UAS acquired thermal images to detect network leakages

Rebecca Wehrle: Criticality assessment of transport infrastructure networks

Daniel Wilkinson: Pyrolysis of polysterene and recycling of mineral fines

Alexander Zienau*: Public-Private Emergency Collaboration in Logistics from a Business Perspective

Tobias Zimmer: Model-based assessment of mobile pre-treatment technologies in bioenergy value chains

*external researcher

International Collaboration and Exchange

The Chair of Business Administration, Production and Operations Management is engaged in various international exchange activities.

Among others, these include:

- Prof. Schultmann is scientific spokesman of the TRENT platform and project (Transnational Competence Center for Environmental Technology and Research Jiangsu Baden-Württemberg).
- Participation and representations to KIT's initiatives with China and further activities within TRENT.
- In June 2023 Prof. Schultmann and Dr. Rudi participated in the Chilean-German Academic Forum in Santiago de Chile.
- As topic lead within the virtual German-Chilean Institute for Eco-Industrial Development (IECO) on Circular Economy Prof. Schultmann and Dr. Rudi took part in the IECO Summer in Concepción in November 2023.
- German-Australian Cooperation

Teaching Activities

The Chair of Business Administration, Production and Operations Management offers several modules in the fields of Production and Operations Management, Risk Management, Project Management, Supply Chain Management and Logistics, and Sustainability. During 2023 around 600 student exams were completed and the chair has supervised 43 bachelor and master theses.

Anlagenwirtschaft / Planning and Management of Industrial Plants

Prof. Dr. F. Schultmann, Dr. Andreas Rudi, Raphael Heck, Paul Heinzmann, Sonja Rosenberg, Diana Temnov, Alexander Schneider

~80 students

This course familiarizes students with industrial plant management along the entire life cycle, starting with the initiation and erection up to operating and dismantling. Students learn how to deal with important methods to plan, realize and supervise the supply, start-up, maintenance, optimization and shut-down of industrial plants. A focus is also given to specific characteristics of plant engineering, commissioning and investment.

Grundlagen der Produktionswirtschaft / Introduction to Production Management

Prof. Dr. F. Schultmann, PD Dr. Rebekka Volk, Niklas Braun, Simon Steffl

~180 students

This course aims to make students familiar with basic concepts of industrial production economics and logistics. The main contents are the different strategic, tactical and operational production strategies and layouts, as well as planning and management methods. The terms and tasks of industrial production are defined and described by interdisciplinary and system approaches. Furthermore, warehouse location problems, operational site planning and production design problems as well as decision making are in the focus. Qualification aims are to enable students to describe the field, to reproduce and analyse decisive aspects and decisions in industrial production contexts, to know, model and solve key planning tasks of strategic production management and logistics.

Life Cycle Assessment - Grundlagen und Anwendungsmöglichkeiten im industriellen Kontext

Prof. Dr. F. Schultmann, Simon Steffl, Nina Treml

~30 students

The lecture focuses on the analysis of the environmental impact of products using Life Cycle Assessment (LCA). Structure and steps are conveyed in detail and selected further developments are shown. In order to record the methodology and classify potential environmental impacts, the practical development of what has been learned is also focused on using LCA software and interactive formats.

Logistics & Supply Chain Management

Dr. Florian Kaiser , Katharina Eberhardt, Dr. Markus Lüttenberg

~70 students

Students learn the central tasks and challenges of modern logistics and supply chain management. They learn and apply methods of risk evaluation and risk management in supply chains like market forecasts, the Bullwhip effect and the difference between a lean and a robust supply chain. Further aspects comprise the analysis and development of efficient incentive-schemes and planning-tools relevant to procurement decisions, optimal location decisions, order management and supplier relationship management.

Produktions- und Logistikmanagement / Production and Logistics Management

Dr. Andreas Rudi, Sandra Huster, Nina Treml

~60 students

This course covers central tasks and challenges of operational production and logistics management. Systems analytically, central planning tasks are discussed. Exemplary solution approaches for these tasks are presented. Further practical approaches are explained. Students get to know the set-up and mode of operation of planning systems such as PPS, ERP and APS to cope with the accompanying planning tasks. Alongside to MRP II, students are introduced to integrated supply chain management approaches in Supply Chain Management.

Project Management

Prof. Dr. F. Schultmann, PD Dr. Rebekka Volk, Dr. Andreas Rudi, Elena Vollmer, Sonia Alikhah, Niklas Braun, Dilana Rauch

~50 students

This lecture introduces the basics of project management starting with a general introduction on projects and standards in the field. Then, scope management as well as time, cost, and resource management principles are addressed and emphasised. Furthermore, aspects of risk, stakeholder, and quality management are described and considered and communication, negotiation, leadership, and controlling in the project management context is examined. The lecture is deepened with practical exercises and complemented by a business game and a software tutorial. Furthermore, we are happy to include two invited talks from employees of Campana & Schott (international management and technology consultancy) and VSE AG (German power supplier). The talks cover the topics "The Role of the Project Manager", "Communication, Negotiation and Leadership" and "Agile Methods of Project Management" from a practical perspective.

Risk Management in Industrial Supply Networks

Dr. Florian Kaiser

~50 students

Students learn methods and tools to manage risks in complex and dynamically evolving supply chain networks. Students learn the characteristics of modern logistics and supply chain management and learn to identify and analyse the arising risks. On the basis of this overview on supply chain management, the students gain knowledge about approaches and methods of industrial risk management. Key aspects include the identification of major risks, which provide the basis for the development of robust networks, together with risk reduction techniques like risk diversification, risk pooling and risk transfer. This provides the students profound knowledge for supply chain risk analysis and for the design of strategic and tactic risk prevention and mitigation measures for supply networks.

Supply Chain Management in the Automotive Industry

Prof. Dr. Frank Schultmann, Dr. Tilman Heupel, Hendrik Lang, Dr. Florian Kaiser

~100 students

Students learn concepts, methods and tools on various aspects of automotive supply chain management. Through concrete application examples of a globally operating automobile manufacturer, the students recognize challenges that are connected with the implementation of these solutions. The students learn theoretical concepts as well as their practical implementation in the context of value chains, procurement logistics, risk management, quality engineering, cost engineering and purchasing, and they can identify, analyse, and evaluate problems in these areas as well as design adequate solutions. At the end of the lecture, students are able to identify links in these fields and to classify them into the overall context of the value chain and the product development process of an automobile manufacturer.

Sustainable Production

PD Dr. Rebekka Volk, Humberto Patarca

~50 students

This course offers an introduction into the basics of sustainability and the linkage of sustainability to production and logistics. Main methods of lifecycle assessment (LCA), social LCA, material flow analysis and ecological accounting are presented. Examples of sustainability assessments and sustainable production systems illustrate actual challenges for the transformation of current production environments into sustainable structures. Also, integrated assessment models, environmental legislation, environmental management approaches and industrial ecology principles are presented. The students get an overview on different sustainability topics, methods, databases, software and legal background in relation to a sustainable consumption and production.

Global Manufacturing

Dr. Henning Sasse

~50 students

This course deals with questions of international management in engineering and production. Advanced knowledge in the field of international production and the internationalization strategies of engineering companies is presented. Basic understanding of international production companies the relevant business and economic models and schools of thought on the subject are provided. Different approaches of the design of internationalization strategies and production networks are presented and relevant location factors for their particular design are investigated. Risks of internationalization and methods of risk minimization as well as issues of supply chain management are discussed in the context of different approaches to the discrete manufacturing and the process industry. The course concludes with selected case studies from the process and discrete manufacturing industry.

Teaching at the Chair for Business Administration, Production and Operations Management

BSc-Module
„Production Management"

- Introduction to Production Management (SS, 5,5 ECTS)
- Sustainable Production (WS, 3,5 ECTS)
- Logistics and Supply Chain Management (SS, 3,5 ECTS)

MSc-Module
"Planning and Management of Industrial Plants"

- Planning and Management of Industrial Plants (WS, 5,5 ECTS)
- Emissions and Environment (WS, 3,5 ECTS)
- Life Cycle Assessment and Projection of Global Development (WS, 3,5 ECTS)
- Global Manufacturing (WS, 3,5 ECTS)

MSc-Module
"Production and Logistics Management"

- Production and Logistics Management (SS, 5,5 ECTS)
- Supply Chain Management with Advanced Planning Systems (SS, 3,5 ECTS)
- Project Management (WS, 3,5 ECTS)
- Supply Chain Management in the Automotive Industry (SS, 3,5 ECTS)
- Risk Management in Industrial Supply Networks (WS, 3,5 ECTS)

Publications

Peer-Reviewed Journals

Bakker, H., Diehlmann, F., Wiens, M., Nickel, S., Schultmann, F. (2023): School or Parking Lot? Selecting Locations for Points of Distribution in Urban Disasters. Socio-Economic Planning Sciences 89, 101670. https://doi.org/10.1016/j.seps.2023.101670

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Baazouzi, S., Rosenberg, S., Huster, S., Schultmann, F., et al.; 2023. Abschlussbericht: Industrielle Demontage von Batteriemodulen und E-Motoren zur Sicherung wirtschaftsstrategischer Rohstoffe für die E-Mobilität – DeMoBat. https://www.ipa.fraunhofer.de/content/dam/ipa/de/documents/Projekte/Industrieprojekte/DeMoBat-Abschlussbericht.pdf

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