Karlsruhe Institute of Technology

Institute for Industrial Production

Annual Report 2024

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 2024. Our three research groups "Sustainable Value Chains", "Risk Management", 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 2024, we worked on 23 third party funded research projects. We published 14 peer-reviewed journal papers, numerous articles in conference proceedings and book chapters. 3 PhDs were completed. Teaching activities resulted in around 540 exams, about 42 bachelor and master theses were supervised and, in addition, an intern from France was supervised. Furthermore, 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 (EOL EV-battery modelling) 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, Paul Heinzmann, Raphael Heck, Nina Treml, Andreas Rudi, Diana Temnov, Sandra Huster, Sonia Alikhah.

Risk Management

Head of research group: Dr. Sonja Rosenberg

The risk management research group develops and provides methods and tools for systematic and comprehensible decision support for complex, uncertain, and dynamic systems. Their research interests extend beyond traditional risk management boundaries.

Today, stakeholders such as companies, communities, and governmental institutions face uncertainties in their systems due to increased complexity from rapid technological changes, global interdependencies, and evolving regulatory landscapes. These systems can include supply chain networks, markets, or critical infrastructures and sectors. Despite the diversity of these systems, the common goal is to improve decision-making.

Consequently, the group's ongoing projects focus on various research areas:

- LandWandel: This project aims to enhance communities' capabilities to make informed and resilient decisions about climate adaptation measures. It connects the socio-technical analysis of the IIP with regional climate change modeling from project partners.
- KommMa: This project seeks to provide a comprehensive database that enables communities to develop individual climate protection strategies tailored to their specific characteristics.
- ALANO: This research project focuses on public crisis and disaster prevention for food emergencies, which can be triggered by various crises.

Typical applied methods within the group are:

- (Empirical) social studies (questionnaire-based surveys and expert interviews)
- Vulnerability and scenario analysis
- Operations research based modelling with a focus on uncertainty and dynamics, including stochastic and robust optimization
- Socio-technical system analysis
- Technology forecasts and market uncertainty assessment

In 2024 members of the group attended several national and international conferences which allowed to present various aspects of research results. Mathematical modelling results were presented at the EURO 2024 in Copenhagen, the INFORMS 2024 in Seattle and the NORS 2024 in Oslo. Furthermore, the ISCRAM 2024 in Münster and a DFG funded conference on crises on critical infrastructure in Darmstadt allowed to exchange results with experts from risk and crisis management.

Members of the research group (from l. to r.): Katharina Eberhardt, Sonja Rosenberg, Amelie Schwärzel.

Resource Management in the Built Environment

Head of research group: PD Dr. Rebekka Volk

The Resource Management in the Built Environment (RM) 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, 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 flowsin residential and non-residential buildings and nuclear power plants and facilities. Furthermore, we work on the planning and decision support model namares for a sustainable urban development on district level which will be further developed in the new Urban Green Infrastructures (UBGI) project. 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 (new SRZ project), ranging from biobased composites (research projects ReGrow, Willow Weave, ReSidence and NEWood) to autoclaved aerated concrete (research projects REPOST, URBAN, InnoBeton) and different types of plastics (research project Kreislaufwirtschaft für Kunststoffe/THINKTANK "Industrial Resource Strategies"). 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 RM group are:

- 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
- Optimization methods
- Agent-based modelling to identify cost-efficient renewable energies' potentials in residential building stocks and municipalities

Main group activities:

- Conference contribution on thermal image processing, AI in AEC, Helsinki
- Conference contribution on EURO Copenhagen on layout routing optimization
- Contribution to KIT stall 'Circular Economy' on Hannover Messe on concrete and cement recycling

- Conference contribution on NEXTBUILT-2024 on 'Innovative robotic-woven willow-clay-composite ceiling elements'
- Presentation on HaiCon 2024, Düsseldorf
- Presentation on EGI2024
- Presentation of concrete waste volume estimation on fib doctoral seminar, Budapest
- Presentation of namares 2.0 project results on the 17. Bundeskongress Nationale Stadtentwicklungspolitik, 17 Sept 2024
- MTET presentation of works on plastics recycling assessments at KIT Campus North
- KNT Symposium two contributions on plastics recycling reverse logistics and on ETICS materials

Members of the research group (from l. to r.): back row – Justus Steins, Simon Steffl, Lena Fuhg and Elena Vollmer, front row – Theresa Kaya, Teresa Oehlcke, Rebekka Volk, Antonia Frank, Rafael Bischof and Niklas Braun (missing on the picture: Sebastian Rauscher)

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 work package 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.

To promote both the platform and IIP's thermography use case, a social media video was shot and webinar talk held in "ANERIS Workshops on AI Basics for Image Processing" in November and December 2023, respectively.The first reporting period concluded in February 2024 after an extensive review meeting with the project's EU coordinator and full report submission. Following this, the first version of the AI4EOSC platform was released in March, alongside the software stack powering it.

Regarding the IIP's thermography-based use case, one of AI models - focused on thermal urban feature segmentation - was showcased at the Helsinki conference "AI in Architecture, Engineering and Construction conference" in March 2024. Various experiments with this model were presented via poster at the "HaiCon24" conference in June in Düsseldorf, where AI4EOSC was additionally represented by colleagues from KIT's SCC through talks and posters. This included a collaborative poster on federated learning, which was also showcased via presentation at the "EGI24" conference in October in Lecce. Aside from this, a paper titled "Detecting District Heating Leaks in Thermal Imagery: Comparison of Anomaly Detection Methods" was published in the journal "Automation in Construction" in October with accompanying code and datasets on Zenodo.

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

Katharina Eberhardt, Amelie Schwärzel, Dr. Sonja Rosenberg

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 examines 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 the next step, alternative supply strategies are 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.

The final year of the research project was filled with a variety of works along the different subtasks of the project. In March 2024 the second online expert workshop took place with the goal to further investigate advantages and disadvantages of alterative concepts for state's emergency food preparedness systems. Therefore, the systems of Finland and Switzerland were contrasted against the German systems.

The empirical survey on private stockpiling, which was conducted in 2023, was prepared and evaluated. The results were prepared in form of a working paper and presented on a DFG-funded conferences about crises on critical infrastructure in September.

Additionally, mathematical models were developed to assess the efficiency of the current German emergency food preparedness system for different crises scenarios, such as long-lasting blackouts. First results were presented at several international conferences such as EURO 2024 in Copenhagen and INFORMS 2024 in Seattle. Corresponding scientific articles have been submitted to scientific journals.

The final report has been published in the "Series of Reports Production and Energy". Further articles have been submitted to multiple scientific journals.

With support from
Federal Ministry of Food and Agriculture
by decision of the German Bundestag
Project manager
Federal Office for Agriculture and Food

IEA EBC - Annex 89 - Ways to Implement Net-zero Whole Life Carbon Buildings

Theresa Kaya, PD Dr. Rebekka Volk

Funding: International Energy Agency (IEA), Federal Ministry for Economic Affairs and Climate Action (BMWK)

Duration: 2023-2027

In light of the critical need to align the building and real estate sector with the goals of the Paris Agreement, this research project explores the pathways and actions required to implement net-zero whole life carbon (NetZ-WLC) buildings in both policy and practice. The project addresses the necessity of considering greenhouse gas (GHG) emissions holistically, encompassing both embodied and operational emissions across all life cycle stages of buildings to achieve climate neutrality by 2050 at the latest. The overarching goal is to contribute to the limitation of global warming to well below 2°C, preferably 1.5°C, above pre-industrial levels..

The project's objectives are pursued through a multi-stage approach:

1. **Development of Guidelines and Carbon Targets**
   The project establishes whole life carbon targets and budgets for the building sector, identifying pathways and actions to align practices with Paris-compatible goals.
2. **Paris-compatible Assessment Frameworks**
   It develops and evaluates frameworks to ensure Paris Agreement compatibility, guiding NetZ-WLC implementation at all scales.
3. **Tools, Aids, and Instruments for Decision-makers**
   The project maps and evaluates decision-making tools for stakeholders, focusing on their relevance and effectiveness in supporting NetZ-WLC outcomes.
4. **In-practice Uptake of Context-based Solutions**
   It examines factors that enable stakeholders to adopt NetZ-WLC approaches, including regulatory, financial, and social aspects.
5. **Stakeholder Engagement and Knowledge Exchange**
   The project promotes engagement and disseminates findings to bridge research and practice, ensuring outputs are globally applicable.

This year saw significant progress in Subtasks 1 and 2. Subtask 1, focusing on science-based approaches for setting and allocating GHG budgets in the construction and real estate sectors, began with an online meeting on April 22 to clarify the work program and align participant contributions. Concrete steps were outlined for the June 20–21 Berlin meeting, organized by Rebekka Volk, Thomas Lützkendorf, and Theresa Kaya. This event emphasized tools and instruments for implementing NetZ-WLC initiatives and Paris-compatible assessment methods. The meeting concluded with task coordination and planning. An additional online meeting on October 7 provided updates and prepared for the Melbourne meeting on November 18–21.

Subtask 2, focused on defining Paris-compatible decarbonization methods and aligning international climate policies with the Paris Agreement, reached key milestones. Meetings on May 13 and October 30 reviewed progress and introduced a Danish assessment method. The Melbourne meeting (November 18–22) accelerated work on all subtasks, emphasized draft guidelines based on background reports and papers, fostered expert exchange, clarified contributions, and engaged Australian stakeholders and ExCo members to enhance the global impact of Annex 89.

EBC
Energy in Building and Communities Programme

CEDIM – Center for Disaster Management and Risk Reduction Technology

Risk Management group, Dr. Sonja Rosenberg

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.

Ongoing work of the interdisciplinary CEDIM Team is to report and evaluate immediately after the occurrence of natural disaster in form of Forensic Disaster Analysis (FDA) reports. In FDA methods and findings of the different involved research disciplines are merged to reconstruct the disaster. In the year 2024 such an FDA was conducted after the Exceptional precipitation and flooding in southern Germany in June 2024.

CARE-o-SENE – Catalyst Research for Sustainable Kerosene

Work package 4 : Impact assessment from a techno-economic and ecological perspective

Paul Heinzmann, Dr. Andreas Rudi

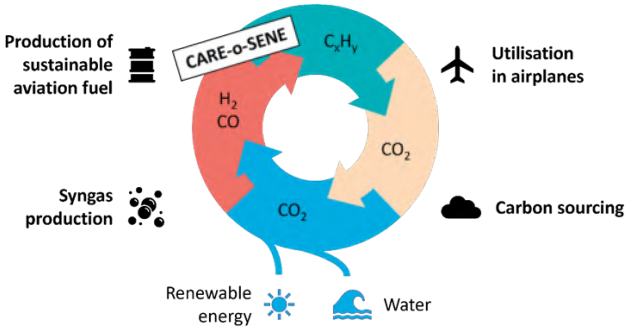
Partner: Sasol Germany GmbH; Helmholtz-Zentrum Berlin für Materialien und Energie (HZB); University of Cape Town, Department of Chemical Engineering (UCT); Fraunhofer Institute for Ceramic Technologies and Systems (IKTS); INERATEC GmbH; Karlsruher Institut für Technologie (KIT), Institute for Catalysis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

Funding: Federal Ministry of Education and Research (BMBF)

Duration: 09/2022 – 09/2026

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

NaWo-Collab

PD Dr.-Ing. Rebekka Volk

Partner: KIT/IfR (Prof. Dr. Michael Janoschka), Universität Freiburg (apl. Prof. Dr. Philipp Späth)

Funding: Innovationscampus Nachhaltigkeit

Duration: 09/2024 - 08/2025

The provision of safe, permanently affordable and climate-neutral housing requires comprehensive transformation processes, and in particular a huge acceleration of energy-efficient, climate-friendly and adaptive building renovations. To ensure broad social acceptance and support for this sustainability transition, these measures must be integrated into existing and new housing concepts.

The NaWo-Collab links stakeholders from politics, business and society in order to change regional housing policy in such a way that sustainable living, building and renovation is strongly promoted. This includes:

- Developing, demonstrating and linking pioneering system innovations for affordable, climate-adapted housing, with the aim of significantly increasing the rate, quality and depth of renovation (climate neutrality) while also ensuring a high degree of neutrality in terms of rent and heating costs;
- Networking of stakeholders and innovations in the field of building renovation, with a focus on overcoming the renovation deficit and promoting social justice in the housing market. It serves as a platform for the exchange of best practices and the development of strategies to reduce socio-spatial inequalities.

The Upper Rhine region, one of the areas in Germany most affected by climate change, faces particular challenges. In the face of longer and more intense heat waves, the region urgently needs innovative solutions for adapting the building stock to changing climatic conditions, particularly with regard to insulation, ventilation and cooling. At the same time, high real estate prices and rents, especially in the 'swarm cities' around Freiburg and Karlsruhe, emphasize the urgency of socially just reconstruction and new construction.

The **NaWo-Collab** therefore uses regional resources and potential, such as geothermal and solar energy sources or possibly forest residual wood from the Black Forest and biogenic waste, to develop innovative, sustainable housing solutions. These approaches allow for a sustainable transformation of the housing stock, strengthen the regional economy, particularly in the skilled crafts sector, and promote the connection between urban and rural areas. The Upper Rhine region is thus becoming a model for climate-adapted housing concepts, with transregional relevance.

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)

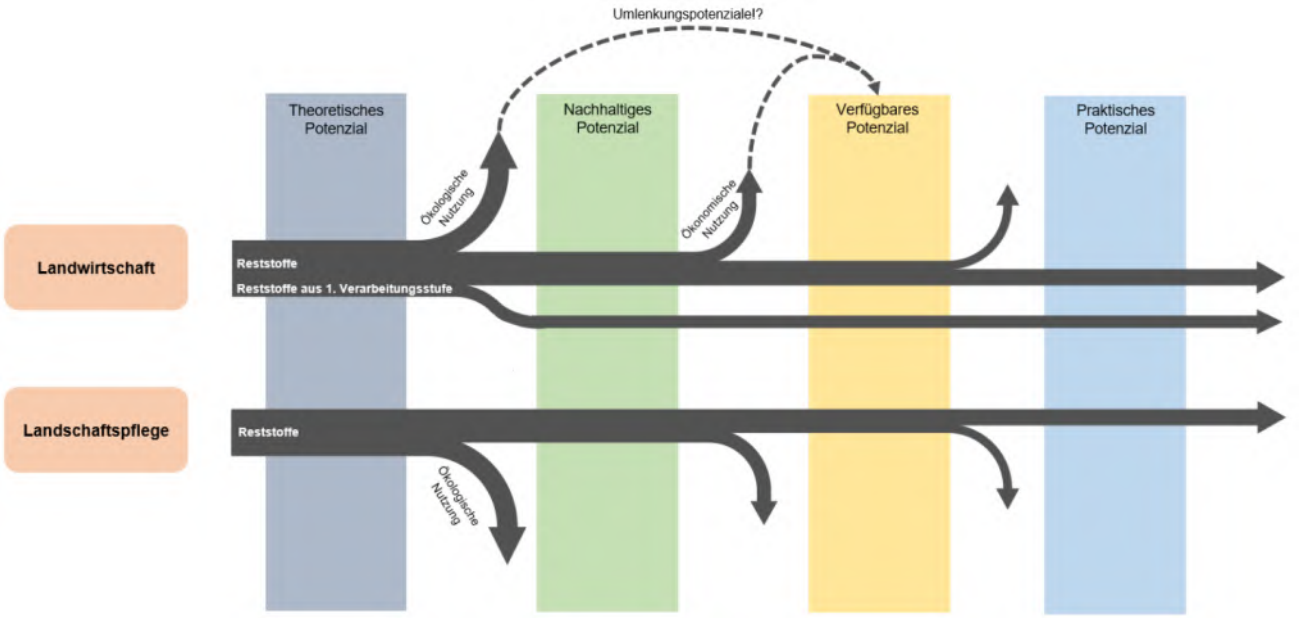
Duration: 09/2022 – 08/2025

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.



E-Akteur Stakeholder Relations in the Circular Supply Chain of Electric Vehicle Batteries

Sandra Huster, Dr. Andreas Rudi

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

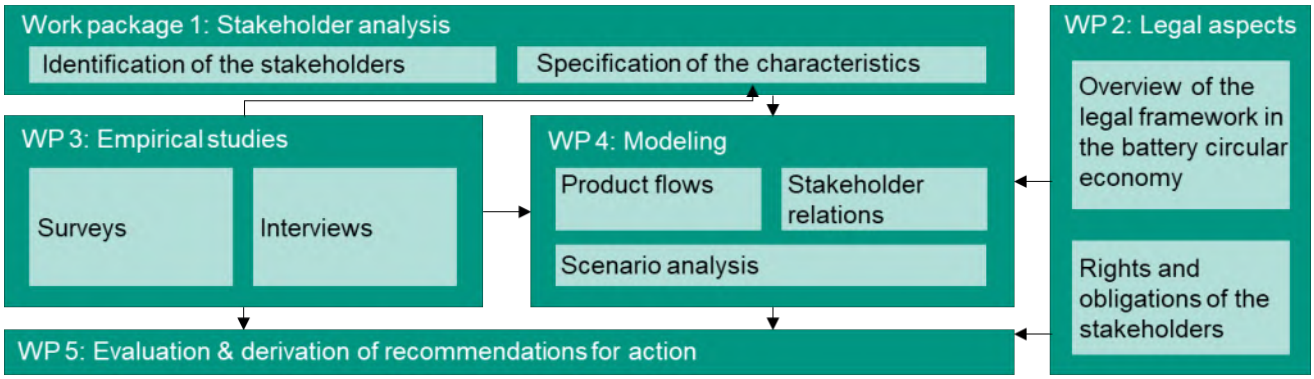
Funding: Ministerium für Wirtschaft, Arbeit und Tourismus Baden-Württemberg (MWAT)

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 first identifies and describes the relevant players. Empirical studies 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 is 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 are be used to derive options for steering battery flows toward different end-of-life paths.



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

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 carries 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.

KommMa – Dynamic database of measures for municipal climate protection

Amelie Schwärzel, Dr. Sonja Rosenberg

Partner: Institute of Meteorology and Climate Research Troposphere Research (KIT- IMKTRO), represented by the South German Climate Office; Institute for Technology Assessment and Systems Analysis (KIT- ITAS), Institute for Transport Studies (KIT- IFV)

Funding: Federal Ministry of Education and Research

Duration: 2024-2027

In light of the increasingly evident effects of climate change in Germany and the undeniable urgency for action, municipalities are implementing concrete and effective measures to protect our planet. Decisions made at the municipal level have a direct impact on energy consumption, mobility organization, environmental pollution, and the quality of life of citizens.

Municipalities have the potential to initiate sustainable changes in areas such as urban planning, transportation, energy supply, waste management, and green space design, thereby ensuring equitable living conditions across society.

However, municipals are faced with a variety of burdens that hinder their decision-making process. For instance, the information available for selecting and implementing climate protection measures is often confusing and of varying quality. Additionally, financial and human resources are frequently limited.

Currently, there is a lack of scientifically sound decision-making support for German municipalities that is tailored to local situations in Germany. Communities as decision-makers lack also options for time- and cost-efficient comparisons with similar communities.

To overcome these limitations the goal of KommMa is to set up a dynamic database of measures, that are scientifically and transparently evaluated but also prioritized according to different output indicators. This pragmatic approach provides municipalities with a concrete tool to achieve their climate protection goals as efficiently and effectively as possible.

Within the joined project of four KIT institutes the IIP is mainly responsible for the set-up of the database and the functioning as decision-support tool.

KommMa

LandWandel – Innovative Climate Parameters for Adaptation Measures in Rural Areas

Dr. Sonja Rosenberg, Dilana Rauch (until fall 2024)

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 BMBF 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

Diana Temnov, Paul Heinzmann, 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.

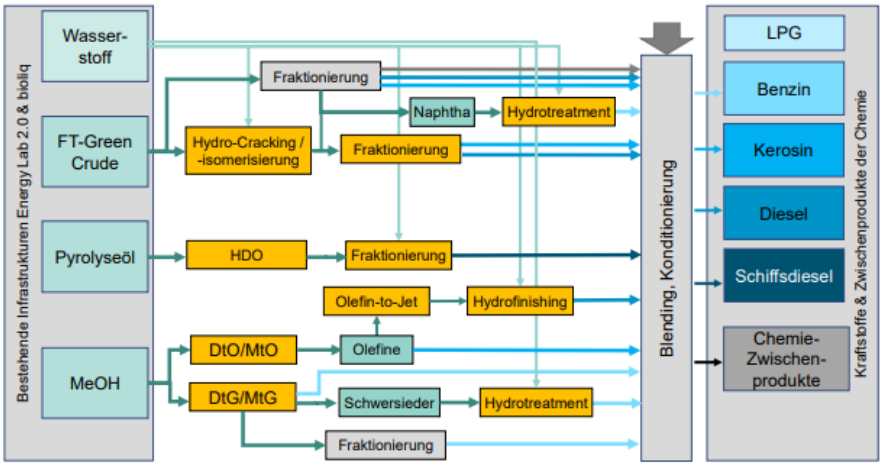


Figure: Diagram of the planned process network. Fuel fractions are produced from the input materials depicted on the left through the yellow-highlighted process stages, and these are further processed into various types of fuels.

reFuels Demo

Alexander Schneider, Paul Heinzmann, Dr. Andreas Rudi

Partner: Institute of Reciprocating Engines (IFKM), Institute for Catalysis Research and Technology (IKFT), Institute of Micro Process Engineering (IMVT), Engler-Bunte Institute (EBI), Institute for Technology Assessment and Systems Analysis (ITAS) and numerous industry partners.

Funding: Ministry of Transport Baden-Württemberg

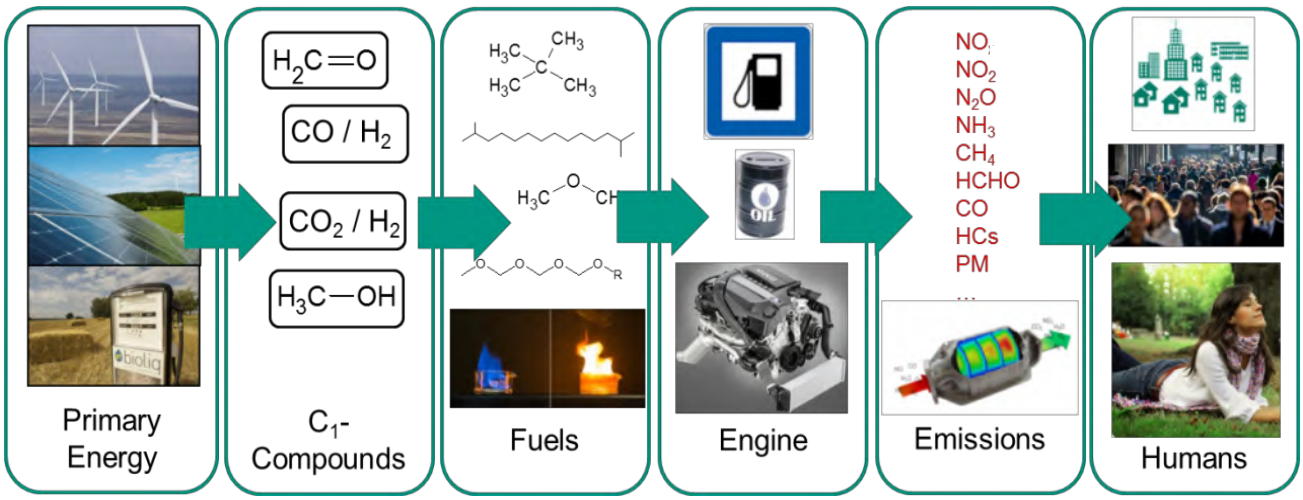
Duration: 2023 - 2025

The utilization of renewable produced fuels (reFuels) is one of the main actions beside electric mobility on the way to a CO2 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.



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 constructio 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.

SeRoZen BW - Regional secondary raw material centres in Baden-Württemberg

PD Dr. Rebekka Volk, Lena Fuhg, Dr. Justus Steins

Partner: Landesanstalt für Umwelt Baden-Württemberg

Funding: Ministry for Regional Development and Housing Baden-Württemberg

Duration: 2024 - 2025

Urban areas and metropolitan regions are the sources of a variety of construction waste and waste streams. Local or regional secondary raw material centres (SRCs) are urgently needed in order to treat these material flows in the future in line with a circular economy and use them to the highest possible quality with minimal transport and handling costs. This need has also been recognised at EU level and initial examples of best practice have been collected.

In this project, SRCs are defined, conceptualised and evaluated for Baden-Württemberg. In addition, the investment requirements will be estimated, optimal locations identified and an optimised recycling network for Baden-Württemberg outlined.

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

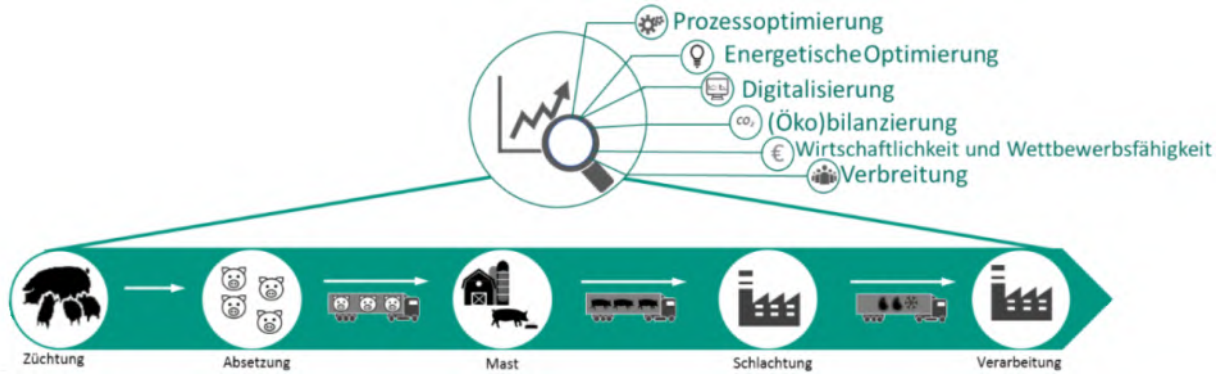
Agriculture and especially animal husbandry are currently facing major challenges, such as ensuring food quality and enabling sustainable value chains. To address these challenges, regional and global food security, animal welfare, efficient use of raw materials, climate and environmental protection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

THINKTANK "Industrial Resource Strategies": Kreislaufwirtschaft für Kunststoffe

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 - 2024

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, IIP works on topics such as circular economy, resource efficiency alongside the entire supply chain. The circular economy framework is 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.

The project "Kreislaufwirtschaft für Kunststoffe" was extended for another year, running from 07/2024 to 09/2025. This project period focuses on three key research areas. First, it involves the development of a system model to explore political strategies for a circular economy for plastics and to estimate the carbon demand of the chemical industry. Second, the project includes a comparative and comprehensive attributional life cycle assessment (LCA) for 5–6 different plastic waste fractions, which will be compared to existing data in the literature. Lastly, it aims to provide an assessment of the potential for contaminant removal through chemical recycling processes in Germany. Together, these efforts contribute to advancing a sustainable and climate-neutral carbon circular economy in Germany.

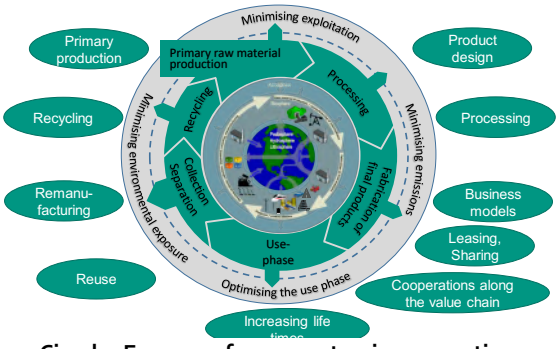


Figure: Circular Economy from a systemic perspective as a key element of research activities within the ThinkTank Industrial Resource Strategies

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

PD Dr. Rebekka Volk, Antonia Frank, Sebastian Rauscher

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). The planned circular flow is shown in the figure. 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. In order to produce this new type of cement, it is essential to estimate the future potential of post-demolition.

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. Different compositions of concrete with 15 and 30% recycled concrete are currently being tested.

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.

In the following, a techno-economic and ecological analysis of the new recycling options is necessary. For this purpose, a process-based life cycle assessment will be carried out to analyse and evaluate all material flows in detail.

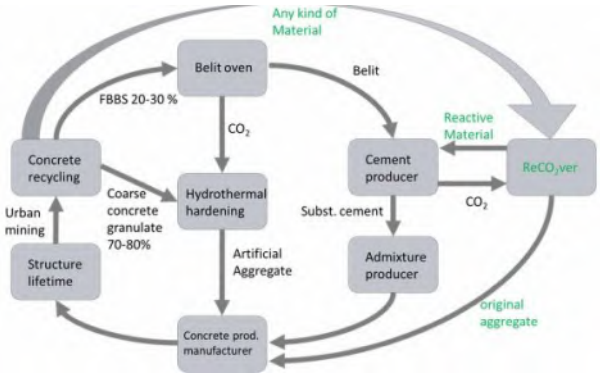


Figure: Circular flows (URBAN), supplemented with the material flows of the Sika project RECO2VER (green)

Innobeton – Innovative Technologien zur Entwicklung eines neuartigen reaktiven Betonzusatz-stoffs 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.

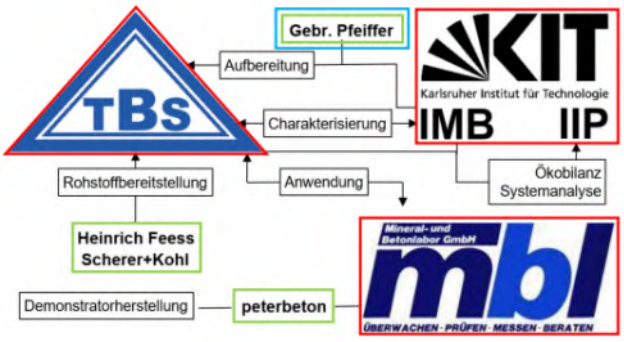


Figure: Composite structure of the project partners

The Institute for Industrial Production (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.

The basis for achieving resource efficiency in the recycling of building materials is to estimate the potential of post-demolition as accurately as possible. This makes it possible to calculate how much post-demolition is available to go back into the cycle of concrete production and thus, in the best case, save CO_2 and conserve primary resources.

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

PhD Dissertation:

Data-enabled decision support system for sustainable urban development: A case of urban green space management

Mihir Rambhia

Urban green spaces (UGS) provide substantial environmental, economic, and social benefits, offering a cost-effective strategy for mitigating climate change. Consequently, preserving and enhancing these areas is of significant interest for city administrators. Sustaining these UGS requires constant management inputs in terms of water, fertilizer, personnel, equipment, and funding. However, in resource-constrained scenarios, it may not be possible to provide necessary management support to all the UGS, necessitating prioritization decisions. For instance, with the increased impact of climate change, many regions of the world are expected to face prolonged dry periods, leading to water shortages. Therefore, the allocation of limited water resources becomes a challenge in such scenarios. Currently, allocation decisions are often made subjectively based on individual experience or limited field observations, potentially resulting in inefficient allocation and a decrease in attainable benefits. Accordingly, to balance diverse objectives, a multidimensional,evidence-based management approach is required.

Accordingly, this dissertation, through four interconnected studies, presents a data-enabled decision support system based on utilitarian principles aimed at maximizing UGS benefits at minimum costs. This is achieved by systematically analyzing both the total costs of sustaining UGS and the benefits they provide to city residents. For estimating the cost, a novel linear time series model, based on soil water balance principles and the Water Use Classifications of Landscape Species approach, is developed. The model provides estimates for the weekly irrigation demand of urban street trees, considering tree characteristics, current and forecasted weather conditions, and soil properties. For estimating the benefit, a novel GIS-based approach is utilized to calculate accessibility and quality benefits. This approach utilizes publicly available data on UGS location, space size, noise maps, remote sensing data, crime statistics, and population distribution in the city. Subsequently, a goal programming-based decision-making model is developed that integrates multiple objectives, including conserving stored carbon, increasing attainable quality and accessibility, and addressing constraints on available resources such as water and personnel. The developed model allows making prioritization decisions at varied spatial scales to allocate resources efficiently and maximize benefits gained. The thesis presents three prioritization approaches: based on demands, based on benefits, and based on combined demands and benefits. The findings demonstrate that the developed method can improve the attainable benefits from UGS in resource-constrained scenarios.

The challenges related to insufficient quality public datasets are addressed through a systematic quality assessment framework based on total data quality management principles. Furthermore, the impact of missing data on decision-making is demonstrated through sensitivity analysis. Additionally, the data quality of existing tree inventory datasets is enhanced by filling missing tree-height data using linear regression and random forest-based regression techniques, enabling decision-makers in cities with limited data availability to make informed decisions.

PhD Dissertation:

Evaluating End-of-Life Electric Vehicle Battery System Disassembly Potential for Reverse Logistics Network Planning

Sonja Rosenberg

Electric Vehicles (EVs) play a pivotal role in achieving sustainable, low-emission private transportation. Substantial amounts of valuable primary resources are needed for the production of Electric Vehicle Battery Systems (EVBSs), which also constitute the largest share of overall material costs in EVs. One action to enhance the overall sustainability of EVs is to implement circular economy recovery strategies for the End-of-Life (EOL) phase of EVBSs. These strategies aim to recover materials or extend the usage phase. While the current number of EOL EVBSs remains relatively low, an exponential increase is anticipated as the EV market expands and existing EVBSs eventually reach their EOL after years of usage. Possible circular recovery strategies, such as recycling or remanufacturing and repurposing of EVBSs, are discussed by research and industry. However, they are often not assessed comprehensively, and the obligatory treatment step of disassembly is neglected.

Therefore, the conducted cumulative dissertation, contains six research studies. The studies long to contribute towards understanding the significance of disassembly for achieving circular EOL pathways with a multi-perspective evaluation. Because designs of disassembly processes decide on the applicable circular strategies, the disassembly itself must first be evaluated. Afterward, potential reverse logistics network structures, including disassembly, can be analyzed.

The first two studies, A and B, aim to identify the market potential for disassembly in the context of various circular economy recovery processes. The research focuses on predicting EOL return quantities and determining the demand for used EVBSs using simulation models. In Study C, a cost estimation for disassembly is performed. For this purpose, collected disassembly durations are combined with a fuzzy logic approach to derive uncertainty-assessed disassembly durations, which are incorporated into the cost estimation. An ecological assessment of disassembly for achieving closed-loop recycling systems is conducted in Study D through combined material flow analysis and life cycle assessment. Studies E and F build upon the results of the previous studies. In Study E, a mixed-integer linear optimization problem is formulated for a two-stage dynamic reverse logistics network. Decisions regarding the operational locations and capacities of disassembly and recycling plants, as well as network structure adjustments over a multi-period horizon, are made. In Study F, a two-stage stochastic optimization problem is set up, which represents a multi-period, multi-product, dynamic capacity, location, and allocation problem, including disassembly technology selection. Uncertainty exists about the quality and quantity of returned EOL EVBSs and revenues from disassembly. All methods are applied to case studies, representing possible scenarios for expected EOL EVBS market volumes in Germany to deduce implications and recommendations for shareholders, such as politics and businesses.

In combination the six studies ensure a comprehensive and integrated assessment concerning the economic and ecological significance of disassembly of EVBSs for reverse logistics networks.

PhD Dissertation:

Potentials and Design of a Circular Economy for Autoclaved Aerated Concrete

Justus Steins

Limiting anthropogenic climate change and transforming to a more sustainable lifestyle are among the current generation's most vital challenges. The built environment plays a crucial role in this context due to high resource consumption and greenhouse gas (GHG) emissions. Therefore, construction and demolition waste recycling is gaining importance but is difficult to realise for some building materials, including autoclaved aerated concrete (AAC). AAC has a low density and excellent thermal insulation properties due to its porous structure. Hence, AAC is a frequently used building material. However, recycling post-demolition AAC (pd-AAC) from the demolition and deconstruction of buildings is complicated as it has low compressive strength and contains sulphate. Therefore, pd-AAC is mainly landfilled. While there are some new pd-AAC recycling approaches, the quantitative, ecological and economic potential of pd-AAC recycling is unknown. Furthermore, no research compares different recycling approaches or examines recycling network structures to identify a circular economy design for AAC. This dissertation addresses these research gaps and answers the following research question: How can a circular economy for autoclaved aerated concrete be designed, and what quantitative, ecological, and economic potential does it have in Germany and Europe?

Quantification shows that pd-AAC volumes reach 1.2 Mm^3 in Germany in 2020 and are expected to rise significantly to over 4 Mm^3 by 2050 (Study A). At the European level (Study B), ten times the German volumes can be expected. A life cycle assessment is conducted to identify the ecological potential of different pd-AAC recycling options (Study C). Using pd-AAC to partly substitute inputs of the lightweight aggregate concrete, light mortar, shuttering block, and AAC production is most promising. The pd-AAC processing only causes little impact, and significant environmental savings can be achieved due to the avoided production of primary materials, reaching total GHG savings of pd-AAC recycling of around 280,000 t CO_2 Eq/a in Germany and more than 8 Mt CO_2 Eq/a in Europe in the future. Additionally, a new recycling option, the production of recycled belite cement clinker (RC-BCC), proves to be ecologically beneficial despite energy-intensive processing (Study D). RC-BCC can replace emission-intensive primary Portland cement. Moreover, pd-AAC recycling has significant economic potential (Study E). Even smaller recycling plants can process pd-AAC cheaper than the average landfilling costs. However, RC-BCC production is not economically viable with current technologies. Mathematical modelling and optimisation methods are used to determine the best design of a pd-AAC recycling network (Study F). According to the computation results, large recycling plants should be preferred, and landfilling should be avoided. Overall, savings of around 4,600 M€ can be achieved until 2050 compared to the status quo.

This dissertation shows that pd-AAC recycling has a significant quantitative and ecological potential. Establishing high-quality recycling options to deal with the increasing future pd-AAC volumes is urgent. An optimally designed pd-AAC recycling network reaches high economic savings and supports the change towards a circular economy of AAC.

Staff 2024

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 – Resource Management in the Built Environment

Dr. Sonja Rosenberg – Risk Management

Research Associates and their PhD-topics

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

Raphael Bischof: Towards a Circular Economy: Techno-Economic and Ecological Evaluation of ETICS End-of-Life Management

Niklas Braun: Logistics optimization in nuclear decommissioning projects

Katharina Eberhardt: Strategic Decision Support in Supply Chain Management: Network Optimization for Efficient Resource Location and Allocation

Antonia Frank: Sustainability in Concrete Construction: Potentials and Design of a Circular Economy System within Concrete Production

Lena Fuhg: Optimizing Resource Hubs for Construction and Demolition Waste: System Integration of Sustainable Secondary Raw Material Recycling Strategies

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 electric vehicle batteries under consideration of stakeholder preferences

Theresa Kaya: National mitigation pathway for the German construction and real estate sector

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

Mihir Rambhia: Urban Green Management

Sebastian Rauscher: Sustainable use of mineral secondary raw materials in Germany

Teresa Oehlcke: The role of chemical recycling in meeting the carbon supply demands of the chemical industry through waste system integration

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

Amelie Schwärzel: Data-driven Risk Management in Supply Chain Networks

Simon Steffl: Composites in a circular economy

Dr. 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: Holistic 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

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 national and international (exchange) activities.

Among others, these include:

- Prof. Schultmann is deputy spokesman of the topic “Circular Economy and Environmental Technologies” within the KIT Climate and Environment Center.
- Prof. Schultmann is scientific spokesman of the topic “Sustainable Material and Energetic Use of Biomass” of the Chilean-German Institute of Eco-Industrial Development (IECO).
- 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.
- German-Australian cooperation and research exchanges, such as in 2024 with Dr. Sam Baroudi from Univerity of Adelaide visiting the IIP to prepare joined research projects with the Risk Management research group.
- PD Dr. Rebekka Volk is PI in the strategic processes of “Stadtforschung am KIT” and “Circular Economy”.

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 2024 around 540 student exams were completed and the chair has supervised 42 bachelor and master theses.

Fundamentals of Production Management

Prof. Dr. F. Schultmann, Niklas Braun, Antonia Frank

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.

Design and Operation of Industrial Plants and Processes

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

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.

Life Cycle Assessment - Basics and Application Possibilities in an Industrial Context

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

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 and Supply Chain Management

Dr. Sonja Rosenberg, Katharina Eberhardt

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.

Production and Logistics Management

Dr. Andreas Rudi, Sonia Alikhah, Nina Treml, Sandra Huster

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, Elena Vollmer, Niklas Braun, Amelie Schwärzel, Lena Fuhg, Teresa Oehlke, Sonia Alikhah, Dr. Sonja Rosenberg

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. Sonja Rosenberg, Amelie Schwärzel

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.

Production Economics and Sustainability

PD Dr. Rebekka Volk, Raphael Bischof

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

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.

Emissions into the Environment

Prof. Dr. Ute Karl

The lecture gives an overview of relevant emissions of air pollutants and greenhouse gases, emission monitoring and pollutant abatement options together with relevant legal regulations at national and international level. In addition, the fundamentals of circular economy, waste management and recycling are explained.

Supply Chain Management with Advanced Planning Systems

Dr. Mathias Göbelt, Claus Bosch

This lecture deals with supply chain management from a practitioner's perspective with a special emphasis Advanced Planning Systems (APS) and the planning domain. The software solution SAP SCM, one of the most widely used Advanced Planning Systems, is used as an example to show functionality and application of an APS in practice.

Teaching at the Chair for Business Administration, Production and Operations Management	
BSc-Module „Production Management" • Fundamentals of Production Management • Production Economics and Sustainability • Logistics and Supply Chain Management	
MSc-Module "Industrial Plants and Processes" • Design and Operation of Industrial Plants and Processes • Emissions into the Environment • Life Cycle Assessment - Basics and Application Possibilities in an Industrial Context • Global Manufacturing	**MSc-Module "Production and Logistics Management"** • Production and Logistics Management • Supply Chain Management with Advanced Planning Systems • Project Management • Risk Management in Industrial Supply Networks

Publications

Heck, R.; Frei, L.; Rudi, A.; Schultmann, F. 2024. Simulation Modelling in Bioeconomy: Unraveling Trends, Gaps, and Insights through Bibliomethric Analysis. Journal of Cleaner Production, 473, 143497. doi.org/10.1016/j.jclepro.2024.143497

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Dissertations

Rambhia, M. 2024. Data-enabled decision support system for sustainable urban development: A case of urban green space management. Dissertation

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Steins, J. 2024. Potentials and Design of a Circular Economy for Autoclaved Aerated Concrete. Dissertation, doi:10.5445/IR/1000170554

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