

UNIVERSITY OF GRAZ
Institute of Environmental Systems Sciences



Annual Report 2022



Institute of Environmental Systems Sciences
UNIVERSITY OF GRAZ

Institute of Environmental Systems Sciences
University of Graz
Merangasse 18/I,
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Editorial

The year 2022 was marked by significant successes among young scientists at the Institute. No fewer than six dissertations were completed this year, for which we offer our sincere congratulations to Hartmut Derler, Hannes Hornischer, Simon Plakolb, Tomas Santa Maria Gonzalez, Annina Thaller and Rafia Zaman (for a description of the projects see section 2.5). Furthermore, an extraordinary number of researchers starting their PhD studies has been reached in 2022 – we warmly welcome Julius Ott, Martin Popowicz, Antonia Pohlmann, Lydia Lienhart, Simone Schreiegg, Katharina Trimmel, Severin Lüps and Fabian Tschofenig as new members of the Institute.

In 2022, the Institute has been given a new name: *Institute of Environmental Systems Sciences*, or ESS. On the one hand, the reference to Environmental Systems Sciences emphasizes the proximity to the bachelor's, master's and doctoral programs of the same name; on the other hand, the new name is catchier and thus contributes to the Institute's profile. The content of the research activities remains unchanged, with a number of focal points, including bioeconomy, circular economy, complex networks and multi-agent systems, data sciences & artificial intelligence, digitalization, humans in sustainability transitions, resilience research, sustainability on the business and product level and sustainable energy and mobility transition (section 2.1). The change of the institute's name was also taken as an opportunity to revise the appearance of the annual report and align it more closely with the corporate identity of the University of Graz.

In 2022, a whole series of research projects has started, covering the fields of Circular Economy, Bioeconomy and Mobility. These are *Forest EcoValue – Supporting multiple forest ecosystem services through new circular/green/bio markets and value chains*, *FREE4LIB – Feasible recovery of critical raw materials through a new circular ecosystem for a Li-Ion Battery cross-value chain in Europe*, *CE-PASS – Circular Economy – Digital Product Passport*, *WEGBEREITER – MOPI-Lab “Aktive Mobilität und MaaS als Wegbereiter”*, *UniStrand – Structural timber construction material of the next generation*, *TransFair – Low-carbon transition in Austria: Exploring social, financial and ethical dimensions of ambitious climate policy* as well as *TRANSFLIGHT – Shaping the future of air travel*.

The institute is responsible for 885 bachelor students as well as 633 master students. 52 master theses were completed or submitted under the supervision of institute members during 2022. In addition to the Environmental Systems Sciences program – which form the core of the institute's teaching activities – the ESS coordinates the international Joint Master Programs in Sustainable Development (SD) and Circular Economy (CE) as well as the Global Studies. In 2022, 16 students from nine different countries started the SD program in Graz, three intakes of CIRCLE students met in Kamerik in the Netherlands and Global Studies celebrated “10 plus 2 years” in a fine event at the main auditorium.

We thank you for your interest in our work and wish you an informative read!

Contents

1	The Institute	3
1.1	Mission statement.....	3
1.2	Faculty and Staff members.....	4
1.3	“ESS Science Talk” and other events	13
2	Research Projects and Activities.....	14
2.1	Research profile	14
2.2	Research Projects.....	17
2.3	Research cooperation and networks	39
2.4	Ph.D. projects (ongoing).....	41
2.5	Ph.D. projects (completed or submitted)	60
3	Publications and other research output.....	66
3.1	Publications	67
3.2	Presentations	72
3.3	Media.....	78
3.4	Events	80
3.5	External Scientific Functions	81
3.6	Institute of Environmental Systems Sciences Reports	82
3.7	Prices and Awards.....	83
4	Teaching.....	84
4.1	Study Programs	84
4.2	Completed and submitted theses	89
4.3	Course list.....	94
4.4	Student statistics	98

1 The Institute

1.1 Mission statement

The Institute of Environmental Systems Sciences investigates possibilities for the transition towards a *more sustainable future*. Therefore, we study transition, innovation, and adaptation processes within socio-technical and socio-ecological systems at various levels. We base our research on systems sciences, innovation, and transition sciences as well as on sustainability science, and develop and apply *inter- and transdisciplinary* methods to analyze and model complex systems, establish scenarios and transition pathways, and assess policies and strategies.

The institute is characterized by the *disciplinary diversity* of its members. Highly motivated and excellent researchers originating from diverse fields of natural, social and formal sciences collaborate on real-world problems. We are highly committed to the promotion of young scientists and to research-led teaching in the study programs of Environmental Systems Sciences, the international Joint Master Programs in Sustainable Development and Circular Economy as well as Global Studies.

All members are actively engaged in national and international (stakeholder) networks, in terms of teaching, research, and practice. We interact with different stakeholders, policy makers, professionals and the general public, and initiate *mutual learning processes* and exchange of knowledge.



Institute staff (2023)

1.2 Faculty and Staff members

1.2.1 Professors



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Univ.-Prof. Dr. **Tobias Stern**

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1.2.2 Administration



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1.2.3 Research and Training Staff



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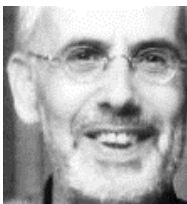
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1.3 “ESS Science Talk” and other events

For the “ESS Science Talk,” the institute is inviting external experts to give a presentation on core research topics (i.e., systems sciences, innovation, transition and sustainability research). These presentations are followed by a discussion and a small buffet. This event is held in English and open for the entire URBI Faculty, other interested colleagues and students and any friends of the institute.

Due to the Corona pandemic, only two talks could be held in 2022:

- “State-of-the-art and research gaps on the substitution impacts of wood use”, Dr. Elias Hurmekoski, 21 June 2022
- “Risk-adjusted decision-making for sustainable management of natural resources”, Dr. Elena Rovenskaya, 17 May 2022

Up-to-date information and the whole list of speakers can be found on our website at <https://ess.uni-graz.at/en/research/ess-science-talk/>.

In addition to these talks, the following events were organized by the Coordination Office for Environmental Systems Sciences (USW Koordinationsbüro):

- How to write a bachelor thesis
- Study Abroad
- USW application check
- USW specials
- Catch up Summer School
- Chat4Future
- Participation in the Open Day
- Masters Welcome
- Participation in the Sustainability Days
- Participation in the Welcome Week
- Time and self-management

Up-to-date information on events organized by the Coordination Office for Environmental Systems Sciences can be found at <http://umweltsystemwissenschaften.uni-graz.at/>.

2 Research Projects and Activities

2.1 Research profile

Three core research areas are combined in the Institute of Environmental Systems Sciences:

- systems research with a focus on methods development
- innovation- and transition research with a focus on innovation systems and diffusion
- sustainability research with a focus on sustainability management and assessment

These are the research areas and foci of our institute (in alphabetical order):

2.1.1 Bioeconomy – bio-based economy

The term bioeconomy refers to a prominent political-economic concept for sustainable development. Different understandings of the concept reach e.g. from the substitution of fossil resources by bio-based ones, the strengthening of bio-based sectors, the future role of life-science-based innovations to a radical reorientation of economies by considering to a radical reorientation of economies by considering the limited availability of natural resources (see Georgescu-Roegen). The adherent causes, dynamics and consequences of the increasing use of biomass and bio-based innovations are in the focus of the institute's research activities.

2.1.2 Circular Economy

Circular Economy (CE) is an emerging topic and highlights the importance of an intelligent design, manufacturing, distribution, use and end-of-life management of resources along the entire value chain of products and services. The European Commission's "Circular Economy Action Plan" underlines the relevance for CE and supports the "European Green Deal" with its ambitious targets for 2050, such as the decoupling of economic growth from resource use. Within the last years, CE has advanced to one of the institute's research and teaching foci, which is reflected in dealing with circular business models, or contributing to the development of methods and concepts for the collection of environmental and social data of certain products and services. One example for our teaching activities is the co-ordination of an international master's program on CE. The institute's CE research and teaching activities are not restricted to the industrial level, but involve those at the level of society at large, including co-operation with civil society.

2.1.3 Complex Networks and Multi-Agent Systems

Systems Science offers many methods that are well suited to simulate complex systems in the field of sustainability research and beyond. One focus of the institute is the development and application of agent-based models, i.e., models that start out from individual components and describe their interaction with each other and their environment. This way of modeling is not only successful when describing all kinds of human systems like opinion dynamics, the labor market, or mobility systems, but can also be used beyond that scope.

Complementary to this technique, network science is used to describe systems in which the links between the components are more important than the components themselves. Examples of such systems include traffic networks or social networks.

Additionally, the combination of different modeling methods is used to gain a more complete picture of the investigated systems.

2.1.4 Data Science & Artificial Intelligence

For most systems that are investigated by the institute, a large amount of data is required to gain a sufficient understanding. Therefore, Data Science is a focus for the Systems Sciences. This includes data collection via text mining as well as processing and interpretation using techniques like topic modeling or sentiment analysis. Additionally, the gathered data is integrated into existing or newly developed models.

Furthermore, other kinds of machine learning methods and techniques from artificial intelligence are employed and developed. This includes for example artificial neural networks that are used to solve various classification or regression problems. Such methods are not only used to process and interpret data, but can also enhance computer simulations or enable us to develop models that would not be possible without AI assistance.

2.1.5 Digitalization

Research on the possibilities and consequences of digitalization relates on the one hand to accessing and processing of data that can be used for, among others, gaining insights into regularities of environmental relevant human decisions and behaviors or into the specifics of certain business activities or production particularities. In other words, this branch deals with data and text mining. On the other hand, systems sciences are also concerned with the use, the research and the development of analysis methods that are currently discussed under the keyword machine learning. One focus here, for example, is on the model-based screening of large spaces of possibilities and the anticipation of sustainable options, summarized under the term Future State Maximization. Additionally, systems sciences are involved in the research network “Human Factor in Digital Transformation”, in which digital developments are tested and investigated in the context of their significance for the human sphere.

Digitalization also goes beyond data accessing and processing of data including emerging technologies and their societal implications.

2.1.6 Humans in sustainability transitions

Sustainable societies cannot be achieved through technological innovations alone. Transitions need to bring on board citizens, consumers, households and decision makers, and involve them beyond awareness raising or providing information about sustainability and climate change. We seek to understand the decision processes of citizens, consumers and organizations and aim to identify the necessary circumstances for sustainable living. We also investigate potentially adverse side-effects of transitions and factors related to acceptance and acceptability of sustainability transitions in different groups of society. This also includes a two-sided perspective including production and consumption patterns, but also the acting of citizens on all levels of their living.

2.1.7 Resilience research

Research on resilience predominantly relates to methods for analyzing and predicting phase transitions in complex dynamic systems, so-called critical transitions. One focus here is on computer-based modeling, which offers the possibility of mapping component interactions, i.e. the actual cause of the behavior of specific systems, in detail. Additionally, network representations are considered to analytically capture system relevant interactions. This allows, on the one hand, to test resilience by systematically perturbing certain parameters in computer-based system models. On the other hand, various statistical metrics, summarized under the term Early Warning Signals, are used to gain insights into the robustness and stability of a large number of different systems.

We also apply the idea of resilience and the respective research concepts on an applied level, trying to support organizations of all kinds in strengthening their ability to anticipate, withstand, cope with and even thrive in the face of challenges. In this context, resilience is an implicit part of many of our research projects.

2.1.8 Sustainability on the business and product level

The central interest in this research area is to support the diffusion and application of sustainable development by integrating it into the company activities, strategies, and products while highlighting the consequences of such integration. This implies that research is conducted on the operationalization of sustainable development at the corporate level (i.e., concepts and frameworks of corporate sustainability management), the motivation of companies to act in (more) sustainable ways, sustainability strategies and sustainable business models, sustainable innovation, sustainability assessment, sustainability design and inter-organizational management related to sustainable development.

2.1.9 Sustainable Energy and Mobility Transition

Both the energy sector and the closely related mobility sector are particular relevant fields for promoting sustainability and in particular for mitigating climate change. The shift from fossil fuel-based energy and transport systems to renewable energy sources and powertrains is urgently needed. However, in the context of the broader sustainability debate, the strong focus on promoting (supply-side) technological innovations has been criticized. Scholars have increasingly recognized the role of behavioral change on the demand side as a necessary component of the required sustainability and low-carbon solutions. Therefore, in our work we consider both perspectives and explicitly integrate the relevant aspect of behavior change by tackling different roles, such as consumers, citizens, policy makers, industry, etc. in close connection with the research field of “humans in sustainability transitions” outlined above. This includes both self-driven as well as policy-driven behavior changes, but also the public acceptance of relevant policy measures or low-carbon technologies as well as innovations in the context of energy and mobility.

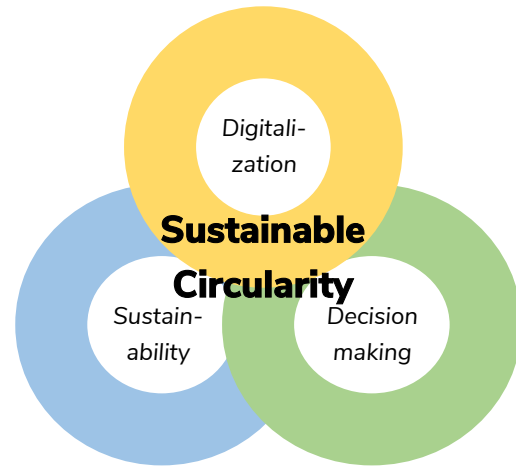
2.2 Research Projects

2.2.1 Christian Doppler Laboratory for Sustainable Product Management enabling a Circular Economy

Introduction

To support the ambitious Circular Economy Action Plan adopted by the European Union, this research laboratory acts as a creative space for developing and conducting research in Sustainable Product Management, the results of which will support the transition toward a Circular Economy.

This research laboratory aims to support companies with new and improved methods and frameworks to maximize the sustainability performance and circularity of their products and services. The research team conducts basic research in the fields of sustainability sciences and social sciences (interdisciplinary research approach) in order to



- operationalize the concepts of Sustainable Development and Circular Economy on the corporate and product level,
- to use the full potential of digitization for Sustainable Product Management, and
- to understand decision-making processes in companies and in supply networks as basis of a lifecycle-wide implementation of Sustainable Product Management.

As a result of the research work, methods and concepts are developed for the collection of environmental and social data on products and services from the supply chain, the use phase and the end-of-life phase. This data will be used for the social and ecological evaluation and design of products and services, as well as for further applications.

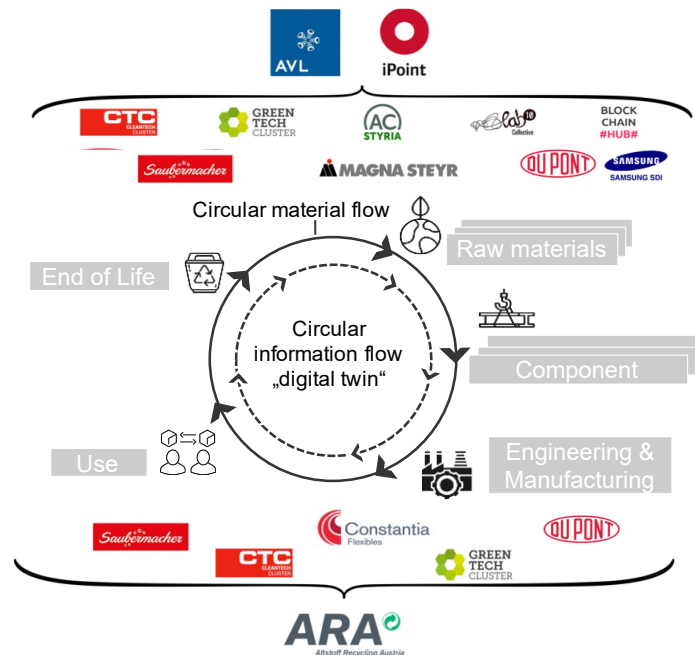
Unique project setting

In Christian-Doppler-Laboratories, application-oriented basic research is pursued at a high level and scientists cooperate with innovative companies. The Christian-Doppler Research Association is an international best practice example for promoting this collaboration. Christian Doppler Laboratories are financed jointly by the public purse and the participating companies. The most important public sponsor is the Federal Ministry of Digital and Economic Affairs.

Use cases

The research in the CD-Laboratory can be distinguished into two overarching use cases. The first, automotive-oriented use case with AVL and iPoint, focuses on the question: "How can sustainable circular economy practices be realized along a full value chain?" and for the second, packaging-oriented use case the following questions are of interest: How can companies such as the ARA AG use the methods and tools developed in this CD-Laboratory

to – (1) assess how sustainable and circular existing packaging solutions are – (2) to optimize packaging solutions from the viewpoint of sustainability and circularity?



Graphical presentation of the two use cases and the involved industry partners (top = automotive, bottom = packaging)

Ongoing research activities

The current research activities focus on (1) the development of a decision-support approach for the early stages of heavy-duty powertrain development that allows the determination of sustainability-related optimal designs in the context of varying use cases, (2) the conceptualization of a digital product passport for vehicle traction batteries, (3) the utilization of probabilistic machine learning for the protection of confidential information in sustainability assessment and product passports, (4) the assessment of the effect of inter-organizational collaboration and digital technologies on circular economy and firm performance, as well as (5) the experimental investigation of the influence of environmental and social information on corporate decision-making.

Recent publications

The recently produced research output concerned itself, for example, with prioritizing resources and capabilities for the transition to circular plastics packaging value chains ([Link](#)), exploring connections between sustainability and the circular economy based on the analysis of 3822 journal articles ([Link](#)), the analysis of circular economy practices, strategies, and their effect on sustainability and firm performance in Austrian manufacturing firms based in 120 interviews ([Link](#)), or the identification of circular economy enablers and barriers and sectoral differences based on interviews and the analysis 131 circular economy business examples ([Link](#)). Furthermore, in the area of digitalization, a concept of a digital product passport for electric vehicle traction batteries was developed ([Link](#)), stakeholders' data availabilities and requirements for such a passport were systematically assessed ([Link](#)), the potential of different digital technologies (IoT, AI, big data, blockchain) for supporting corporate

sustainability management was estimated ([Link](#)), and the degree of implementation of these digital technologies in Austrian manufacturing firms was investigated ([Link](#)).



Bundesministerium
Digitalisierung und
Wirtschaftsstandort



Head of the Laboratory

Prof. Dr. Rupert J. Baumgartner

Project team 2022

Magdalena Rusch, BA MSc,
Katharina Berger, BSc, MSc,
Katharina Roche, MSc,
Moritz Kettele, BSc, BSc, MSc,
Lukas Stumpf, BA, MSc,
Severin Lüps, MSc,
Julius Ott, MSc,
Josef-Peter Schöggel, PhD,
Tanja Untergrabner

Duration

2018 – 2025

Website

<https://circular.uni-graz.at/en/>

Project partners and funding

Austrian Federal Ministry for Digital and Economic Affairs, National Foundation for Research, Technology and Development Christian Doppler Research Association, iPoint-systems GmbH, AVL List GmbH, ARA AG

2.2.2 ELANET

The European Latin American Network in Support of Social Entrepreneurs (ELANET) has the ambition to become a leading platform in support of social entrepreneurs (SEs). This project will lead partner universities to implement an IT-based platform that consolidates already existing tools, resources, and coaching material for SEs. Our consortium involves 17 project partners (among which 4 European Universities and 12 Latin American Universities) and 35 associated partners. Through ELANET, partners institutions will seek to develop exchange best practices for the support of SEs and stimulate the internationalization of SEs, and their solutions to social challenges. The project is for 3 years (2021-2023) and is funded by the Erasmus + Capacity Building Program. University of Graz is playing an advisory role in the project.

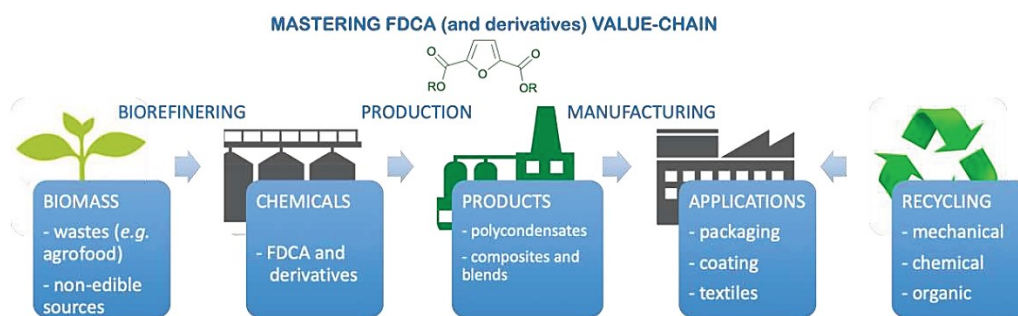
Project team	Prof. Dr. Rupert J. Baumgartner Dipl.-Ing. Dr. Ralf Aschemann Arijit Paul, PhD
Project Partners	Vrije Universiteit Brussel (Belgium), Ashoka BelgiumKoalect (Belgium) University of National and World Economy (Bulgaria), LIBERA Universita Maria Ss. Assunata (Italy), Universidad Catolica Boliviana San Pablo (Bolivia), Universidad Mayor de San Simón (Bolivia), Colegio De Estudios Superiores De Administración (Colombia), Universidad de La Sabana (Colombia), Fundación Universidad del Norte (Colombia), Technological University of Bolívar (Colombia), Universidad del Magdalena (Colombia), Escuela Superior Politécnica del Litoral (Ecuador), Universidad de Cuenca (Ecuador) Universidad de Piura (Peru), Universidad Continental (Peru)
Duration	15/01/2021 – 14/01/2024
Funding	European Commission's grant under Erasmus+ capacity building in the field of higher education agreement number 617788-EPP-1- 2020-1-BE-EPPKA2-CBHE-JP

2.2.3 European network of FURan based chemicals and materials FOR a Sustainable development (FUR4Sustain) CA18220



The main goal of this COST Action is the international linking of research activities in relation to 2,5-furanedicarboxylic acid and its derivatives. Innovation at the current level of research and development is to be promoted in order to overcome scientific, technological and industrial barriers that hinder the widespread use of new FDCA products. To achieve this goal, FDCA synthesis, polymers, development and characterization of polymer materials as well as the most important technical, economic, ecological and social factors are considered together. In addition, the COST Action supports the exchange of cross-sector knowledge through dissemination and networking tools. The aim is to create an open platform for cooperation and a common vision in relation to research, qualification of human resources and industrial implementation.

The University of Graz is involved in Working Group 3 (WG 3) and also provides the working group leader.



Concept of the FDCA value chain

WG 3 aims at contributing to the Cost Action by identifying the main economic obstacles, market demands, supply chain challenges, environmental hotspots as well as legislative restrictions that need to be addressed. This requires a holistic approach that includes the consideration of the entire value chain from resource to end-of-life.

Project Team	Univ.-Prof. Dr. Tobias Stern Julia Wenger, MSc. Verena Haas, BSc.
Lead Institution	University of Aveiro
Partners	Universities and Companies from Austria, Czech Republic, Germany, Italy, Netherlands, Serbia, Sweden, Belgium, Denmark, Greece, Latvia, Poland, Slovakia, Switzerland, Bulgaria, Finland, Iceland, Luxembourg, Portugal, Slovenia, United Kingdom, Cyprus, France, Ireland, Malta, Romania, Spain
Duration	November 2019 – November 2023
Funding	European Cooperation in Science and Technology (COST) supported by Horizon 2020 Framework Program of the European Union

2.2.4 Forest EcoValue – Supporting multiple forest ecosystem services through new circular/green/bio markets and value chains

Forests play a key role for climate change mitigation and resilience in the Alpine region, offering multiple ecosystem services, environmental social benefits, like CO₂ absorption, air pollution reduction, increase of biodiversity, resilience to natural risks and many others. Alpine forests are threatened by abandonment, climate change and territorial degradation that progressively lead to a pauperization of natural resources and to a decrease in the provision of forest ecosystem services (FES). As a result, forests maintenance costs are high and economic sustainability for the public and private owners is unsatisfactory: public funds and the revenues generated by the traditional wood value chains are no longer sufficient and the attraction of additional resources becomes an evident need. Along these lines, the definition of economic valuation methods and the development of payment schemes to be applied to FES-schemes are widely debated, but only occasionally successfully applied.

The Forest EcoValue project is based on the acknowledgment that restoring and maintaining healthy forests can generate a value for the benefit of the whole Alpine region, as well as green businesses and sustainable job opportunities for the alpine communities. The Forest EcoValue project intends to tackle this challenge and turn it into an opportunity, by developing innovative sustainable win-win business models for forest management and maintenance, based on new value chains, and involving different sectors (energy, construction, chemistry/pharma, food, recreation etc.), public and private actors, as well as citizens. The project will propose new frameworks for public-private markets and payment schemes, maximizing the value of FES towards the regional value chains. The proposed solutions will be tested in a pilot action consisting of a network of five Living Labs (In Austria, France, Italy, Slovenia and Switzerland).

The Institute of Environmental Systems Sciences is responsible for the economic assessment of FES in the Alpine region. As a result, conditions for efficiently developing FES markets and business model archetypes will be elaborated. In this way, payment schemes for public and private players will be identified. In addition, policy/governance enabling factors will be further addressed. Subsequently, the proposed economic approach will be tested in the Living Labs, and lessons will be drawn and exchanged in the interregional network. As the last step, a national/regional capacity building workshop and Alpine Region Summer School on FES Markets will be organized in order to foster capacity development and knowledge transfer between target groups at different territorial level.

Project team	Univ.-Prof. Dr. Tobias Stern Raphael Asada, PhD Mag. Annechien Dirkje Hoeben, MSc. Viktoriiia Iavorskaia, BA
Lead Institution	Finpiemonte SpA
Partners	Finpiemonte SpA – Regional financial and development agency, FLA – Lombardy Foundation for the Environment, Lombardy Green Chemistry Association, Biobase – Austrian innovation platform for bio- economy and circular economy, University of Graz, Slovenia Forest Service, Ifuplan – Institute for Environmental Planning and Spatial Development GmbH & Co. KG, INRAE National Research Institute for Agriculture, Food and the Environment, Regional Centre for Forest Property Auvergne-Rhône-Alpes, Forests National Office
Duration	October 1st, 2022 – September 30, 2025
Funding	Interreg Alpine Space, co-funded by European Union

2.2.5 FREE4LIB – Feasible recovery of critical raw materials through a new circular ecosystem for a Li-Ion Battery cross-value chain in Europe

Since 2022 the Institute of Environmental Systems Sciences at the University of Graz is part of the Horizon Europe project FREE4LIB (Feasible Recovery of critical raw materials through a new circular Ecosystem FOR a Li-Ion Battery cross-value chain in Europe). FREE4LIB aims to

develop at TRL 5-6 technologies to achieve 6 new sustainable and efficient processes to recycle end-of-life (EOL) LIBs (dismantling, pre-treatment and 4 materials recovery processes) delivering very innovative recycling solutions to reach highly efficient materials recovery (metal oxides, metals and polymers) improving the supply of secondary resources at EU level. FREE4LIB also will deliver technologies to improve 3 processes aiming at metals and polymers re-using and electrode synthesis on the same value chain as secondary raw materials for re-manufacturing greener batteries, and it will study options to harness non-reusable elements in other fields. FREE4LIB will also deliver a methodology based on the Battery Passport principles to improve processes traceability.

FREE4LIB



Project Team	Univ.-Prof. Dr. Rupert Baumgartner Josef-Peter Schögl (PhD) Julius Ott Martina Zimek
Duration	September 2022 – August 2026
Funding	European Commission

2.2.6 RESONATE: Resilient forest value chains – enhancing resilience through natural and socio-economic responses

Climate change poses a growing threat to European forests as evidenced by the increasing frequency and severity of heat waves, extended periods of drought, storms and other natural disturbances over an increasingly larger scale. As a result, forest ecosystem dynamics, ecological resilience and tree species suitability are altered at minimum and likely deteriorated. As climate change continues, forest management has to cope with short-term and likely long-term impacts on the stability and the capacity to deliver ecosystem services. As a result, it is necessary to increase knowledge on how value chain resilience interlinks with the natural resilience of ecosystems and how this feeds back into operational guidance towards enhancing resilience in European forests and their associated forest-based value chains.

The RESONATE project aims to generate such needed knowledge and practices for making European forests, the services they provide, and related economic activities more resilient to future climate change and disturbances. Hereby, the H2020-project aims to guide decision-making towards enhancing resilience of forests and forest value chains in response to four resilience challenges: First, changing suitability of tree species due to climate change; Second, increased risks of forest disturbances; third, changing societal demand on forest products and ecosystem services; and fourth, biodiversity decline.

The Institute of Environmental Systems Sciences is responsible for assessing the current resilience of European forest-based value chains to short-term and immediate stressors (e.g., disturbances) and more gradual effects over a longer term (e.g., climate change). More precisely, the stability of different value chains in terms of product output volumes and service

provisioning will be investigated, after which factors will be derived that have a positive effect on value chain resilience. Taken together these factors will form the basis of a framework for achieving resilient forest-based value chains. As a last step, the framework will be evaluated by forest sector decision makers and stakeholders.

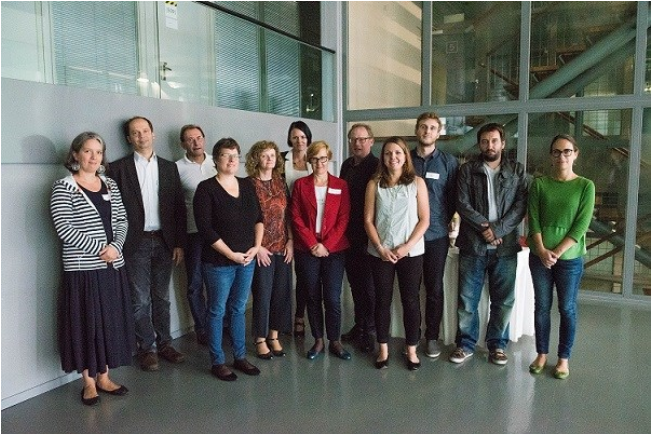
Project team	Univ.-Prof. Dr. Tobias Stern Raphael Asada, PhD Annechien Dirkje Hoeben, MSc.
Lead Institution	European Forest Institute (EFI)
Project partners	University of Vigo, Galician Forestry Industry Agency, Papierholz Austria GmbH, University of Natural Resources and Life Sciences (BOKU), Czech University of Life Sciences Prague, Prospex Institute, University of Helsinki, University of Copenhagen, Wageningen Environmental Research, Technical University of Munich, Albert Ludwig University of Freiburg, National Resource Institute Finland, Bournemouth University, Croatian Forest Research Institute, Ecological and Forestry Applications Research Centre, French National Research Institute for Agriculture, Food and the Environment, Agriculture and Food Development Authority Ireland, Innova Wood, Forestry Commission.
Duration	April 2021 – March 2025
Funding	Horizon 2020
Website	https://resonateforest.org

2.2.7 START CIRCLES – Supporting Transition from Linear to Circular Value Chains



The project objective is to increase sustainable innovation and resource efficiency in the program area, especially for SMEs. START CIRCLES is designed to enable SMEs better access to information, activities, as well as innovation partners in order to strengthen and support their cooperation with RTD partners.

The main project outcome is to integrate SMEs in cross-border innovation networks sustainably and circular economy oriented value chains to increase innovation and develop new products / materials. START CIRCLES has been developed from the perspective and needs of SMEs and RTD organizations. The project will monitor SMEs from innovation initiation to the launch of the new products while delivering new and sustainable support services for each phase.



The following approaches in the project are new/innovative:

- documentation and utilization of RTD skills for the circular economy
- establishment of new cooperation models, especially regarding reuse-oriented value chains (training of mediators / facilitators)
- supporting SME in RTD networks
- support the launch of new products by developing new business models
- deliver a policy recommendation on a new theme: business models in the circular economy.

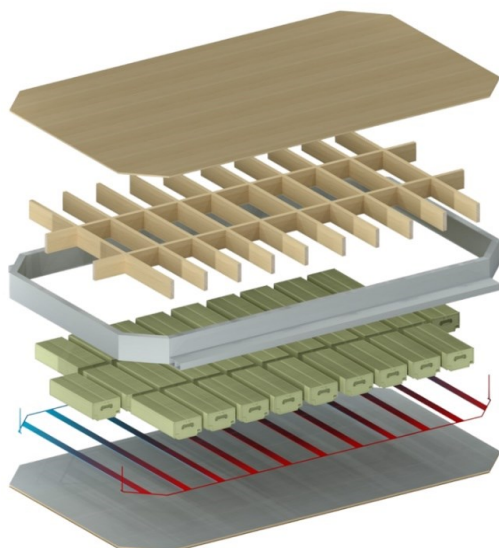


Project team	Univ.-Prof. Dr. Tobias Stern Assoc. Prof. Dr. Romana Rauter Daniel Holzer, MA
Project partners	Chamber of Commerce and Industry of Slovenia (Lead Partner), Wood Carinthian Competence Center, Limnos Ltd., asteenergy Ingenieurbüro, Faculty of Polymer Technology, University of Graz, Forschung Burgenland GmbH
Duration	September 2018 – March 2022
Website	http://www.si-at.eu/en2/start-circles/

2.2.8 Biolib – Biobased Multifunctional Laminates in Battery housings



The long-range batteries of modern electric vehicles offer ever-increasing capacities while occupying the whole underfloor space between back axle and subframe. Correspondingly, the battery has a significant impact on weight, volume and costs of an electric vehicle. To optimize



the weight of the vehicle, the battery and its compartment are not only being used as a supporting structure but also to function as a thermo management system, to prevent catastrophic battery failure, to protect the battery from vibrations & impact and to increase the durability and failure safety. Current battery compartments are manufactured from steel and aluminum which may not be as sustainable as wooden based alternatives. Besides a potentially lower environmental footprint the choice of material also needs to account for the safety of the occupants, weight and economic viability. Wood may be a very promising alternative

as it has favorable characteristics such as a low thermal conductivity, high specific strength, comparatively low material cost and a lower environmental footprint.

The project aims to develop a demonstrator of a segment manufactured from a steel-wood hybrid and verify its properties regarding thermo-management, vehicle safety and sustainability. To achieve this, the research focus lies on connection technology between wood and steel, wood modification to enhance certain properties of wood, the behavior of the hybrid material in case of fire, its environmental footprint and potential socioeconomic consequences of the broad utilization of wood in the modern automotive sector. The Institute of Environmental Systems Sciences will assess the environmental impact by conducting a Life Cycle Assessment (LCA) of the defined application case. To investigate potential socioeconomic consequences an Input-Output analysis will be performed.



Project team	Univ.-Prof. Dr. Tobias Stern Claudia Mair-Bauernfeind, PhD DI Paul Krassnitzer
Lead institution	Graz University of Technology (VSI)
Company partners	FILL, Weitzer Wood Solutions, nolax, business upper Austria
Scientific Partners	University of Natural Resources and Life Science, University of Graz (ESS), Graz University of Technology (VSI), Innovationszentrum W.E.I.Z
Duration	April 2021 – March 2024
Funding	FFG

2.2.9 CE-PASS – Circular Economy – Digital Product Passport



CE-PASS is an industrial research project focusing on the issue of sustainability-aware automotive design for the circular economy. It contributes to the twin transition to a digital and sustainable economy, in line with the European Green Deal. The project goal is to evaluate the feasibility of digital product passports to improve the sustainability and circularity of automotive products and to facilitate the information flow from end-of-life actors to beginning of life actors to increase refurbishing and recycling possibilities and the shares of secondary materials.

The University of Graz has the lead of work package 2, stakeholder and use case requirements analysis, which focuses on the identification and definition of data requirements in the automotive supply chain as the basis for the development of a digital product passport, and work package 3, Sustainability, CE and Lifecycle Assessment, which deals with the

development of a data-driven design for sustainability and circularity approach and aims at the integration of data from digital product passports into LCA and circularity assessment.

Project team	Prof. Dr. Rupert Baumgartner Josef-Peter Schöggel, PhD Antonia Pohlmann, MSc Martin Popowicz, MSc
Project partners	Salzburg Research Forschungsgesellschaft m.b.H, iPoint-Austria GmbH, AVL List GmbH
Duration	January 2022 – December 2024
Funding	FFG, IKT der Zukunft – 9. Ausschreibung (2020)

2.2.10 GEL ODP – Green Energy Lab Open Data Platform

The transition from a fossil fuel-based, unidirectional to a renewable, decentralized energy system requires the widespread adaptation of new technological innovations. Novel technologies require information exchange and data transfer among different stakeholders and may lack individuals' acceptance. Moreover, the implementation of technical innovations may foster end users' behavior change. Distribution System Operators typically have very little information about the load flows in their grids, and end users and energy suppliers could benefit from a better knowledge of disaggregated consumption profiles.

The main goal of the OpenData project is the development and implementation of an Open Data Platform (ODP) for the energy sector to provide an easy access and overview of relevant data and interdependencies of a current and future integrated energy system for different stakeholders, such as end-users, system operators, start-ups, or policymakers.



The ODP aims to provide all end users insight into their energy consumption or efficiency data, allowing a comparison with similar end-users (such as households), and tailor-made recommendations for energy relevant measures. This shall increase the understanding and acceptance among end-users.

Therefore, disaggregated end-user data will be processed to identify most electricity consuming appliances and consumption patterns. This enables a better understanding of electricity cost and system impacts. Based on consumption patterns, predictive models will be developed providing a better understanding of load flows and enabling the identification of flexibility options in the energy system. In addition, data-driven persuasive strategies are envisaged for the ODP, helping to change the behavior and underlying attitudes of participants. User participation is critical for the widespread deployment of technological innovations. Hence, models of participation are developed for respective stakeholder groups, aiming to increase the rate of adoption.

The intended effect is decentralized demand-side management by incentivizing the consumer to participate in the energy system actively and provide flexibility. The GEL ODP will be integrated into the overall Green Energy Lab coordination to ensure the open data approach and monitoring key performance indicators of the Green Energy Lab.

The project is supported with the funds from the Climate and Energy Fund and implemented in the framework of the RTI-initiative “Flagship region Energy.” For detailed information, see also: <https://www.greenenergylab.at/projekt/open-data-platform/>.



VORZEIGEREGION
ENERGIE



Project team	Univ.-Prof. Dr. Alfred Posch Univ.-Prof. Dipl.-Ing. Dr. Tobias Stern Eva Fleiß, MA PhD Mag. Stefanie Hatzl, PhD
Project partners	TU Vienna, University of Applied Sciences Burgenland, EVN AG, AIT Austrian Institute of Technology, AEE – Institute for Sustainable Technologies, twingz development GmbH, ms.GIS Informationssysteme GesmbH
Duration	November 2018 – April 2022
Funding	2nd Call – Energy Model Region (FFG)

2.2.11 Innovationscamp “BIG Bio” (Zirkuläre Bioökonomie Intelligent Gestalten. Biogene Innovation mit nachhaltiger Orientierung)



BIG Bio’s goal is to empower sustainable biobased innovations (e.g. products, processes, business models) through the transfer of competencies, assessment of potential consequences, and integration into development. This is achieved through training courses guided by research institutions and implemented through specific case studies provided by corporate partners. These case studies will examine topics such as the assessment of new or modified recycling processes, comparison of innovative biobased product systems with non-biobased substitutes, and modeling of business-related carbon flows and their changes.

The acquired competencies will be implemented directly by production-oriented corporate partners and further conveyed by service sector partners to advise other companies. The documents and experiences generated through the project, including feedback from companies, will result in the development of further education opportunities on sustainability-driven innovation.

Structure of the modules and selected topics are:

- Mission and Vision: Basic introduction to fundamental contents, concepts & topic-specific deepening
- Eco-Design Paradox: Introduction to methods of sustainability assessment to counter the Eco-Design Paradox
- Sustainability modelling: multi-criteria (ecological, economic, social) sustainability assessment of innovations
- Technology impacts: Consequences and impacts of the use (conflicts) of biomass

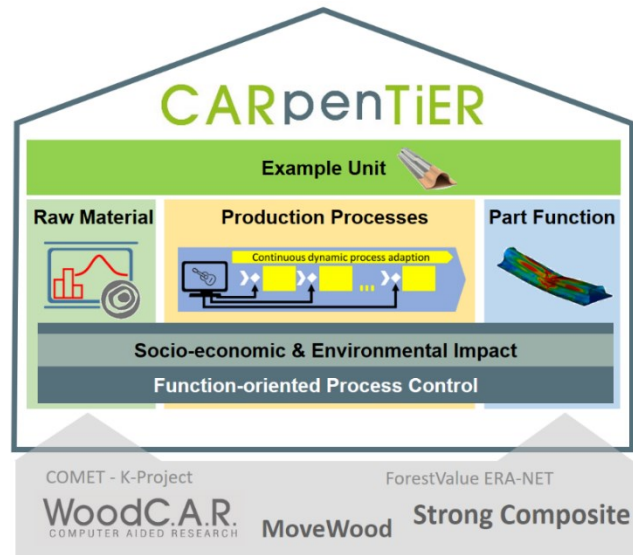


Project team	Univ.-Prof. Dr. Tobias Stern Daniel Holzer, BA MA
Lead Institution	University of Graz (EES)
Scientific Partners	FH Kufstein, Innovationszentrum W.E.I.Z, Institut für Industrielle Ökologie, Kompetenzzentrum Holz – Wood Kplus,
Company partners	Holzcluster Steiermark GmbH, IPJ Ingenieurbüro P. Jung GmbH, Kobzina Consulting, Lean MC, PROJEKTkompetenz.eu, STRATECO OG, Team 7 Natürlich Wohnen GmbH, Vinzenz Harrer GmbH, Weitzer Wood Solutions GmbH,
Duration	November 2022 – October 2024
Funding	FFG, Innovationscamp M

2.2.12 Modelling, Production and further Processing of Eco-Hybrid Structures and Materials – CARpenTiER

The aim of CARpenTiER is the development of production technologies for wood-based hybrid constructions in automotive, systems and mechanical engineering. Applications include hybrid structures made of laminated wood, plywood or strand materials, which can be reinforced with natural fibers. In previous research activities of the consortium, various demonstrators for the mobility sector in multi-material mixed construction have been successfully developed. The results show that 10 to 40% of the dead weight can be saved by using wood-based materials without losing performance. In future this can make a positive contribution to climate goals, as weight reduction has the highest impact on avoiding greenhouse gas emissions.

Although former research work has laid a solid basis in finite element modelling, there is a lack of suitable production technologies for industrial implementation. For this reason, the continuing research program will focus primarily on process development and process control. Both, process and component are represented as digital twins (i.e. digital reproduction of product and process).



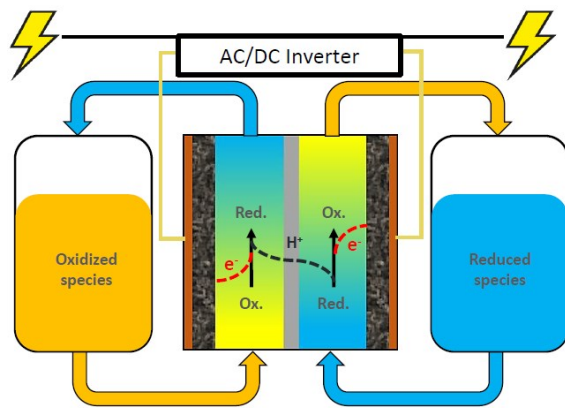
The Institute of Environmental Systems Sciences is looking into sustainability requirements within the project. Designing and developing processes dealing with material variability as well as the potential effects, thresholds and constraints in regards to resource availability, recycling technologies, rejection rates or process design decisions is complex and needs to be simulated in a dynamic model to solve the various (and sometimes contradictory) requirements. The model also allows to support the technical R&D by providing continuous information on thresholds, changes and impacts along the life cycle of the wood-based hybrids.



Project team	Univ.-Prof. Dr. Tobias Stern Claudia Mair-Bauernfeind PhD Theresa Boiger MSc
Lead Institution	Innovationszentrum W.E.I.Z
Company Partners	AC-Styria, IB Steiner, DYNAMore, FHP, FILL, Glanzstoff, HC-Styria, Klumpp, Lean MC, VW, Weitzer Woodsolutions
Scientific Partners	University of Natural Resources and Life Science, University of Graz (ESS), Graz University of Technology (IMAT), Virtual Vehicle (Vif), Innovationszentrum W.E.I.Z
Duration	May 2021 – May 2025
Funding	FFG, COMET-Projects
Website	Further information: http://www.carpentier.at/project.html

2.2.13 SABATLE – Safety assessment of flow battery electrolytes

Redox flow batteries are an emerging technology for medium and large-scale stationary energy storage and are considered as a viable option to buffer fluctuations in the energy grid. These fluctuations are caused by the increasing share of renewable energy (e.g. solar and wind energy) whose production is dependent on weather and seasonal conditions.



The core elements of a redox flow battery (RFB) are two tanks filled with the electrolytes. Currently used electrolytes feature several issues such as limited regional availability, stability, volatile price, lack of sustainability and – often neglected – significant toxicity. In SABATLE, we aim at investigating the safety and (nano)toxicity aspects of current and emerging electrolytes in redox flow batteries as well as the corresponding environmental

impacts by performing a life cycle assessment of the whole life cycle from resource extraction to the end-of-life. We will investigate electrolytes from the following commercially available RFB technologies: vanadium, zinc-bromine/chlorine, iron, and compare them to emerging electrolytes based on organic compounds derived from lignins, so called quinones, currently being developed at one of the partners. The lignins as well as decomposition products of the electrolytes may contain also nanoparticles which may pose an additional risk for the environment. Human toxicity and ecotoxicity of electrolyte solutions will be assessed using algae, daphnia, and zebrafish biological models. Exposure scenarios upon accidents during operation of the battery and after end-of-life will be considered, and realistic doses for human exposure and ecotoxicity will be developed. Further, high impact will be generated by developing a tailored safe-and-sustainable-by-design (SaSbD) concept. Through the implementation of this concept a mitigation of potential hazards will be secured and more sustainable and inherently safe electrolytes will be provided. Public concerns, including risk assessment and stakeholder engagement will be covered in the project.



Project team	Univ.-Prof. Dr. Tobias Stern, Claudia Mair-Bauernfeind PhD, Julia Wenger M.Sc. MSc
Lead institution	Graz University of Technology, Institute of Bioproducts and Paper Technology
Company partners	Mondi AG, Biobide
Scientific Partners	BioNanoNet Forschungsgesellschaft;
Duration	January 2021 – March 2023
Funding	FFG

2.2.14 WEGBEREITER – MOPI-Lab “Aktive Mobilität und MaaS als Wegbereiter”

Most of the passenger transport takes place in suburban and rural areas. Especially there, motorized individual transport continues to dominate, as attractive alternatives are often lacking. For a successful implementation of the climate and sustainability goals, it is therefore indispensable to understand people’s realities of life outside of large cities and to find targeted mobility solutions adapted to the respective region. This involves measures to shift and avoid private transport through targeted spatial planning and the strengthening of intermodal mobility offers, consisting of active mobility (cycling and walking), innovative and flexible Mobility-as-a-Service (MaaS) offers and public transport. In addition to incentives and offers, such a package of measures will also have to include restrictions in order to mitigate the dominance of private transport and create equal opportunities for other modes of transport.

The exploratory project WEGBEREITER will evaluate the potential and necessary first steps for the creation of a Mobility Policy Innovation Lab (MOPI-Lab) in the Weiz-Gleisdorf region, including the surrounding municipalities and the transport corridor to Graz. The region of Weiz-Gleisdorf with the small towns of Gleisdorf and Weiz, surrounded by rural settlement areas and close to the provincial capital, is a particularly interesting case, as on the one hand initiatives towards soft mobility already exist and innovative concepts are being implemented, but on the other hand the private car still dominates by far.

Project team	Univ.-Prof. Dr. Alfred Posch Thaller Annina, BSc, MSc, PhD Eva Fleiß, MA PhD; Simone Schreiegg, BSc MSc
Project partners	Wegener Center for Climate and Global Change (Raphaela Maier, BSc MSc, Mag. Doris Wiederwald, Dr.rer.nat Holger Hoff); University of Technology Graz (Dipl.-Ing. Dr.rer.nat.,Eva Schwab, Dipl.-Ing. Johannes Bernsteiner)
Lead Institution	University of Graz, Institute of Environmental Systems Sciences
Duration	September 2022 – September 2023
Funding	FFG, Mobilität der Zukunft, 18.Ausschreibung

2.2.15 UniStrand – Structural timber construction material of the next generation

Short description: In recent years, timber construction has been able to prove its suitability for multi-story construction through various lighthouse projects (e.g. HoHo, LCT ONE, etc.). The use of wood in the construction sector is not only supported by the substitution of energy-intensive raw materials with simultaneous carbon storage, but also by the need to satisfy the enormous additional demand for building materials. A significant increase in the utilization of the resources used is just as essential as an efficient design and dimensioning of the components. Currently successful timber construction products such as cross-laminated timber are mainly based on sawn softwood and have a low raw material yield (30-40%) due

to the process. With the project “UniStrand” the technological and constructive foundations for a (approx. 7-20cm) thick, panel-shaped timber construction material for multi-story, structural construction applications are to be sketched and researched. The starting material is long, thin wood particles (strands), which can be produced with a high raw material yield (over 75%). The main raw material is to be hardwood assortments or a combination of softwood and hardwood. By bonding as unidirectionally as possible to beach plates of different densities, a predictable intermediate product with improved mechanical properties compared to already established beach-based products (OSB, LSL) is to be created. By crosswise layer bonding of the panels, the required “barrier” effect and material thickness of the layered wall and ceiling elements is finally achieved. On the basis of the constructive optimization of the finished elements, coupled with an application-oriented cutting optimization, targeted elements can be produced that use high-performance panel material only where this is statically necessary. The results are evaluated in parallel by a process-oriented oil balance or by a technology assessment. The foundations created form the basis for large-scale industrial implementation and pave the way for a resource-efficient wood-based construction material of the next generation.

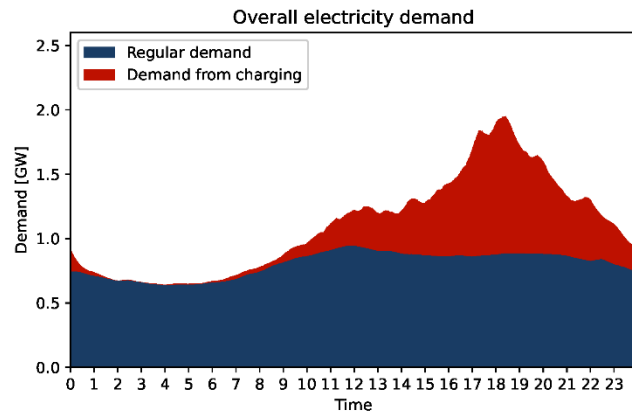
Project team	Univ.-Prof. Dr. Tobias Stern, Claudia Mair-Bauernfeind PhD, Julia Wenger M.Sc. MSc
Lead institution	University of Natural Resources and Life Sciences (BOKU), Institute of Wood Technology and Renewable Materials
Company partners	Dynea AS; Wirtschaftskammer Österreich Fachverband der Holzindustrie Österreichs; Hasslacher Holding GmbH; Holzcluster Steiermark GmbH; Huntsman Europe BV; Kaindl Flooring GmbH; Metadynea Austria GmbH; Österreichische Bundesforste AG; RWT plus ZT GmbH
Scientific partners	University of Graz; Kompetenzzentrum Holz GmbH
Duration	December 2022 – November 2025
Funding	FFG

2.2.16 Charging Rushhour



The targeted decarbonization of passenger transport by 2040 will only be possible by operating passenger cars exclusively via electric motors in the future. This will not only lead to a drastically increased demand for electricity but will also create unprecedented demand peaks when many cars are being charged at the same time during rush hours. The Charging Rushhour project uses an agent-based computer model to explore the extent of this problem, in which regions and at what times, and what counterstrategies are useful. In particular, the situation of at-risk regions in Styria is investigated.

Although it is not yet completely clear how the path to sustainable mobility will look like, we already know a lot about the goal to be achieved by 2040. One of the most important points here is the expansion of e-mobility. The declared goal of decarbonizing passenger transport can only be achieved when almost every passenger car is powered by an electric motor. This poses many new challenges for administration, companies, and individuals. The increased demand for electric power is one of these challenges. On the one hand, it must be ensured that this demand can be met from sustainable sources, and on the other hand, our energy network must be able to work with the demand peaks that will arise.



The aim of Charging Rushhour was to estimate the risk of such an overload. We investigated different regions, and found that urban, suburban and rural areas are similarly affected. Simulations of possible counterstrategies revealed, that small policy changes are not enough to deal with this problem. Disruptive changes to our mobility system are needed.



Project team	Ass.-Prof. Dr. Georg Jäger Lisa Göberndorfer, BSc Milica Savanovic
Duration	November 2021 – October 2022
Funding	Land Steiermark (Province of Styria)

2.2.17 TransFair – Low-carbon transition in Austria: Exploring social, financial and ethical dimensions of ambitious climate policy

ACRP Project Nr. KR20AC0K18211

Ambitious climate change mitigation policies will require substantial cuts in greenhouse gas emissions. If taken seriously, these policies will radically transform energy systems, economic circumstances and eventually impact social systems. Although the overall long-term impacts of such policies are expected to be positive, there will also be adverse effects (particularly in the short term), and it is likely that neither the benefits nor the costs will be distributed equitably. The implementation of ambitious climate policies is thus inherently linked with issues of social fairness and equity, and requires strategies that allow for dealing with vulnerable groups and potentially adverse impacts.

The key objectives of this project are to explore the structure of adverse social effects of ambitious climate policy in Austria and to develop strategies to mitigate them. The project moves beyond traditional financial considerations and explicitly considers non-financial impacts. We will analyze currently planned and discussed climate policies, identify vulnerable groups, and examine the adverse effects that these groups potentially face by means of methods from economics, social sciences and philosophy (discourse analysis, CGE modeling, Q-sorting, discrete choice experiments, normative assessments).

The added value of the project is that it does not merely focus on economic and financial effects. It explicitly considers the non-financial impacts, social perceptions and citizen preferences related to the selection of policies, complemented by normative assessments regarding the legitimacy of citizen's expectations. Thereby, the project will also shed light on strategies and response mechanisms that go beyond standard measures of financial compensation such as compensation payments, tax exemptions or increased commuting allowances, and include non-financial measures as well.



Project team	Thomas Brudermann (ESS / Project lead) Michael Kriechbaum (ESS) Katharina Trimmel (ESS) Tobias Stern (ESS) Birgit Bednar-Friedl (Wegener Center) Stefan Naberneegg (Wegener Center) Teresa Lackner (Wegener Center) Lukas Meyer (Institute for Philosophy) Rutger Lazou (Institute for Philosophy)
Duration	January 2022 – June 2024
Funding	Austrian Climate Research Program

2.2.18 TRANSFLIGHT – Shaping the future of air travel

All sectors and areas of life must reduce greenhouse gas emissions in order to achieve climate targets. The area of mobility is facing especially great challenges due to rising emission figures. In the case of air travel in particular, so-called “carbon lock-in”, i.e. a situation in which it is difficult to break out of emission-intensive systems, in conjunction with increasing globalization and networking, is leading to a steadily rising demand for air travel around the world.

While air travel has in principle become indispensable for leisure, corporate, or academic research, the COVID-19 pandemic has drastically changed this situation. Travel restrictions to limit the risk of infection have brought global air travel to a standstill, and trips have been canceled, postponed, conducted using other transportation methods, or replaced with digital solutions.

Against this backdrop, the TRANSLIGHT project tackles air travel from a comprehensive perspective, including the three areas of leisure, business and academic travel, by acknowledging differences and uncovering mutual learning potentials. It is characterized by an intensive stakeholder integration process throughout the whole project duration, aiming at co-design and co-generation of socially robust and highly relevant knowledge. We provide data on the current travel behavior and future behavior intentions by using different carbon lock-in levels and scopes of personal action as an innovative theoretical background. For this, we integrate practitioners' views and preferences with scientific approaches. We apply different quantitative and qualitative methods from social science and modelling in an interdisciplinary and international project team. Lastly, we will develop roadmaps and emission pathways for all three areas of air travel, which are expected to have high societal response.

Project team	Univ.-Prof. Dr. Alfred Posch Thaller Annina, BSc, MSc, PhD Assoc. Prof. Dr. Romana Rauter Dr. rer. nat. Marie Kapeller, BSc M.Sc., BSc MSc Eva Fleiß, MA PhD Mag. Dr. Anna Schreuer Lydia Maria Lienhart, B.A.(Econ.), MAIS
Lead Institution	University of Graz, Institute of Environmental Systems Sciences
Scientific partner	Centre for Climate and Energy Transformation, University of Bergen (P1)
Duration	March 2022 – February 2024
Funding	ACRP, 13th Call

2.2.19 Regional and sustainable business models for the Alpine region

The research team aimed to explore different types of business models that, due to their characteristics, can be aligned with the Sustainable Development Goals and are particularly suitable to be implemented in the Alpine region. This geographical focus is chosen because of its relevance, the various challenges it is facing and its alignment with the funding body ALC Alpine Lions Cooperation. Existing conceptualizations of sustainable business models in literature are being applied to explore business models in two areas, namely tourism and coworking spaces in support of new forms of working and living. In this context, two master thesis projects were carried out by Klara Jochum and Veronika Kirbisser and additional desk research and case analysis complements their findings. The findings concerning coworking spaces highlight the importance of engagement with locals and the municipality, cooperation and exchange with the network, and the individual adaption of the coworking space to the village's needs. Further it is crucial to raise awareness for the concept within the local community and to search for enough financial support or a building provider. The findings concerning the social dimension of sustainable business models in the Alpine region suggest to further analyze the competitiveness of sustainable tourism initiatives in the Alpine region in light of changing demand and the juxtaposition of environmental limits to socioeconomic

sustainability needs. Also, more research in the fields of community-based sustainable business, value mapping and value flows, as well as social value creation is needed. The philosophy and criteria catalogue of the Mountaineering Villages can be seen as a guiding framework for a sustainable transformation of the Alpine tourism sector.

Project team	Assoc. Prof. Dr. Romana Rauter Eva Nenninger, BSc
Duration	October 2021 – July 2022
Funding	ALC Alpine Lions Cooperation

2.2.20 Digi@Socialwork

This participatory and practice-oriented research project continued the research carried out in a previous project ('Digi@Work') and thereby put focus on digitalization in the Austrian social sector. Digital media and technologies as well as different tools are widely used and open new possibilities as concerns communication, collaboration and care work. In such a setting, the research team aimed to answer questions such as the following ones: How do employees perceive digitalization in their daily work? Or how can they actively shape the digital transformation in their companies? The results of an online survey (N=1246) and 9 group discussions (N=24) with employees have shown that acceptance of digitalization among employees was medium to rather high, with differences seen in gender and age. A large proportion of respondents wished for more time and space to be able to try to learn new things in the area of digital technologies and employees wanted to be more involved in the selection of new digital technologies. Furthermore, the usage of private devices for professional purposes needed to be clearly defined. The central outcome of this project is a toolbox to support shaping digital transformation processes in the social sector.

Project team	Eva Nenninger, BSc Doris Prach, BSc Assoc. Prof. Dr. Romana Rauter
Project partners	University of Graz – Institute of Educational Sciences (project lead)
Duration	June 2020 – May 2022
Funding	Arbeiterkammer Steiermark – 2. Ausschreibung des Projektfonds Arbeit 4.0

2.2.21 METSET – Identification of opinions, enabler technologies, and technology adoption paths of smart energy technologies

With the Green Deal, Europe aims to become the first climate-neutral continent by 2020, with the energy transition playing a major role. In order to establish a decentralized, secure energy system based on renewable energy sources, the Green Deal relies on the development of a fully integrated and digitalized EU energy market. At the household level, intelligent technologies, such as smart home applications are important. In addition to smart entertainment, security or comfort applications, smart energy technologies (SET) (e.g., smart

meter or energy management systems (EMS)) enable energy efficiency, promote sector coupling (e.g., e-mobility), communicate with the energy system or enable the integration of renewable energies.

SET can contribute to optimizing, stabilizing, and increasing resilience of the energy system, as they components, grids and actors to interact with each other. The contribution of digitalization to the green transformation is subject of the research.

METSET focuses on two questions:

- 1) **What types of SET opinions are present?** The prevailing opinion on SET influences individuals' acceptance and willingness to use SET, and consequently the diffusion of the technologies at the macro level. To make a statement about the contribution of digitalization, i.e., specifically SET, to the green transformation, it is relevant investigate the prevailing opinion about SET (i.e., attitudes, values, needs, etc.) amongst (potential) users.
- 2) **What is the role of SET in the individuals' technology adoption paths (TAP)?** With their decisions to buy and use SET, households act as active players in the energy transition. To date, the relation between adopting SET and other (smart) technologies is still unclear. Does the adoption of one technology influence the adoption of another? Are there patterns in individuals' adoption decisions over time, and if so, how does such a TAP look like?

Project Team	Eva Fleiß, MA PhD Katharina Trimmel, Dipl.-Ing. BSc
Lead Institution	Campus 02, University of Applied Sciences, Information Technologies & Business Informatics
Duration	October 2021 – February 2023
Funding	Land Steiermark, Green Transformation

2.3 Research cooperation and networks

2.3.1 Climate Change Graz

Climate Change Graz works on anthropogenic climate change, which is widely regarded as one of the greatest challenges of the 21st century. In order to limit rising temperatures to an increase of 1.5 to 2 degrees, in line with the targets set by the Paris Agreement, CO₂ emissions must be reduced by at least 50 percent by the year 2030, and around 90 percent by 2050. Making the transition to an almost emission-free and climate-stable economy and society requires a fundamental change of direction. At Climate Change Graz, one of the university's profile-building areas, a team of over a hundred researchers is exploring what economic, production engineering, social, political and legislative changes are needed to make this profound and sustainable transformation possible.

2.3.2 Complexity of Life in Basic Research and Innovation (COLIBRI)

Complexity of Life in Basic Research and Innovation (COLIBRI) is concerned with the profound changes that lie ahead in our living environment. Research findings from the science of complexity will soon provide a vital basis for decisions in business and policy-making. The findings come from modelling and computer simulation of complex systems in humans and nature, such as the optimization of transport and logistics systems, the investigation of vulnerabilities in ecosystems and the fields of biologically-inspired technologies and research into swarm intelligence.

2.3.3 HFDT – Human Factor in Digital Transformation

Digital “information and communication technologies” have found their way into the last corner of our lives and private spheres. They open up unimagined new possibilities, often facilitate our activities, accelerate exchanges between people and potentially raise them to a global level. At the same time, these developments are also associated with dangers and risks. The interdisciplinary network “Human Factor in Digital Transformation” pursues the goal to raise awareness for these risks and to enhance the consideration of the “human factor” in the development and implementation of ICT products and services (“SSH in ICT”). This goal is to be achieved by bringing together existing competences at the University of Graz. The network has been established since 2017 as an intra-university project with a strong interdisciplinary focus.

2.3.4 ISDRS – International Sustainable Development Research Society

The International Sustainable Development Research Society (www.isdrs.org) was formally founded in 2006 and built upon a 20-year history of the International Sustainable Development Research Conferences. The vision is to establish a forum where diverse research communities can come together creating a transparent dialogue on key problems, issues, initiatives, policies and strategies needed to make sustainable development a reality. It aims to foster and communicate the importance of sustainable development in a global society, to promote high-quality dialogue and collaboration and to build bridges between different research communities and also between research and its applications in society. In

2022, the 28th annual International Sustainable Development Research Conference was held in Stockholm.

2.3.5 Early Career Researchers Network of Networks

Early Career Researchers Network of Networks (ECR NoN) is uniting early career researcher organizations from all over the world to facilitate cooperation, to break silos across disciplinary backgrounds and engage with interdisciplinary issues. ECR NoN also addresses science-policy translation issues and provides early career researcher opinion in initiatives like Future Earth, the International Social Science Council (ISSC) and other relevant groups and organizations.



Institute of Environmental Systems Sciences (ESS) is part of this ECR NoN since mid-2016, with another 16 international networks involved. Each of the member organizations has the freedom to create working groups for certain topics of interest. ESS, represented by Arijit Paul and Anna Diaz Tena, together with 16 other networks/organizations have joined the Future Earth Working Group (FE WG), which concentrates specifically on sustainability and interdisciplinary research. Recently, Arijit Paul has been elected as the working group coordination committee chair at the executive committee of the ECR-NoN. Anna Diaz Tena has also joined the communication team of the executive committee of ECR-NoN.

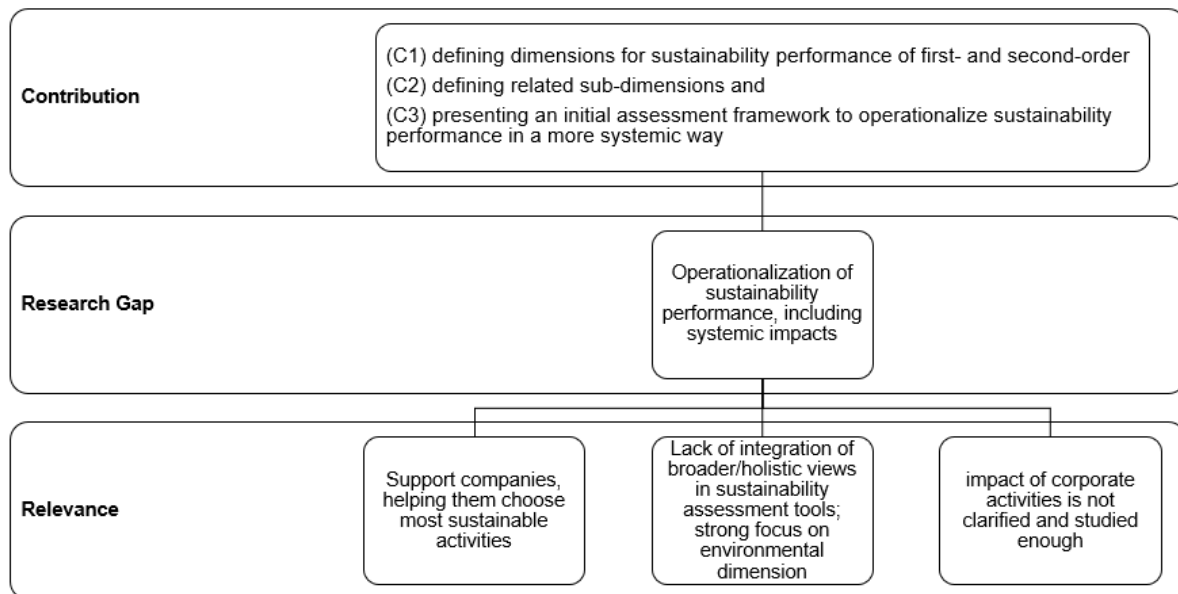
2.4 Ph.D. projects (ongoing)

2.4.1 Systemic sustainability performance: Operationalization of first- and second-order environmental and social sustainability performance

Business has become the focus of attention, as unsustainable business activities contribute to the narrowing of the “funnel” which implies unsustainable development (Broman and Robèrt, 2017; Robèrt, 2000). The “funnel” is a metaphor for the global decreasing capacity to provide enough resources for a steadily increasing world population. That is why it is important to achieve global sustainable development. To achieve global sustainable development, it is crucial to reduce unsustainable processes of society and businesses and to operate in a more systemic way. In this regard it is important that corporations better understand and assess their business processes. Sustainability assessments have emerged in different forms in the literature in recent years (Bond et al., 2012). Various definitions, instruments and techniques exist for sustainability assessment. Examples of sustainability assessment instruments include indicators and indices (i.e. non-integrated, integrated and regional flow indicators), product-related assessment instruments (i.e. Life Cycle Assessment (LCA), product material flow analysis and product energy analysis) and integrated assessment instruments (i.e. conceptual modelling, system dynamics, multi-criteria analysis and impact assessment) (Ness et al., 2007). However, these instruments are mostly not holistic (strong focus on one sustainability dimension) and they are not systemic, as only the direct impacts of the analyzed object of system are measured. This results in single or partial improvements without taking into account the systemic view.

This dissertation contributes with an operationalization of the concept of sustainability performance while integrating a systemic viewpoint in order to take direct and systemic sustainability impacts into account. More specifically, this dissertation will address three main objectives: (1) defining dimensions for first- and second-order environmental and social sustainability performance, (2) defining related sub-dimensions and (3) presenting representative questions to measure sustainability performance in a more systemic way. Such an operationalization of systemic sustainability performance is relevant, as it helps corporations to better understand their processes, to choose the most sustainable corporate activities and to consider a broader and systemic view in the future.

Regarding this the following main research question will be answered: *Which dimensions and sub-dimensions are central to operationalize environmental and social sustainability performance from a systemic perspective?*



Contribution of present research, importance of topic (relevance) and identified research gap

PhD student	Martina Zimek
Duration	2016 – 2022

2.4.2 Exploring drivers and challenges of embedding sustainability in business models of early-stage ventures

For more than a decade, scholars have increasingly paid attention to the motivations, existence and conditions under which new ventures shape the economic transformation towards sustainable development. This inclination to focus on early-stage ventures and their founders is an appropriate countertrend to the inherent focus on established firms in the existing sustainability literature.

Early-stage ventures are described as change agents and important catalysts, capable of disrupting the established, unsustainable order of industries by addressing challenges to promote sustainability and contribute to solving environmental and social issues. Striving for sustainable development provides early-stage ventures as a valuable source of differentiation, enables new business opportunities and provides them credibility when claiming to be part of the solution and not part of the problems caused by established firms. As newcomers, however, early-stage ventures are under enormous pressure due to their limited business experience, their lack of access to critical resources and the attempts they make to reconcile often multiple competing sustainability goals. For this purpose, a business model is required that enables the implementation of the business strategy with regard to sustainability.

With this background in mind, my PhD dissertation focuses on the business model development of early-stage ventures that strive for sustainability, mainly articulated around three research projects:

- In the first project of the dissertation, business models of aspiring ventures were investigated with regard to sustainability aspects. In this context, this work sheds light on

early development phases of business models by illustrating (1) how sustainability was allocated to individual business model elements and (2) reveals the drivers that encouraged early-stage ventures to include sustainability aspects in their business models from an imprinting theory perspective.

- The second project investigates tensions, early-stage ventures face when striving for sustainability. In this context, a paradoxical lens is used to shed light on (1) the kind of sustainability tensions and (2) how these tensions change over time; and (3) how the investigated ventures use different coping strategies to deal with them.
- The third project is dedicated to the development of a practical toolkit to review interdependencies and potential contradictions in business models. The urgent shift towards a sustainable trajectory requires tools to encourage the reflection on contradictions that may lead to tensions and supports early-stage ventures that strive for sustainability in the development of their first viable business models. In this work, the activity theory-inspired gap analysis is presented as a potential approach to overcome challenges from a contradictory set of goals exemplified by the three dimensions of sustainability.

PhD student	Martin Glinik
Duration	2018 – 2023

2.4.3 SMEs in a circular economy: A management perspective on key factors influencing a transition towards a circular economy

In the course of the transition towards socially and economically more sustainable systems, the concept of the circular economy (CE) has emerged, which is intended to counteract a product-based linear economy with a “take-make-dispose” tradition. A circular economy aims to create an economic system that replaces the end-of-life concept through the reduction, alternative use, recycling and recovery of materials in production/distribution and consumption processes. In addition, it can promote new business opportunities, innovation and the creation of new jobs, while saving energy and raw materials and minimizing the impact of activities on nature.

However, it is unclear whether these stimulating factors act as enabling factor for all companies equally, in particular for small and medium-sized companies (SMEs). SMEs differ from larger organizations in terms of their available resources as well as their technology and R&D capacities, which affects several types of business activities. 99% of all enterprises in the EU are SMEs, responsible for 70% of total industrial pollution and 40-45% of industrial air emissions.

To explore this gap, my PhD thesis addresses the following questions:

- What are the barriers to and drivers for a CE in general?
- Which topical areas perceive Austrian SMEs as important in the context of CE and how are they perceived to perform respectively? The purpose of this research is to identify key CE issues for Austrian SMEs.

- Furthermore, which contextual factors (e.g. company size, sector or external influences) influence the perceived importance and performance in these topical areas?
- Finally, due to the heterogeneous nature of SMEs, similarities between SMEs in different sectors are investigated in order to get a deeper understanding of the motivational factors for CE adaptation.

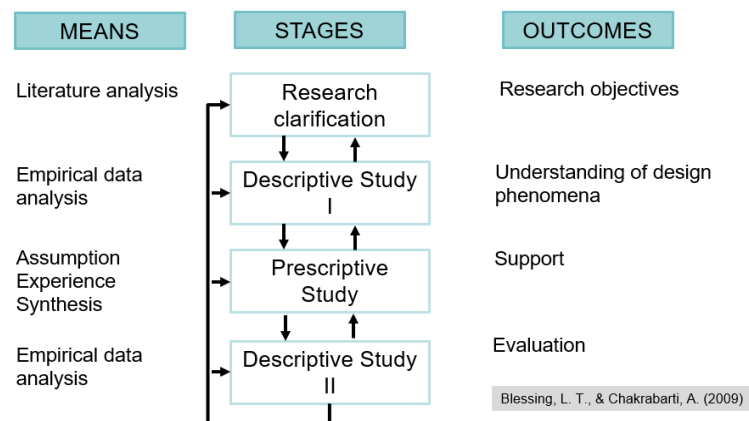
A further emphasis of the PhD thesis is the consumer perspective regarding CE. Moreover, consumer motivations for CE are investigated, with the aim of identifying overlaps between SMEs and consumers in the context of a CE in order to explore a unique business/consumer interaction. For the research analyses I use both, primary empirical data based on conducted surveys and secondary data sources.

The doctoral thesis is embedded in the activities of the INTERREG project “Start Circles”.

PhD student	Daniel Holzer
Duration	2018 – 2022

2.4.4 Sustainable product lifecycle management in a circular economy

The accelerated population increase and the economic activity boost experienced within the second half of the 20th century has put human activities in the spotlight as principal agent of change for many biophysical indicators on the functioning of the planet. Circular economy (CE) has been proposed as an enabler of sustainable development, allowing humans to thrive economically without overshooting the planet’s carrying capacity. For businesses, CE means adopting several value-retention options (Rs) along their operations. These aim at preserving and recovering the integrity of their assets and products for as long as possible. These strategies encompass long-established end-of-pipe interventions such as recycling or recovering the energy of products. Nevertheless, preferred options occur before that point – e.g., products’ redistribution, refurbishing or reusing. The process by which products are made fit for these strategies is product design, in which around the 80% of the total environmental impact of a product is determined. The goal of this research project is to develop and evaluate the implementation decision-making support during the design process of products for a CE. The PhD research is structured according to the Design Research Methodology (DRM) (Blessing & Chakrabarti, 2009) and follows the research stages displayed in the figure below.



The research questions that this research project aims at answering are:

- Which product-related aspects relevant for its performance in a CE are decided upon in each phase of the design process and which criteria are used to guide the decisions?
- Which decision-making support, key actors and lifecycle information flows are involved at each phase of the design process of a product for a CE?
- How do product design alternatives score against circularity criteria?
- Does increased products' circularity lead to increased sustainability performance?

PhD student	Anna Diaz Tena
Duration	2018 – 2022
Reference	CRESTING ITN MSCA Project

2.4.5 Organizational requirements for a more sustainable circular economy

The concept of a circular economy (CE) has gained considerable political and public attention in recent years, including growing scientific output and an ambitious CE agenda in two of the largest economic regions in the world, namely China and the EU. At the same time, CE is a highly dynamic field, driven by various stakeholders (think tanks, NGOs, science, politics, business), but without clear definition or framing. The promises of a transition of the economic system from a linear to a more circular one are – from the perspective of the European Commission – (i) more sustainable production and consumption patterns, (ii) job creation, as well as (iii) economic growth. Hence, CE is supposed to support all three pillars of sustainability and is consequently thought to contribute decisively to achieving the Sustainable Development Goals (SDGs). However, various obstacles have been identified in the transition towards a more circular economy.

- There appears to be a non-linear relationship between circular economy and sustainability due to manifold reasons: improvements in production patterns might be too incremental, too superficial organizational transformation disable deep transformation, inadequate and incomplete assessment leads to a lack of information and security, and CE seems present mainly on a process level while excluding social factors.
- Research interest around the CE is highly dynamic and exponentially growing in the past years. Due to its multi-stakeholder nature, various stakeholders drive the concept according to sometimes differing agendas. Consequently, confusion arises around the concept itself and what organizations need in order to be “circular economy ready”
- Circular economy is likely to require action and new paths in inter-organizational collaboration. Inter-organizational collaboration has the potential to push circular and sustainable practices forward: There is indication, that inter-organizational collaboration is helpful for effective eco-design and environmental improvements of products. Nevertheless, neither in the political sphere nor in the scientific community, this issue is yet to become a major focus of attention.

This research contributes to the definition of organizational requirements and obligations towards a more sustainable and circular economy on product level. This is achieved by a

threefold approach: First, the relationship of sustainable development and circular economy is revised and concretized through the definition of principles of a sustainable circular economy. Second, future developments and requirements for organizations for a transition towards a sustainable circular economy are investigated, taking into account the multi-stakeholder nature that forms CE, as well as emerging enabling technologies based on various forms of digitization. Based on the first two steps, a thorough analysis of inter-organizational collaboration delivers results regarding key actors and behavioral aspects that can enable sustainable circular practices. Thereby, this research also addresses complex interaction between actors that define sustainability and circularity aspects, as well as drivers for circular transition.

PhD student	Lukas Stumpf
Duration	2018 – 2022

2.4.6 Process and product innovations in advanced biorefineries: assessing factors, interrelationships and opportunities towards a sustainable knowledge-based bio-economy

To cope with the problems associated with the fact that today's energy carriers and chemicals are to a large extent based on fossil resources, and to promote regional and rural development, moving towards a more bio-based economy is discussed as a potentially viable option. For this, biorefining, defined as the *sustainable processing of biomass into a spectrum of marketable bio-based products and bioenergy*, is expected to play an important role. A future economy that uses bio-based resources also in an environmentally and socially sustainable way will depend on the production of a variety of products such as food, feed, materials, chemicals and energy from limited resources.

Research plays a major role in the development of new technologies, but most ideas that are followed in research fail to reach the market. One reason for that might be that research projects are often strongly focused on technological development, but for the development of profitable and sustainable biorefineries, challenges along the whole value chain need to be tackled, involving a range of different disciplines and stakeholders.

Lignocelluloses and, in particular, lignocellulosic residues are the dominant feedstock mentioned in published biorefinery research. Technical lignin is a relatively large (estimated at 50 million tons per year) and underutilized residue stream from the pulp and paper industry, which is now mainly burnt on site for the purpose of gaining energy. Investigations on technological aspects of lignin for several conceivable applications have been the focus of research for many years, whereas the level of knowledge in the field of markets and innovation diffusion of lignin is rather low. Currently, only a limited market for lignin exists, but it is said to play a major role in biorefinery conception in that it is a residue that could be further valorized and a promising substance which in future could replace certain petrochemical products in a more sustainable way.

In order to fill the knowledge gaps between the technical research on the other hand and economic and sustainability approaches on the other hand and to investigate the discrepancies between biorefinery research and biorefinery implementation, the following main objectives are pursued:

- Investigation on how different feedstock classes, products, and regions have been described in the scientific literature on the development of biorefineries, comparison of these results with information on the practical implementation of biorefineries, discussion of trends and discrepancies (systematic literature review);
- Investigation of the diffusion of selected technical-lignin-based innovations:
 - Identify the relevant decision-makers and their relevant attributes, behaviors, and interactions (several approaches);
 - Exploration of how the diffusion of certain lignin-based innovations on the market could look like in different future scenarios, taking into account economic and technological factors (agent-based model).

The Ph.D. thesis is embedded in the activities in the course of the report “Natural Fibers and Fiber-based Materials in Biorefineries” and the COMET-project Flippr².

PhD student	Julia Wenger
Duration	2018 – 2022

2.4.7 Innovation in the forest-based sector in the light of climate change

Climate change is undoubtedly one of the main environmental challenges of the 21st century, its ripples disturbing natural and human-made systems alike. Institutions and organizations at all levels are establishing agreements (e.g., Paris Agreement), and participating in programs (e.g., Horizon 2020), strategies (e.g., Europe 2020) and joint initiatives (e.g., COST, EIP-AGRI) to foster a development model which counts on knowledge, innovation, sustainability and GHG reduction among its main pillars. The role that forestry and innovation are to play within the next decades has been widely identified as paramount in the action plans against climate change. Forests and the forest-based sector potentially offer one of the most efficient, economically feasible and socially beneficial options to capture and store CO₂. However, this mitigation potential is threatened by the negative impacts that climate change is having on forest-based systems. Thus, innovation emerges as a necessary process that is of the essence to adapt them to the new scenarios generated under the effects of global warming.

With this background in mind, my PhD dissertation will be focused on the interrelations between climate change and innovation in the forest-based sector, mainly articulated around three research projects:

- The first project consists of a systematic literature review of the existing literature on the link between climate change and innovation in the forest-based sector in a global scale. Despite the considerable amount of literature on climate change mitigation and adaptation in forestry, and separately innovation and innovativeness in the sector, our study seems to

be the first analyzing the important gap on how they relate to and influence each other and its outcomes.

- The second project studies the factors influencing the innovation (pre)disposition of companies in the forest-based sector towards climate change mitigation and/or adaptation. A survey designed in cooperation with colleagues from the InnoRenew CoE Institute in Slovenia, sent to companies in the forest-based sector, will allow us to collect data on the matter and establish a comparative analysis. It will initially be tested in Austria and Slovenia, and upon its success, the survey will be also used in Finland and Spain. This study is developed within the “Innovation activities of Austrian and Slovenian companies in the wood-value chain” project, funded by the Austrian Agency for International Cooperation in Education and Research.
- The third project will investigate the effect of climate change on collaborations among the different agents of the forest-based sector’s quadruple helix (academia, industry, government, and civil society).

PhD student	Miguel Moreno
Duration	2019 – 2023

2.4.8 Innovation strategies of companies in the mobility sector to reduce GHGs emission

In order to limit the impacts of climate change, deep cuts in global transport GHGs emissions are direly necessary. The topic has moved into the focus of policy makers, non-governmental organizations (NGOs), businesses and society as a whole. Increased competition, uncertain technological trends, long development cycles, highly capital-intensive product development, saturated markets, and environmental and safety regulations have subjected the sector to major transformation and innovation race. Consequently, technological innovations like electric vehicles are emerging as mobility company’s major strategy to deal with climate change. Broadly, in the context of the mobility eco- system not only specific clean technologies but approaches and input from various companies related to mobility management are also significant. Not only low carbon but for the overall sustainable mobility system, strategies like Avoid-Shift-Improve (ASI) is considered as one of the best and holistic solutions. Aligning to this framework, the study aims to investigate on the innovation strategies of automotive firms exploring both technological and non-technological innovations for the achievement of the low carbon sustainable transport system.

For this, one aspect of the study investigates the technological innovation through the lens of patents through patent landscape analysis. With the aim of generating state-of-the-art of sustainable mobility innovations in paper I, I used the systemic perspective of the sustainable mobility paradigm Avoid-Shift-Improve to present a patent landscape of the entire land transportation system. Paper I is entitled “A patent landscape of sustainable mobility innovations in land transportation” and is currently under review.

My second study is based on the improve related strategy of the sustainable mobility paradigm. In order to understand the potential for a zero-emissions transportation future for incumbent automotive original equipment manufacturers (OEM), the second paper is based on the investigation of firm's innovation performance in the successful commercialization of their ZEVs. The paper manuscript is currently under development and the initial manuscript paper entitled "*Innovation performance of incumbent automotive firms in climate change mitigation*" is being submitted to conferences for feedback and comments.

My third study aims to explore the global technological collaboration of OEMs for the innovation of zero-emission vehicles based on a global patent collaboration network by adopting social network analysis (SNA). For this, the data collection and sorting work is going on at present.

Additionally, a case study was carried on the plausible low carbon sustainable transport system policies. The paper entitled "*Policy options for low-carbon sustainable transport systems in the Kathmandu Valley, Nepal: A survey-based study*" is currently under review. Through this study, I tend to add the overall stakeholder perspective supplementing the firm perspective of my PhD study.

PhD student	Jyoti Prajapati
Duration	2019 – 2023
Reference/Project	FWF Doctoral College Climate Change

2.4.9 Information and Knowledge Retrieval with NLP in Environmental Systems Sciences

While computers can handle large and structured data, such as tables, with ease, working with unstructured data or in other words raw text proves to be far more difficult. Unfortunately, most information on the internet is mainly available in this unstructured form. In order to use this vast amount of data the field of Natural Language Processing (NLP) has been formed and found an increasing number of uses across several disciplines over the last decade.

A powerful driving force in the recent progress of NLP has been the use of neural networks to transform words into numeric vectors, which contain semantic information and therefore make it possible for a computer to understand their meaning. With the help of these word vectors applications such as topic clustering, keyword extraction and text similarity calculations as well as more common machine learning processes such as supervised classification can be utilized to extract information. This is especially helpful when it comes to data sources, that are too large to be processed by hand, for example the plethora of scientific articles released each year.

In fields with highly congruent vocabularies such as medicine or material sciences, many of these methods have been used to produce very promising results. But when it comes to system sciences, a field where many specializations intersect, the use of different descriptions

for the same overarching point of interest becomes more likely. This in turn increases the difficulties when trying to extract knowledge from these works with help of NLP. However, this also means the potential gains could be of significant assistance when it comes to further research and to assisting policy makers in making informed decisions.

As such the main focus of my PhD work will be on how to make these applications feasible and determine in which areas they may provide the biggest benefit. Additionally, it will also be investigated if the results provided can be further applied as input for scientific models.

PhD student	Raven Adam
Duration	2020 – 2024

2.4.10 Digital product passport for an electric vehicle battery

The uptake of electric vehicles is projected to lead to an increase in demand for corresponding traction batteries, which often contain critical raw materials (e.g., lithium and cobalt). Furthermore, electric vehicle batteries (EVBs) are often linked to sustainability issues (e.g., high energy demands during cell production, land use and water depletion during raw material sourcing, etc.). Given these issues, EVBs require to be managed sustainably. To support a sustainable product management (SPM) of an EVB, the concept of circular economy could provide support (e.g., via EVB refurbishment, recycling, reduction of primary material sourcing, etc.). Consequently, value chain actors along the EVB value chain require high-quality data to support their decision processes to enable the transition from linear to a more sustainable and circular EVB value chain. That said, persisting data gaps along the value chain make it challenging to value chain actors to access needed data. In this context, the Digital Product Passport (DPP) could serve as valuable data source which may enable sustainability information flows along the EVB value chain.

The objective of this PhD project is to develop a concept for (dynamic) DPP for an EVB in the context of SPM. The concept development is driven by exploring the following topics:

- Identification of the EVB value chain actor eco system, as well as respective SPM decision-situations
- Identification of EVB value chain actors' data needs and requirements for SPM decision support
- Exploring a DPP's potential for SPM support for the use case EVB, thus at product level
- Exploring innovation enablers and barriers for DPP uptake
- Exploring factors and barriers for incentivizing value chain actors' data sharing behavior
- A valid and practical concept, or rather information model for a DPP for an EVB in the context of SPM

First results regarding DPP conceptualization, as well as empirical insights regarding EVB value chain actors' data needs and requirements for DPPs can be found in the following journal articles: <https://doi.org/10.1016/j.jclepro.2022.131492> and <https://doi.org/10.1016/j.cpl.2023.100032>.

PhD student	Katharina Berger
Duration	2020 – 2023
Reference/Project	Christian Doppler Laboratory for Sustainable Product Management enabling a Circular Economy

2.4.11 Carbon neutral transportation methods for urban last-mile delivery

In the past decade, an enormous growth of e-commerce has been observed, which can be expected to continue in the future. In 2019, business-to-consumer e-commerce accounted for approximately 11% of Austria’s private household retail sales and 68% of the population used delivery services at least once that year. This enormous increase affects the delivery sector and challenges to look for innovative solutions. At the same time, more and more cities become aware of their big responsibility in climate change mitigation and seem to be willing to take policy measures on different levels. Due to incentives and big efforts, electric alternative transportation methods like e.g. electric vehicles, e-bikes or drones gain in popularity, which is a hopeful evolution.

In my PhD project, I examine and evaluate the usage of carbon neutral transportation methods for urban last-mile delivery. The usage of smaller delivery vehicles (bikes, scooters, drones, ...) brings many advantages in dense urban areas. In small city centers, some streets may not be accessible for larger vehicles or are even completely car-free. Finding a parking place might even pose a bigger challenge in an urban context. A case study in London showed that delivery cars were parked for 62% of the time, while the drivers had to walk from the parking spot to several customers.

Apart from evaluating alternative transportation methods, my research also focusses on the urban network topology, in an attempt to determine properties of the customer network which play in the advantage of a certain transportation type. This should facilitate delivery companies to rethink their routes in order to make optimal use of carbon-neutral vehicles.

Because of their limited capacity, small vehicles need to be reloaded more often. Many solutions to this logistic issue are described in the literature or are put in practice already. In this project, I will compare existing strategies for Graz, including the distribution of parcel collection points in the city center or synchronization between large and small vehicles. When applying such solutions in a concrete situation, as is planned for the city of Graz, logistics have to be properly worked out to synchronize the timetables of different vehicles. Decisions have to be made about the clustering of customers, matching specific vehicles to certain customer sets, finding out where different vehicles could meet, and where to place parcel collection points. Providing a framework in which these decisions can be made and compared easily will be of advantage for both delivery optimization and city planning.

PhD student	Annelies De Meulenaere
Duration	2020 – 2024

2.4.12 Resilience in food supply chains against external shocks: the case of Covid-19

Supply chain management has moved to the spotlight of research over the last decades and demands corporations to extend their view outside the organization. Increased competition and globalization force closer relationships and stronger cooperation. Furthermore, the Covid-19 pandemic hit the world by surprise and, apart from the devastating health impacts, caused major disruptions in business operations. Unemployment spiked in multiple countries, world trade declined suddenly, and the consequences are far-reaching. Supply chains struggled to keep operating. This research project aims to learn from these events to be better prepared for the future. The intersection of supply chain management, food processing, and resilience is analyzed to achieve this objective. Food supply chains proved to be especially vulnerable to pandemic disruptions, as they got hit by multiple disruptions simultaneously. Maintaining a constant supply of food is vital to avoid more detrimental effects on people and society in general.

To analyze the behavior of food supply chains, modelling approaches to detect weaknesses and increase resilience are applicable. Simulation-based supply chain modeling has already been well researched; therefore, an agent-based modeling approach will be applied. Simulations enable the analysis of dynamic and complex behavior over time to optimize the outcome and identify performance issues or vulnerabilities. In this case the simulation will pursue a micro level approach focusing on the Austrian milk supply chain, with input data based on secondary data sources as well as expert-interviews.

To address the previously described problem the following research questions are framed around three major topics:

- Gain knowledge insights by simulating the behavior of the supply chain actors.
 - How can an agent-based approach be implemented to analyze the behavior of the Austrian milk supply chain?
 - How can food supply specific characteristics be considered during the modelling and simulation of supply chain behavior? Which actors are part of such a chain and how is their performance influenced by disruptions?
- Gain insights on resilience management and quantification.
 - How can resilience within a food supply chain be quantified? What indicators can be used to quantify the impact and recovery of a disruption?
 - Which countermeasures can be developed to increase the quantified resilience? Which effects on the supply chain stability can there be measured?
- Derive managerial implications based on the increased knowledge.
 - How can multiple simultaneous disruptions within a supply chain be managed? What decisions can be made? How can the decision-making process be supported?
 - What strategies do exist for each of the actors within the supply to mitigate risks before a disruption, during the disruptive events and what can be derived afterwards?

As these disturbances are unparalleled, the consequences on supply chains have rarely been witnessed before. The uniqueness of these events creates new research opportunities.

Amongst others the analysis of rare and high impact disruptions, the assurance of food supply & security and the application of quantitative approaches to measure resilience. The goal of this research project is to take advantage of these opportunities and explore strategies to create more resilient food supply chains in the future.

PhD student	Moritz Kettele
Duration	2020 – 2024

2.4.13 Culture and Computation: How artificial societies contribute to the understanding of cultural dynamics

Literature on culture is vast and multi-faceted. Culture and its role in social life have been studied for many years now. Still, many of its dynamics, properties and mechanisms are not yet fully understood. This research aims to identify existing gaps and show how the study of culture may be approached from a complex systems and multi-agent perspective. We take into account the interplay between different cultural dynamics distinguishing between three levels of cultural analysis in particular: the macro level focusing on macroscopic phenomena, patterns and regularities, the micro level dealing with individuals and their interactions, and the nano level describing mental representations and underlying cognitive processes. Multi-agent models allow us to study a wide range of cultural phenomena. Our aim is to further contribute to the understanding of culture and culture related topics by modelling cultural dynamics with the use of artificial societies. In this endeavor, we will focus on two things: First, contribute to the understanding and modelling of the transmission process of cultural information, and second, connect the three levels of cultural analysis (nano, micro, and macro) to create a better understanding of the systemic relationships between them. To address these two areas of focus, we have formulated the following general research questions:

- **Research Question 1:** What theories exist on the transmission process of cultural information and how can they be translated into formal multi-agent models of cultural dynamics? This question specifically targets the study of micro level interactions and underlying nano level processes. It includes the identification of key properties and mechanism from an informal sociological and psychological point of view and, subsequently, from a formal modelling point of view.
- **Research Question 2:** How may the three levels of cultural analysis (nano, micro, and macro) be linked through multi-agent models and what kind of systemic properties can be identified in this process? This includes the identification of causal relationships and directional feedbacks between different levels. For example, micro level interactions might lead to certain cultural macro patterns. But as soon as these patterns have established themselves on the macro level, they can work back on the micro level, possibly shaping and reshaping future micro interactions.
- **Research Question 3:** How can the understanding about key mechanisms from Research Question 1 and the understanding about systemic interplay between the three levels of cultural analysis from Research Question 2 be used to provide decision support for dealing with real-life social groups and cultural dynamics. For example, targeted interventions of

certain cultural dynamics might be formulated based on the identification of critical parameters that amplify certain dynamics, or on key types of social agents that hinder or promote certain dynamics, or on other systemic structures that amplify certain dynamics such as echo-chambers that promote polarization in social networks.

PhD student	Daniel Reisinger
Duration	2020 – 2024

2.4.14 Sustainable Operations Management: Linking Sustainability with Operational Excellence

Operations management is essential for fulfilling an organization's sustainability goals. However, research has so far has not been able to provide practical models that include sustainability objectives into several aspects of operations management – an obstacle for any organization that must meet business requirements in a short period of time. At the same time, a corporation must create, or maintain, an adequate organizational culture, appropriate leadership skills, and operational excellence, all of which are required for long-term success. Therefore, within sustainable operations management, models that combine operational excellence with sustainability are essential.

To that purpose, the thesis examines existing, holistic frameworks for both operational excellence as well as sustainability as a basis and attempts to adapt and test them for a potential framework linking sustainability with operational excellence. Hoshin kanri, a type of policy deployment, is a potential management system for linking strategy and implementation. Hoshin kanri is a process-based framework that incorporates environmental aspects (i.e., to eliminate waste) as well as social aspects (e.g., integrating all employees and levels of decision making), with great potential in combining operations management with sustainability. The Framework for Strategic Sustainable Development was chosen as the framework for sustainability to be combined with hoshin kanri. This framework aims to help organizations and institutions become more sustainable. It is used in this research due to its practicality, its clearly defined sustainability principles, and planning process as well as combination possibilities with other management methods and tools.

The goal of this thesis is to provide a comprehensive framework to support sustainable transformation in companies, within sustainable operations management. This will be done through three interconnected research steps: (1) literature review for framework development, (2) case-study approach testing and refining the framework, and (3) identifying benefits and barriers of applying the framework by means of sustainability assessment.

The main research questions that this research project addresses are:

- How can a framework for linking Sustainability with Operational Excellence look like?
- Where and how can the framework be implemented towards Corporate Sustainability?
- What are the main benefits and challenges in applying the framework for Sustainability and Operational Excellence?

PhD student	Katharina Roche
Duration	2020 – 2024

2.4.15 The Potential of Digital Technologies as Enablers for Sustainable Product Management in a Circular Economy

Unrestrained demand for natural resources is not possible in a finite world, and the current linear or “take-make-waste” approach as the predominant consumption and production model has devastating consequences on our planet. The urgency for a sustainability transformation increases as long as society continues to move in an unsustainable direction and companies uphold their “business as usual” approaches that contribute to the linear economy. However, in the last years, the circular economy concept gained attention for decoupling economic growth from linear resource consumption. It envisions a regenerative system that minimizes the use of natural resources and the creation of waste. But a widespread implementation of the circular economy is not yet taking place, and companies have difficulties operationalizing it. In the literature, digital technologies are described as potential facilitators for implementing corporate circular economy actions. They can be used to monitor products and parts in multiple lifecycles and ease the collection, management, aggregation, and exchange of product data. Thus, this thesis aims to explore how digital technologies can facilitate the implementation of a circular economy, especially on a product and company level. A design research methodology approach combining qualitative and quantitative methods was used to guide the research of this dissertation. As a result, a conceptual framework for sustainable product management is provided that should facilitate the implementation of a circular economy. Then, the role of digital technologies, particularly the internet of things, artificial intelligence, big data, and blockchain, for this implementation was further explored both in theory and practice. This resulted in a detailed description of the implementation level of digital technologies for sustainable product management in companies. Furthermore, the findings also reveal the status quo of the availability and quality of sustainability-related data in companies to support sustainable product management in a circular economy. In conclusion, in a circular economy, it is key that in addition to closing product and material flows, the corresponding information flows also need to be circular. Further research should therefore explore how to ensure consistent information flows along circular product lifecycles. In addition, more research is needed on how to implement sustainable product management and operationalize circular economy in companies.

PhD student	Magdalena Rusch
Duration	2020 – 2023

2.4.16 Modeling the life cycle system of wood: Multi-objective optimization of sustainability objectives

Wood as a renewable resource is used in several applications, both as material and energy. It can contribute to climate change mitigation by the carbon sink function of forests and carbon

capturing and storage of harvested wood products. Wood also has the potential to substitute non-renewable materials and energies. It is not known how wood is used in the best way from a sustainability view. Considering the problem from a system perspective, it is not clear which application of wood is more sustainable and if wood or alternatives should be preferred. This becomes especially relevant when new applications like using wood for the automotive industry come up. It is not known whether wood for vehicles is sustainable on a macro-level and how the design of components and processes influences their sustainability.

The aim of this PhD project is to analyze and optimize the system of wood use from a holistic perspective, looking at wood uses and its substitutions simultaneously and including existing and innovative applications. All three dimensions of sustainability, environmental, social and economic aspects, are included in the assessment to find an optimal wood distribution for the whole system (Austrian market).

A system dynamics model is used to describe the dynamics of the system including wood availability, wood use and substitution combined with environmental, economic and social impacts. A sub-model of the innovative wood application for the automotive industry depicts the life cycle including production processes. Multi-objective optimization is used to identify the optimal process design of a component over the whole life cycle for the use in the automotive industry and to compare it to the overall sustainability effects on the system (Austrian wood uses). The model of the overall system is optimized with multi-objective optimization to balance environmental, economic, and social goals and to find the optimum for a sustainable use of wood.

This research contributes on the one hand to provide insights on the effects when designing products and processes in the automotive industry and to make wood products for vehicles more sustainable and competitive. On the other hand, the assessment of the overall system will show the dynamics and the optimum (environmental, social, economic) of the system of wood use and present ideas on how to create a more sustainable future.

PhD student	Theresa Boiger
Duration	2021 – 2025

2.4.17 Sustainability assessment of different Li-Ion battery recycling techniques integrated into a digital battery passport framework

Lithium- ion batteries (LIBs) are a central technology for decarbonization and due to technological advancement, governmental programs and decreasing prices, recent years have seen a growth of demand and usage of LIBs and in the coming years this growth is expected to continue. To combat resource scarcity and avoid waste, currently a lot of research activity is focused on the recycling of LIBs.

While the efforts to recycle and circularize Li-ion batteries is already related to sustainability, the goal of this PhD project is to go one step further and evaluate the sustainability performance of different process options. To select the most sustainable recycling option, two

conditions have to be met. The first one is a holistic assessment of different sustainability aspects which can be provided by using the different methods applied in this research.

- Social risk assessments and a social life cycle assessment based on the UNEP/SETAC guidelines
- Multi-regional input-output (MRIO) analysis for estimating the potential wider social impacts of upscaling the developed recycling processes on the European economy
- Circularity assessment and a second-order sustainability assessment

The second one is transparency. The information gathered about the sustainability of a product has to be somehow communicated to the different stakeholders. For this reason, the results of the sustainability assessment will be the basis for a digital product passport. Battery passports can be used to trace a battery throughout its lifetime and therefore provide the necessary data for the sustainability assessment, while it can be also used to communicate the results of the sustainability assessment to different stakeholders.

The research is embedded into the Horizon Europe project FREE4LIB which provides the benefit to gain first source information from industrial organizations.

PhD student	Julius Ott
Duration	2022 – 2025
Reference/Project	FREE4LIB

2.4.18 Improving circular economy and sustainability along the value chain via Digital Product Passports

Circular economy (CE) has become an increasingly discussed concept over the past decades, both by politicians as well as scientists. It aims at extending products' lifetimes and retain the value and quality of products and materials throughout their life cycle while keeping them in the cycle as long as possible. Hence, CE is related to how products are designed and how business operations are organized. The practical implementation of CE requires vast amounts of relevant, up-to-date and data trustworthy data along products' value chains. As digital technologies, and more specifically, digital product passports (DPPs), may facilitate data collection and the tracking of resources, materials and products, they may be considered an essential enabler for accomplishing the transition towards CE. The main prerequisite for DPPs is complete, reliable and available information and therefore, the involvement of all relevant actors along the respective value chains is essential.

Hence, the overall research goal of this thesis is to assess how the targeted use of DPPs and the related systematic integration of multiple stakeholders' perspectives can effectively promote CE and sustainability along products'/components' lifecycles. The aim is to explore the potentials of digitalization, and more specifically, of digital product passports to facilitate information collection and exchange. In order to gain an in-depth understanding of DPPs, two concrete use cases are chosen: the electric vehicle battery and the internal combustion engine. Here, it is the objective of the presented research to get a deep understanding of the

information requirements of each stakeholder along the use cases' value chains in order to support CE-oriented decision-making. Furthermore, due to the huge importance of available data for the effective implementation of DPPs, this research also deals with the enhancement of information sharing between value chain actors. It considers influencing factors, challenges, obstacles and incentives with regards to information sharing. Thereby, this thesis delivers an important contribution to foster information exchange and thereby support the transition towards circular economy.

PhD student	Antonia Pohlmann
Duration	2022 – 2025
Reference/Project	CE-PASS

2.4.19 Digitalization and circular economy: Digital product passports as transition enablers

The increasing use of natural resources causes severe environmental challenges, which need to be dealt with for achieving a more sustainable future. One of the concepts contributing to sustainable development is the so-called circular economy. Although a transition towards a circular economy could contribute to a more sustainable future, the worldwide implementation is still in its early stages. Therefore, possibilities and enablers have to be found in order to accelerate the transition towards a more sustainable and circular economy. For achieving a circular economy, another ongoing transition, the transformation from an analogue to a digital economy, commonly referred to as digitalization, can play a crucial role. In the context of digitalization, one possible facilitator are technologies, which increase the availability of information for value chain actors in a circular economy. Effective planning and management, for instance planning of reuse or recycle scenarios, require reliable information, which is in most cases not available for decision makers, rooted in the fact, that most companies are nowadays interlinked in increasingly complex supply chains.

Therefore, this thesis focuses on how digital technologies can help in providing decision makers all along the life cycle of products with the needed information to enable effective decision support with regards to sustainability and circularity. A special focus is thereby put on the design phase of products, given that most of environmental impacts are determined during this stage of the product life cycle. The research aim of this thesis is to facilitate the development of digital product passports, as means of information providers, by identifying different stakeholders and their corresponding information requirements and to identify tools for sustainability assessments, which use data provided by digital product passports for early-stage sustainability assessments to enable sustainability improvements in the early design phase.

PhD student	Martin Popowicz
Duration	2022 – 2025
Reference/Project	CE-PASS

2.4.20 Sustainable Mobility in rural areas

Passenger transport takes place for the most part in suburban and rural areas, and it is precisely there that the dependence on private cars is particularly high. There is often a lack of attractive alternatives to motorized private transport or a lack of acceptance of alternative mobility offers among the population, which in turn constitutes an obstacle to their use. In order to achieve Austria's climate targets, it is of utmost importance to break the dominance of private motorized transport in the area of passenger transport and to change behavior, especially among the rural population. The research objective is to discuss how this dominance of private transport and the dependence on private cars can be broken in rural areas and how alternative mobility offers and active mobility can be made more attractive.

The first contribution to my dissertation deals with perceived barriers and enablers whilst implementing sustainable mobility measures. Based on a single-case study, both political actors and mobility providers in a rural region of Styria are asked about perceived barriers and enablers of implementing sustainable mobility measures within the framework of qualitative guided interviews.

PhD-student	Simone Schreiegg
Duration	2022 – 2026

2.4.21 Social justice and fairness dimensions of ambitious climate policy and discourse

Mitigating global climate change is crucial for securing safe living conditions for human and non-human life. At the same time, climate change mitigation poses a challenge to governance systems on any scale and relies on public support for ambitious climate change mitigation policies. Since the transition to a low carbon society creates benefits and costs that can be unequally distributed across time scales and actor groups, it is relevant to account for potentially adversely affected actor groups and fairness concerns.

The objective of this research project is therefore to examine contested climate change mitigation policies within the broader context of a just transition to carbon neutral production and consumption modes. The aim is to understand different social perspectives on their acceptability as well as potential constraints for policy acceptance for affected groups in order to develop policy recommendations and increase policy acceptance, effectiveness and efficiency.

This will be accomplished through a mixed methods approach: a discourse analysis spanning multiple discursive arenas, a Q methodological study examining social perspectives, and survey research to, inter alia, increase understanding of policy acceptance.

To summarize, this research project aims to answer the following research questions:

- How does the discourse on climate policies look like in Austria and which groups are potentially adversely affected by those policies that dominate the discourse?

- How do actors within the groups make sense of the contested policies and which expectations about future states of affairs are perceived as potentially frustrated?
- What are the affected actor groups' preferences for climate policies, and which parameters determine acceptance?

PhD student	Katharina Trimmel
Duration	2022 – 2026
Reference	TransFair Project

2.5 Ph.D. projects (completed or submitted)

2.5.1 Local Food Systems for Sustainable Development: Open, Connected and Circular

My Ph.D. thesis is divided into three projects that deal with the sustainable transformation of the food system towards sustainable development (Caron et al. 2018).

Research project one and two state results of two inter- and transdisciplinary case studies. The first investigated how the urban and peri-urban food system of Graz including its surrounding districts can be changed such that more local food products are consumed within the target area. Research on urban food systems is increasingly concerned with assessing potentials for cities to “localize” their food supply through their surrounding areas (Cardoso et al. 2017). Therefore, the research process was guided by the question of how a resource-efficient local food supply may be enhanced in the target area. To support the research process with data, textual materials, including national and international reference projects on the local food supply in urban areas were analyzed and semi-structured interviews with multiple local agri-food stakeholders were conducted. Furthermore, territorial food-carrying capacities by means of food self-sufficiency rates (FSSR) for seven food items were calculated. In a series of workshops, knowledge from scholars and practitioners were brought together, and summarized in a roadmap, showing how local agri-food stakeholder can contribute towards a resource-efficient and sustainable food provision.

The second case study represents a transdisciplinary case study (TCS, Scholz et al. 2006) on the development of sustainable food products. TCS is based on the idea of educating students in real-world settings. It combines three components, namely case studies, transdisciplinary and sustainable development, and draws on PBL as a didactic framework. The research was carried out to determine how food technology and sustainability education could be promoted amongst secondary school students. The first objective of the research was to explore the students' food decisions by applying participatory research methods. The second objective, based on the initial findings, was to identify and produce sustainable food products by students for students. As such, the pull-concept for mutual learning was applied (Posch and Steiner 2006), which posits that learning occurs in a circular rather than a linear relationship among knowing, understanding, and applying. The students engineered sustainable food products from scratch and, as they went through their product development process, engaged in iterative learning steps.

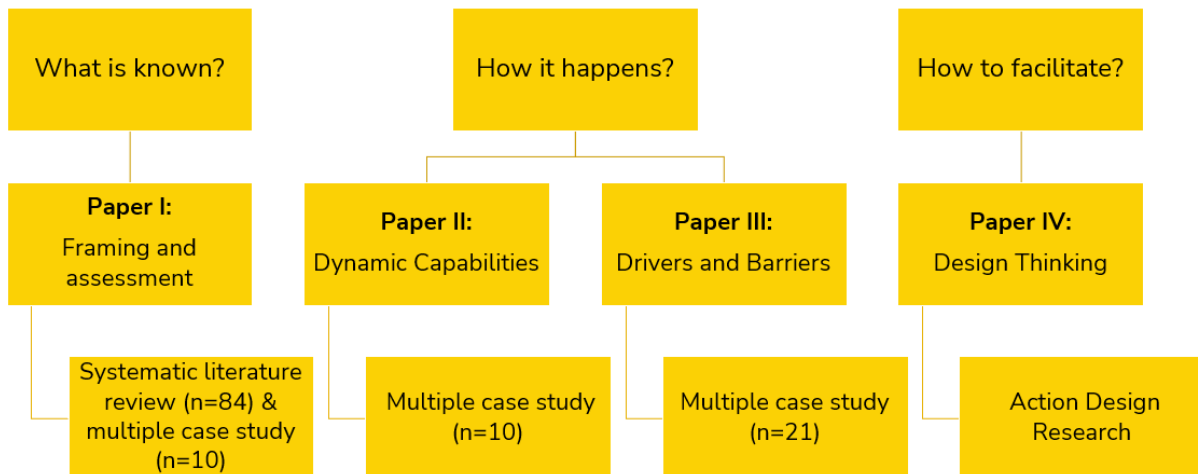
The third project investigates how insects (i.e. *T. Molitor*) can contribute towards a sustainable protein supply in Austria. At first, a literature review on suitable substrates for the mass rearing of *T. Molitor* was conducted. Subsequently, agricultural and industrial by-products along the food supply chain were identified and quantified for Austria. Furthermore, the nutritional content of these feed sources was analyzed (e.g. in terms of fat, carbohydrates, sugar) and feeding trials were conducted. The paper states the first findings of a five-year-long study. Furthermore, it highlights the role insects can have in a circular food system in Austria.

PhD student	Hartmut Derler
Duration	2018 – 2022

2.5.2 Business Model Innovation for the Circular Economy: What is known, how it happens and how to facilitate

In recent years, the circular economy has gained traction as a promising contributor to sustainable development. However, the implementation of sustainable and circular business models remains relatively low. Although the related literature is rapidly evolving, there is still a lack of understanding of the complex process of circular business model innovation, a need for concrete guidelines for firms and calls for more empirical studies. This thesis explores three related questions: what is known about circular business model innovation? how does it happen? and how to facilitate it? To this end, first, a systematic literature review on the emergent field of circular business model innovation is combined with a multiple-case study on ten firms. A summary framework of present and future research is offered, framing and assessing current literature and identifying major research gaps. Secondly, building on the theory of dynamic capabilities, the multiple-case study data is abductively analyzed to identify 26 best practices for circular business model innovation. These are grouped in twelve micro foundations of dynamic capabilities, and highlighting practices such as the adoption of a lifecycle perspective and ecosystem collaboration. Thirdly, 21 innovation cases are analyzed to identify 10 drivers and 25 barriers that affect the different types of circular business innovations. And finally, following an action design research approach, a design thinking-based process framework for guiding the design and implementation of circular business models is developed, including twelve specific tools. This thesis provides an improved understanding of business model innovation for the circular economy, offering concrete guidance for practitioners and a set of context-adaptable tools to support firms in their sustainability transformations.

Business Model Innovation for the Circular Economy



PhD student	Tomas Santa Maria Gonzalez
Duration	2018 – 2022
Reference	CRESTING ITN MSCA Project

2.5.3 Decarbonizing passenger transport through policy-driven behavior change

Climate change is one of the greatest challenges of our time. A particularly problematic area in the context of mitigation is transport, where emissions are still rising. Although the magnitude of the task ahead is clear, action necessary to not exceed the 2-degree target is still lacking. But why? In this thesis, I argue that, while many of the efforts to date have focused heavily on technological improvements, behavior changes on the demand side must also occur to address this crisis. This requires the development and implementation of so-called “disruptive” policy packages that fundamentally change the current system. At the same time, there is a tension between the relevance of push measures that make driving less attractive, on the one hand, and the need for public acceptance for the implementation of such packages of measures, on “the” other. By applying quantitative and qualitative social science research in the Austrian context, I show that a balanced policy package is needed to effectively address climate change in passenger transport. Building on this, a quantitative analysis underlines the importance of policy packages for considering distributional aspects. Since the lack of public acceptance for such policy packages can hinder their implementation, I also examine the support for particularly restrictive policies. Finally, a case study of academic air travel sheds light on factors that influence people’s willingness to reduce flying in the future. In the discussion, I address the importance of disruptive change and discuss its implications for policy by outlining current plans for transport policy, lessons learned from the pandemic, and critical factors for successful implementation. I also outline the content limitations of the thesis and propose several potential areas for future research.

Main research questions: How can rapid decarbonization in passenger transport be promoted through policy-driven behavior change? Which implications can be derived for policymaking?

Included papers:

Dugan, A., Mayer, J., Thaller, A., Bachner, G. & Steining, K. (2022). Developing policy packages for sustainable passenger transport: A qualitative and CGE analysis of trade-offs and synergies, *Ecological Economics*, 193. doi:10.1016/j.ecolecon.2021.107304

Thaller, A., Schreuer, A., Posch, A. (2021). Flying high in academia – Willingness of university staff to perform low-carbon behavior change in business travel. *Frontiers in Sustainability – Sustainable Organizations*, 2, 790807. doi:10.3389/frsus.2021.790807

Thaller, A., Posch, A., Dugan, A. & Steining, K. (2021). How to design policy packages for sustainable transport: balancing disruptiveness and implementability. *Transportation Research. Part D: Transport & Environment*, 91, 102714, doi:10.1016/j.trd.2021.102714.

Thaller, A., Wicki, M., Fleiß, E., Maier, R., Posch, A (in press). Pushing low-carbon mobility: A survey experiment on the public acceptance of disruptive policy packages. *Climate Policy*

PhD student	Annina Thaller
Duration	2018 – 2022 (thesis submitted in Dec 21; PhD defense 16 Mar 22)

2.5.4 Transition towards a low-carbon electricity system: Analyzing the contexts of emerging Asia from a system reconfiguration perspective

Fighting against energy poverty and upscaling sustainable energy access through low-carbon development in poor rural areas is considered a feasible climate change mitigation action. At present, 759 million people in developing Asia have no access to electricity, thus facing wealth and income constraints as well as human developmental deficits that make them vulnerable to the vicious cycle of poverty. Over the last 15 years, governments have promoted off-grid solar electricity in rural areas through a market-based system in association with donor agencies. However, a market system falls short in reaching out to rural households in the last mile, requiring governments to play a crucial role in electrifying over 600 million to achieve the sustainable development goal on energy (SDG 7) by 2030. Therefore, in electricity access deficit countries such as Bangladesh, India, Kenya, and Nigeria, national governments are adopting a quasi-market-based approach involving local political leaders to implement 'solar energy safety nets' and deliver clean energy services through rural energy markets. Nonetheless, off-grid solar energy endeavors raise distributional equity concerns.

My doctoral research is built on interdisciplinary theoretical insights, particularly trans(-)action (cost) theory in new institutional economics by J.R. Commons and Oliver Williamson, governance logic of transition studies by Timothy Foxon, and distributive justice principles, Jhon Rawls. In my research, I aim to investigate the effect of different institutional arrangements on the outcomes of the low-carbon off-grid electrification in the context of energy-poor regions of Bangladesh. In particular, I address the following research questions taking both the positivist and pragmatist approaches:

Firstly, what is the impact of market concentration on the installation of solar home systems in rural off-grid areas? Paper one is entitled, 'The impact of supply structure on solar home system installations in rural off-grid areas' (Environmental Innovations and Societal Transitions – <https://doi.org/10.1016/j.eist.2021.10.015>).

Secondly, whether a microcredit lending model distributes the financial cost of energy loans equitably across rural households facing borrowing constraints? Paper two is entitled, 'Distributional inequality in market-based solar home system programs: Evidence from rural Bangladesh' (Energy Economics – <https://doi.org/10.1016/j.eneco.2021.105523>).

Finally, does the geographical representation of local leaders affect the distribution of solar energy safety nets in Northern rural villages? Paper three is entitled, 'Spatially distributive benefits of solar energy safety nets: Local political representation matters!' (work-in-progress). Additionally, my research also comments on how solar energy safety nets improve pandemic-resilient livelihoods in rural areas? The research letter is entitled, 'Energy access and pandemic-resilient livelihoods: The role of solar energy safety nets' (Energy Research & Social Science – <https://doi.org/10.1016/j.erss.2020.101805>).

PhD student	Rafia Zaman
Duration	2018 – 2022

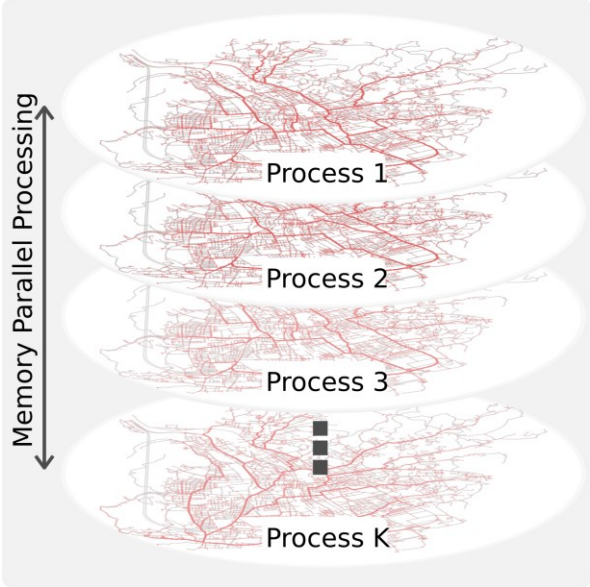
2.5.5 Model based decision support for low carbon transport – Leveraging large scale network research with parallel computing

Current transportation and traffic models are vast and various. However, they fail to achieve a computational speed which would foster creative and interactive decision-making processes. The traffic model recently developed at the University of Graz already outperforms other models of similar scope in terms of speed. Nevertheless, the possibility of further acceleration and improvement is still given.

The first part of optimization regards the algorithmic expression for the already included Monte-Carlo like trip generation scheme. An alternative formalism could not only yield less computational demand, but furthermore still provide a qualitatively similar result. In the subsequent parallelization step, this algorithm is implemented upon a graphical processing unit (GPU). Such a highly parallel processing architecture may ultimately lead to almost instantaneous results. Therefore, a combined approach of a novel algorithm and parallel execution model is proposed to leverage such an implementation fostering interactive decision making.

Moreover, through the introduction of route choice based on the principle of future state maximization, also the realism of the model is aimed to be improved. On a microscopic level such a shift from a deterministic to a stochastic route planning model could yield a more human like driving behavior. Insights in the application of future state maximization may also help drive this novel field of research into new, prospering provinces.

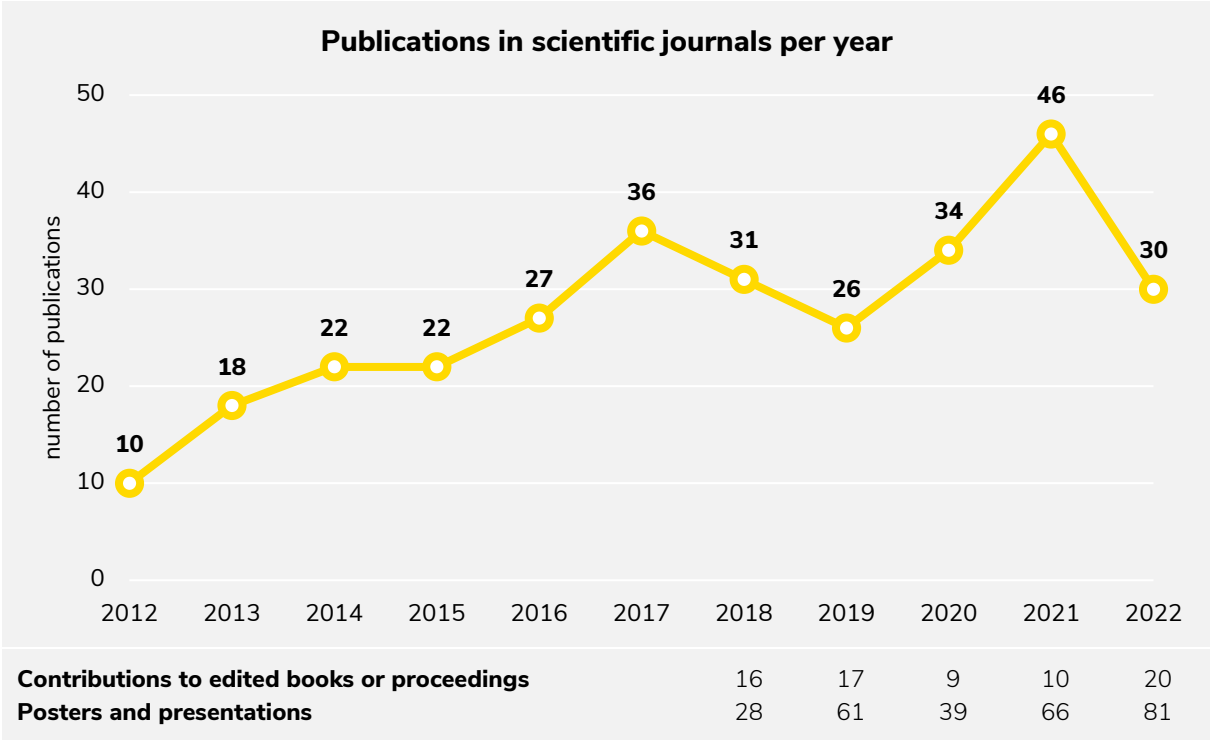
Hence, the project encompasses a threefold approach of optimization, parallelization, and future state maximization. This trinity aims to overcome the struggle in between an accurate and a fast simulation adapting the scope from micro- to mesoscopic detail.



PhD student	Simon Plakolb
Duration	2019 – 2023

3 Publications and other research output

In this section, a detailed report on the institute’s research output is presented. An overview is given in the figure shown below, presenting the development of scientific contributions of members of the Institute of Environmental Systems Sciences over the last years. While contributions to journals in 2022 remained below the exceptional number of 2021, significant increases were recorded for contributions to edited books and proceedings as well as posters and presentations.



Number of publications in scientific journals over the last years

Besides contributions targeted at a scientific audience, a science2public book stood out in 2022. In September, Thomas Bruderermann published “Die Kunst der Ausrede” (in English: “The art of making excuses”). The book deals with the excuses which citizens, consumers and politicians use instead of engaging in serious climate protection – and offers explanations based on insights from psychology and other behavioral sciences. In the book, Thomas also outlines why sustainability transitions need to consider behavioral and psychological knowledge (or in other words, why the contents he has been teaching in his decision making courses over the last ten years actually matter).

Thomas uses hands-on examples, humor and self-irony to target a readership also beyond academic bubbles. Cartoons and illustrations by Annechien Hoeben add to the entertaining note of the book and its mission: Communicating one of the central and most serious challenges of our generation with a good sense of humor. Despite this more than promising concept, publishing houses were not exactly queuing up for the manuscript rights. In fact, most of them choose to ignore contact attempts. Fortunately, Thomas’ favorite publishing house in the sustainability sector, Munich-based Oekom Verlag, offered to take over the

project despite rather scanty sales projections. The URBI department agreed to support the project financially.

Eventually, the book was well received by readers, and more importantly, media. To the surprise of everybody, “Die Kunst der Ausrede” was featured on national TV and radio channels, in several major Austrian newspapers, and even in a few German media outlets. One chart from the book went viral on social media (700,000 views and over 4,500 reactions on LinkedIn) and further increased the interest in the book. Thomas was also invited to talk about “climate excuses” during the TEDx event in Haslach in November. With this wave of attention, book sales exceeded the conservative sales projections already after a few months. The first edition was largely sold out by the end of the year, and a second edition forthcoming in early 2023.



Left: Book cover. Right: Thomas and Annechien presenting the book (Credits: Uni Graz/Tzivanopoulos)

3.1 Publications

3.1.1 Monograph

Brudermann, Thomas: Die Kunst der Ausrede. Warum wir uns lieber selbst täuschen, statt klimafreundlich zu leben. München: Oekom 2022.

3.1.2 Edited volume

Gelbmann, Ulrike-Maria; Pirker, Christian; Schöggel, Josef; Weichsler, Lisa (Ed.): Globale Lieferketten. Graz Eigenverlag: Eigenverlag 2022.

3.1.3 Contribution to journal

Berger, Katharina; Schöggel, Josef-Peter; Baumgartner, Rupert J.: *Digital battery passports to enable circular and sustainable value chains: Conceptualization and use cases*, in: Journal of Cleaner Production Volume 353 (2022), 131492. DOI: <https://doi.org/10.1016/j.jclepro.2022.131492>

Diaz, Anna; Reyes, Tatiana; Baumgartner, Rupert J.: *Implementing circular economy strategies during product development*, in: Resources, Conservation and Recycling 184 (2022), 106344. DOI: <https://doi.org/10.1016/j.resconrec.2022.106344>

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- Ilieva, V.; Janeska-Iliev, A.; Debarliev, S.; Nakov, L.; Drakulevski, L.; Brudermann, Thomas: *Knowledge overconfidence among entrepreneurs from Austria and North Macedonia*, in: *Journal of East European Management Studies* 27,2 (2022), 259-279. DOI: doi.org/10.5771/0949-6181-2022-2-259
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3.1.4 Contribution to an edited book

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Gelbmann, Ulrike-Maria; Kolb, Ariane: *Nudging als Mittel zur verringerten Nutzung verpackter Lebensmittel in Supermärkten*, in: Pomberger, Roland, et al. (Ed.), *Recy- und Depotech 2022 Konferenzband*. Leoben: Montanuniversität Leoben 2022, n.a.

Hoeben, Annechien Dirkje: *Überwindung von Zielkonflikten und Förderung von Synergien in der multifunktionalen Waldbewirtschaftung: Auswirkungen auf Bildung in der multifunktionalen Waldbewirtschaftung*, in: Philipp Assinger (Ed.), *Betriebliche Bildung in der Holzwirtschaft Digitalisierung und Kompetenzvalidierung*. Bielefeld: wbv Media GmbH & Co. KG, Bielefeld wbv.de 2022, 31-44. DOI: 10.3278/9783763971589

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Kriechbaum, Michael: *The Global Redox Flow Battery Innovation System: Mapping Knowledge Networks and Search Directions*, in: STRN – Sustainability Transitions Research Network (Ed.), 13th International Sustainability Transitions Conference: *Sustainability Transitions in a Global Context*. online: Conference website 2022, n.a.

Novy, Andreas; Brudermann, Thomas; Frankhauser, Julia; Getzner, Michael; Ohndorf, Markus: *Kapitel 25. Theorien des Wandels und der Gestaltung von Strukturen: Marktperspektive*, in: Görg, C., V. Madner, A. Muhar, A. Novy, A. Posch, K. Steininger und E. Aigner (Ed.), *APCC Special Report: Strukturen für ein klimafreundliches Leben*. Berlin/Heidelberg: SpringerSpektrum 2022, 16.

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- Rauter, Romana; Santa-Maria, Tomas; Schögggl, Josef-Peter: *Sustainable Business Models: State of the Art and Emerging Avenues*, in: Dalia D'Amato, Anne Toppinen, Robert Kozak; (Ed.), *The Role of Business in Global Sustainability Transformations*. London: Routledge 2022, 26-44. DOI: <https://doi.org/10.4324/9781003003588-4>
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- Kettele, Moritz; Schögggl, Josef-Peter; Baumgartner, Rupert: *Circular Companies – Wie Unternehmen die Chancen der Kreislaufwirtschaft nutzen können*. Graz: Green Tech Cluster Styria Green Tech Cluster Styria 2022.
- Schreuer, Anna: *Moving on in life and moving around more sustainably: What key life events of young adults have to do with sustainable mobility*. Graz: climatefootnotes.com (DK Climate Change) climatefootnotes.com (DK Climate Change) 2022.

3.2 Presentations

3.2.1 Oral presentation

- Adam, Raven: *Climate Change coverage in Der Standard*, for: ESS-Idea-Lab, Arijit Paul, Graz (Austria), 23.03.2022.
- Adam, Raven: *Climate protection in Austrian newspapers: An automated content analysis and comparison*, for: 6th International PhD Conference – Digitalization in Science and Society, University of Ljubljana, Ljubljana (Slovenia), 27.10.2022.
- Baumgartner, Rupert J.: *Circular Economy as central element for a sustainable transformation*, for: R&D Day, voestalpine AG, Linz (Austria), 18.10.2022.
- Baumgartner, Rupert J.: *Corporate Sustainability Management in Times of Crises*, for: Trans-Atlantic Research and Development Interchange on Sustainability: Sustainability and Resilience in the Face of Emergent Threats, Tardis, Miskolc (Hungary), 14.09.2022.
- Baumgartner, Rupert J.: *Sustainable Business Practices: Drivers, Agents of Change and Performance*, for: IMES 2022 (Innovation Management, Entrepreneurship and Sustainability Conference), Prague (online) (Czechia), 25.05.2022.

Baumgartner, Rupert J.: *Teilnahme Diskussionsrunde "Kreislaufwirtschaft"*, for: SFG Zukunftstag, Steirische Wirtschaftsförderungsgesellschaft SFG, Graz (Austria), 22.06.2022.

Baumgartner, Rupert J.: *Welchen Beitrag leistet ihr Produkt zu einer nachhaltigen Zukunft?*, for: oberösterreichisches Zukunftsforum, Linz (Austria), 08.03.2022.

Baumgartner, Rupert J.: *Zukunftsmodell Kreislaufwirtschaft*, for: Forum KVP und Innovation: Green Innovation & Good Communication, ÖPWZ, St. Johann/Pongau (Austria), 23.06.2022.

Baumgartner, Rupert J.; Kettele, Moritz; Schöggel, Josef-Peter: *Circular Companies – Wie Unternehmen die Chancen der Kreislaufwirtschaft nutzen können*, for: Green Tech Cluster Seminars, Green Tech Cluster Styria, online (Austria), 28.04.2022.

Berger, Katharina: *Opportunity costs of sharing information along supply chains to enable sustainable product management*, for: 9th International EurOMA Sustainable Operations and Supply Chain Forum, European Operations Management Association, Zagreb (Croatia), 21.03.2022.

Boiger, Theresa: *Effizienz von Holznutzung aus einer Nachhaltigkeitsperspektive*, for: Waldökonomisches Seminar 2022, Münchenwiler (Switzerland), 14.11.2022.

Boiger, Theresa: *Factors of Wood Substitution and their Effects in the Construction Sector*, for: InnoRenew CoE International Conference 2022, Izola (Slovenia), 17.11.2022.

Boiger, Theresa: *SHP2SIM: A Python Pipeline for Modelica based District and Urban Scale Energy Simulations*, for: International Sustainable Energy Conference, Graz (Austria), 06.04.2022.

Boiger, Theresa; Claudia Mair-Bauernfeind; Tobias Stern: *Modeling the sustainability of wood use from a system's perspective*, for: Sustainability Science Days 2022, Helsinki (Finland), 18.05.2022.

Brudermann, Thomas: *"Die Kunst der Ausrede" oder "Keine Ausreden mehr!"*, for: Klimawissen Online aus 1. Hand: Im Video-Chat mit Expertinnen und Experten rund ums Thema Klima, UBZ Steiermark, Online / UBZ Steiermark (Austria), 30.11.2022.

Brudermann, Thomas: *"It is already too late" – The psychology of climate excuses*, for: Public Climate School, Students4Future, Universität Witten/Herdecke, Online / Witten (Germany), 11.11.2022.

Brudermann, Thomas: *25 Ausreden für Klimasünden – Einblicke in die Klimapsychologie*, for: Webinarreihe "Klimawissen online", Ecoversum, online / Ecoversum (Austria), 15.02.2022.

Brudermann, Thomas: *Climate Psychology – Towards creating sustainable choice architecture*, for: EIT Health – iDays Austria 2022, Photonics Austria, Graz (Austria), 21.09.2022.

Brudermann, Thomas: *Climate Psychology: From individual behaviors towards a systemic perspective*, for: AUSTRIAN ENVIRONMENTAL PSYCHOLOGY MEETING, University of Vienna, Vienna (Austria), 12.09.2022.

Brudermann, Thomas: *Die Kunst der Ausrede – Selbsttäuschung statt Klimaschutz*, for: Lectures4Future, Vetmed Uni, Online / Vetmed Wien (Austria), 29.11.2022.

Brudermann, Thomas: *Die Kunst der Ausrede – Selbsttäuschung sticht Verhaltensänderung*, for: Lasst uns reden – Führungsverantwortung in herausfordernden Zeiten. Führungskräftekonferenz des Haus Graz, Campus02, Flughafen Graz (Austria), 15.06.2022.

Brudermann, Thomas: *Die Kunst der Ausrede – Vortrag für OC4CC*, for: OC4CC – Open your course for climate change, Students 4 Future Graz, Graz (Austria), 04.05.2022.

Brudermann, Thomas: *Die Kunst der Ausrede: Selbsttäuschung statt Klimaschutz*, for: Kreislaufwirtschaft für eine nachhaltige Zukunft, Holzinnovationszentrum Zeltweg, Oberwölz (Austria), 06.12.2022.

Brudermann, Thomas: *Die Kunst der Ausrede: Selbsttäuschung statt Klimaschutz*, for: Kreislaufwirtschaft für eine nachhaltige Zukunft, Holzinnovationszentrum Zeltweg, Zeltweg (Austria), 01.12.2022.

Brudermann, Thomas: *Die Kunst der Ausrede: Selbsttäuschung sticht Klimaschutz*, for: Kamingespräch mit Thomas Brudermann, FH Kufstein, Online / FH Kufstein (Austria), 10.11.2022.

Brudermann, Thomas: *Psychologie des Klimawandels (und des Nicht-Handelns)*, for: S4F Akademie, Scientists for future, online / S4F (Austria), 04.03.2022.

Brudermann, Thomas: *Rethinking the role of individual decisions for a sustainable future*, for: The InnoRenew COE International Conference 2022: Rethinking buildings and materials for a sustainable future, InnoRenew COE, InnowRenew Center Izola (Slovenia), 17.11.2022.

Brudermann, Thomas: *Sustainable Development*, for: Nachhaltigkeitstag, Universität Graz, Meerschweinschlössl, Uni Graz (Austria), 08.06.2022.

Brudermann, Thomas: *Umweltfreundlich Denken, umweltschädlich Handeln. Einblicke in Umwelt- und Klimapsychologie*, for: Gastvortrag im Rahmen der Ausstellungsreihe "CLOSE(D) FUTURE", Kunstverein Kärnten, Museum Moderner Kunst Kärnten (Austria), 09.08.2022.

Brudermann, Thomas: *Was steckt hinter unseren Klimaausreden?*, for: TEDx Haslach, Haslach an der Mühl / TEDx (Austria), 25.11.2022.

Fleiß, Eva: *User-oriented Design of Energy Data Platforms*, for: 17th Conference on Sustainable Development of Energy, Water and Environment Systems, Zypern, online (hybrid) (Cyprus), 07.11.2022.

Fleiß, Eva: *User-oriented Design of Open Data Platforms*, for: STS Conference Graz 2022, (Austria), 04.05.2022.

Füllsack, Manfred: *Predicting Change in Integrated Information – on the example of Early Warning Signals in assortative spin-shifting networks*, for: BBS Springschool @ Graz, BBS Springschool @ Graz, Graz (Austria), 08.04.2022.

Gelbmann, Ulrike-Maria: *Nudging als Mittel zur verringerten Nutzung verpackter Lebensmittel in Supermärkten*, for: Recy- und Depotech 2022, Montanuniversität LEoben, Leoben (Austria), 10.11.2022.

Gelbmann, Ulrike-Maria: *Plastik ist nicht böse, böse sind wir*, for: Lectures for the Future, BOKU Wien, online/Wien (Austria), 07.12.2022.

Gelbmann, Ulrike-Maria: *Vorstellung des Projekts UNverpackt*, for: Informationstag Vermeidung von Kunststoffabfällen, Land Steiermark, Abt. 14, Graz online (Austria), 31.03.2022.

Göberndorfer, Lisa; Savanovic, Milica; Jäger, Georg: *Charging Rush Hour*, for: ESS – Idea Lab, University of Graz, Graz (Austria), 30.11.2022.

- Jäger, Georg: *Umweltsystemwissenschaften*, for: Nachhaltigkeitstage, Uni Graz, Graz (Austria), 08.06.2022.
- Jäger, Georg; Göberndorfer, Lisa; Savanovic, Milica: *Nachhaltige Mobilität*, for: Pop-Up Store, Uni Graz, Graz (Austria), 16.05.2022.
- Kettele, Moritz: *Experienced disruptions and mitigation strategies from the Covid-19 crisis in the Austrian dairy supply chain*, for: 29th EurOMA Conference, University of Sussex Business School, Berlin, Germany (Germany), 04.07.2022.
- Kriechbaum, Michael: *The Global Redox Flow Battery Innovation System: Mapping Knowledge Networks and Search Directions*, for: 13th International Sustainability Transitions Conference: Sustainability Transitions in a Global Context, STRN – Sustainability Transitions Research Network, Stellenbosch (South Africa), 21.11.2022.
- Mair-Bauernfeind, Claudia; Boiger, Theresa; Roche, Katharina; Stern, Tobias: *Social Risks in the Wood Processing Industries in Austria – A Generic Analysis of Sectoral Differences*, for: S-LCA Conference 2022, RWTH Aachen University, Aachen (Germany), 07.09.2022.
- Mair-Bauernfeind, Claudia; Kettele, Moritz; Schöggel, Josef-Peter; Meltzer Andreas: *Umweltbewertung im Wandel: von der Produktbewertung zum digitalen Produktpass*, for: URBI Science Talk, Umwelt-, Regional- und Bildungswissenschaftliche Fakultät, Graz (Austria), 03.05.2022.
- Mair-Bauernfeind, Claudia; Wenger, Julia; Stern, Tobias: *SABATLE – Safety Assessment of Flow Battery electrolytes*, for: 2nd BioNanoNet Gold Member Webinar, BioNanoNet, online (Austria), 31.05.2022.
- Paul, Arijit: *theory of business (in)action on climate change*, for: Philosophy of Management 2022 Conference, University of Oxford and University of Greenwich, Oxford, UK (United Kingdom), 02.07.2022.
- Posch, Alfred: *Nachhaltige Mobilitätstransformation in Österreich: Ergebnisse des Forschungsprojektes QUALITY*, for: *Mobilität gestalten: Roadmap zum Umbau des Verkehrssystems*, Österreichische Verkehrswissenschaftliche Gesellschaft, Wien (Austria), 03.05.2022.
- Posch, Alfred: *Sustainable Innovation*, for: *Climate Change Risks in a Changing World*, ARQUS, Seggau (Austria), 27.04.2022.
- Rauter, Romana: *Unternehmerische Nachhaltigkeit und Organisation der Arbeit: Status Quo und Potentiale für die Zukunft*, for: Denkwerkstätte Graz 2022, Graz (Austria), 06.05.2022.
- Roche, Katharina E.: *Supporting sustainable transformations in corporations – Development of a strategic framework linking operational excellence with sustainability*, for: 28th International Sustainable Development Research Society Conference – Sustainable Development and Courage: Culture, Art and Human Rights, International Sustainable Development Research Society, Stockholm (Sweden), 15.06.2022.
- Rusch, Magdalena: *Data Management for Sustainable Product Management in a Circular Economy*, for: Sustainable Development and Courage: Culture, Art and Human Rights, International Sustainable Development Research Society (ISDRS), Stockholm (Sweden), 14.06.2022.
- Rusch, Magdalena: *Information challenges in a circular economy – An empirical investigation of the availability and quality of sustainability-related data in the manufacturing sector*, for: Sustainable Development and Courage: Culture, Art and Human Rights, International Sustainable Development Research Society (ISDRS), Stockholm (Sweden), 15.06.2022.

- Rusch, Magdalena: *The potential of data-science approaches for improving data collection, exchange, and analysis in Life Cycle Assessment*, for: 3rd Life Cycle Innovation Conference – Collaborate, Innovate, Co-create!, Forum for Sustainability through Life Cycle Innovation, Berlin/online (Germany), 30.06.2022.
- Schögggl, Josef-Peter: *Auf dem Weg zur digitalen und nachhaltigen Kreislaufwirtschaft – Herausforderungen, Potentiale und Status Quo*, for: Product Management und Marketing Circle, Plattform für Innovation, VOEST Alpine Stahlwelt, Linz (Austria), 30.03.2022.
- Schögggl, Josef-Peter: *Coming at the circular economy from different angles: a text-mining and contingency-based analysis of 3000 projects*, for: 28th International Sustainable Development Research Society Conference, Stockholm (Sweden), 17.06.2022.
- Schögggl, Josef-Peter: *Nachhaltige Produktentwicklung am Beispiel der Automobilindustrie: qualitative und quantitative Ansätze im Kontext des Eco-Design Paradoxons*, for: Sustainability Challenge 2022, Universität Graz, Graz (Austria), 30.03.2022.
- Schögggl, Josef-Peter: *Sectoral differences in the circular economy implementation of Austrian manufacturing firms*, for: Recy-Depotech Konferenz, Montanuniversität Leoben, Leoben (Austria), 10.11.2022.
- Schögggl, Josef-Peter; Rusch, Magdalena; Berger, Katharina: *Sustainable product management in a circular economy – the role of digital technologies and collaboration*, for: Forschungsberichte am Montag, TU Wien (Institut für Wassergüte und Ressourcenmanagement) und die BOKU (Institut für Abfallwirtschaft), Wien/online (Austria), 27.06.2022.
- Schreuer, Anna: *Escaping carbon lock-in to frequent flying in academia: An exploration of the room for manoeuvre of universities*, for: 20th Annual STS Conference Graz 2022 “Critical Issues in Science, Technology and Society Studies”, TU Graz, IFZ, Graz (Austria), 04.05.2022.
- Stern, Tobias: *Bioeconomy related Innovation and Transition*, for: Climate Change Risks in a Changing World – ARQUS, Universität Graz, Seggau (Austria), 28.05.2022.
- Stern, Tobias: *Holzbasierte Bioökonomie der Zukunft: Potenziale, Risiken und Herausforderungen*, for: Netzwerkempfang Bioeconomy Austria, Bioeconomy Austria, Wien (Austria), 08.11.2022.
- Stern, Tobias: *In stürmischen Zeiten: Chancen für Wald und Holz in der Krise erkennen*, for: 26. Internationales Holzbau-Forum (IHF) 2022, FORUM HOLZBAU, Innsbruck (Austria), 02.12.2022.
- Stumpf, Lukas: *Sustainability Encounters Vol 1: Decarbonising events*, for: Sustainability Encounters Vol 1: Decarbonising events, PlanA, Berlin (Germany), 07.07.2022.
- Stumpf, Lukas; Schögggl, Josef-Peter; Baumgartner, Rupert J.: *Adapting circular packaging design from an absorptive capacities’ perspective – theoretical perspectives and practical insights*, for: Sustainable Development and Courage: Culture, Art and Human Rights, International Sustainable Development Research Society, Stockholm (Sweden), 15.06.2022.
- Thaller, Annina: *Klimawandel und Mobilität*, for: Writers in Climate (Crisis), Tint Journal, Graz (Austria), 19.08.2022.
- Thaller, Annina: *Low-carbon and policy-driven behavior change: Insights from passenger transport*, for: Climate Change Risks in a Changing World, ARQUS, Seggau (Austria), 28.04.2022.

- Thaller, Annina: *Low-carbon mobility behavior and policy options*, for: Austrian Environmental Psychology Meeting, Environmental Psychology Vienna, Universität Wien (Austria), 12.09.2022.
- Thaller, Annina: *Sustainable mobility behavior and policy-driven behavior change*, for: WIPOL – Wirtschaftspolitische Akademie, SpaceLend Graz (Austria), 12.04.2022.
- Thaller, Annina: *Verkehr und Klimakrise: Wie nachhaltige Mobilität gelingen kann*, for: Europäische Mobilitätswoche, Klimabündnis Österreich, Online (Austria), 16.09.2022.
- Trimmel, Katharina: *Potentially adverse effects of low-carbon transitions: Analysing narratives associated with Austrian climate policies*, for: International Sustainability Transitions Conference, Stellenbosch University, Monash University and Georgetown University, online (South Africa), 21.11.2022.
- Trimmel, Katharina: *Potentially adverse effects of low-carbon transitions: Analysing narratives associated with Austrian climate policies*, for: Symposium Konsum Neu Denken, Universität für Bodenkultur Wien, Universität für Bodenkultur Wien (Austria), 23.09.2022.
- Trimmel, Katharina: *Representations and proposed measures of political parties on climate change: Vienna provincial and municipal elections in October 2020*, for: STS Conference Graz 2022, Technische Universität Graz, Graz (Austria), 04.05.2022.
- Vogeler, Georg; Füllsack, Manfred;: *AI und Kultur*, for: PopUp-Store, Uni Graz, Graz (Austria), 26.04.2022.

3.2.2 Poster presentation

- Berger, Katharina; Baumgartner, Rupert; Weinzerl, Martin; Bachler, Johann; Schöggel, Josef-Peter: *What should a digital battery passport contain? – An investigation of the data needs and requirements of potential users*, for: Batterieforum Deutschland, Kompetenznetzwerk Lithium-Ionen-Batterien e. V., Online (Germany), 2022.
- Brohmer, H., Köstenbaumer, D., Thaller, A., Fleiß, E., Posch, A., Athenstaedt, U.: *Changing behavior while having climate change in mind? An investigation of social-psychological predictors for specific pro-environmental behaviors in the energy domain*, for: Tagung der Oesterreichischen Gesellschaft für Psychologie, OeGP, Klagenfurt (Austria), 2022.
- Gelbmann, Ulrike-Maria, Edlinger, Julia, Holzer, Christoph: *Das Unverpackt-Regal und die Sicht der Kund*innenauf die Vermeidung von Verpackungen im Supermarkt*, for: REcy- und Depotech 2022, Montanuniversität Leoben, Leoben (Austria), 2022.
- Hoeben, Annechien Dirkje; Brudermann, Thomas: *Ausreden für Klimasünden: Über den Umgang mit kognitiven Dissonanzen bei individuellen Klimaschutzbemühungen und nachhaltigen Lebensstilen*, for: Symposium zu Suffizienz, Wien 2022 Symposium Konsum Neu Denken, Institut für Marketing und Innovation Universität für Bodenkultur, Wien (Austria), 2022.
- Hoeben, Annechien Dirkje; Brudermann, Thomas: *Warum ist es so schwer, klimafreundlich zu handeln? Erklärung von Konzepten aus der Klimapsychologie mit Cartoons*, for: Brennpunkt WissKomm22, Wissenschaftskommunikation, Graz (Austria), 2022.
- Jäger, Georg; Göberndorfer, Lisa; Savanovic, Milica: *E-Mobilität = Nachhaltige Mobilität?*, for: Lange Nacht der Forschung, Uni Graz, Graz (Austria), 2022.
- Jäger, Georg; Göberndorfer, Lisa; Savanovic, Milica: *Nachhaltige Mobilität*, for: Pop-Up Store, Uni Graz, Graz (Austria), 2022.

3.3 Media

3.3.1 Media article

- Brudermann, Thomas: *Mit gutem Gewissen in die Klimakrise*, Die BRÜCKE Nr. 30, S. 18-19, print, 01.09.2022.
- Brudermann, Thomas; Axmann, Thomas (Moderation): *Klimaexperte Prof. Thomas Brudermann im Gespräch mit den Antenne Steiermark Muntermachern*, Antenne Steiermark, radio, 08.11.2022.
- Brudermann, Thomas; Baumeister, Daniella: *Thomas Brudermann über die "Kunst der Ausrede"*, hr2 – Sendung hr2-kultur, radio, 06.09.2022.
- Brudermann, Thomas; Bayer, Lukas (Interview & Artikel): *Ausreden für Klimasünden: Die Erderwärmung schönreden*, Arbeit&Wirtschaft, print, internet, 28.09.2022.
- Brudermann, Thomas; Belazzi, Thomas (Interview): *Die Kunst der Ausrede – Interview mit Assoz. Prof. Dipl.-Ing. Dr. Thomas Brudermann, Umweltpsychologe am Institut für Umweltsystemwissenschaften, Universität Graz*, bauXund, internet, 09.12.2022.
- Brudermann, Thomas; Benini, Sandro (Interviewer): *Interview zu Needle-Spiking: "Gegen soziale Panik ist niemand gefeit"*, Tages-Anzeiger, print, internet, 30.08.2022.
- Brudermann, Thomas; Deckner, Simone (Interviewerin): *Wir ignorieren Fakten, die nicht zu unserem Weltbild passen*, Hinz und Kunzt, print, internet, 29.09.2022.
- Brudermann, Thomas; Faber, Annegret (Interview & Redaktion); Kühn, Kathrin (Moderation): *Aus Kultur- und Sozialwissenschaften*, Deutschlandfunk, radio, 29.09.2022.
- Brudermann, Thomas; Falser, Alexander; Podszus, Ralf (Moderation): *12. Dezember 2022: Die Kunst der Ausrede, 5 Tassen täglich – der Tchibo Podcast*, internet, other media type, 12.12.2022.
- Brudermann, Thomas; Franke, Sarah (Interviewerin): *"Ich tue doch schon etwas": Warum wir uns beim Klimaschutz so oft selbst täuschen*, RND / Dresdner Neueste Nachrichten / Göttinger Tagblatt / Hannoversche Allgemeine / Leipziger Volkszeitung / Märkische Allgemeine / Neue Presse / Kieler Nachrichten / Lübecker Nachrichten / Peiner Allgemeine / Schaumburger Nachrichten, print, internet, 25.09.2022.
- Brudermann, Thomas; Franke, Sarah (Interviewerin): *Klimapsychologe im Interview – Warum wir uns beim Klimaschutz so oft selbst täuschen*, Redaktionsnetzwerk Deutschland / Kölner Stadtanzeiger / Landeszeitung für die Lüneburger Heide / Oberhessische Presse / Ostsee Zeitung / Winsener Anzeiger / Wolfsburger Allgemeine Zeitung, print, internet, 25.09.2022.
- Brudermann, Thomas; Hacker, Miriam (Interview): *Alles nur Ausrede: Warum uns nachhaltiges Handeln so schwerfällt*, ECO* Journal, print, internet, 08.11.2022.
- Brudermann, Thomas; Hoeben, Annechien (Illustrationen); Stachl, Markus (Redaktion & Interview); Feuerstein, Christoph (Moderation): *Welt im Wandel – was bringt ein klimafreundlicher Lebensstil?* (ORF Thema), ORF2, television, 07.11.2022.
- Brudermann, Thomas; Kakl, Horst (Interviewer): *Zubetonieren und zersiedeln: »Im Lavanttal gäbe es aus Sicht der Nachhaltigkeit noch einiges zu tun«*, Unterkärntner Nachrichten, print, 07.09.2022.
- Brudermann, Thomas; Oster, Carmen (Interviewerin): *Warum wir in Sachen Klimaschutz nie um eine Ausrede verlegen sind*, Kleine Zeitung, print, internet, 18.09.2022.

Brudermann, Thomas; Polsinger, Daniel (Interviewer): *Lavanttaler Autor nimmt unsere Klima-Ausreden unter die Lupe*, MeinBezirk.at, internet, 05.09.2022.

Brudermann, Thomas; Walch, Gregor (Redaktion); Mader, Nadja (Moderation): *Aktuell nach Eins – Psychologe zu Energiespar-Tipps*, ORF2, television, 15.09.2022.

Brudermann, Thomas; Wanko, Martin (Interviewer): *Ausreden sind menschlich.*, 40 Plus – Periodikum für alle Lesenden, internet, 23.11.2022.

Brudermann, Thomas; Zeithammer, Barbara (Moderatorin): *Denken Sie auch, dass Sie das Klima nicht retten werden?*, Ö1 – Punkt Eins, radio, 05.09.2022.

Gelbmann, Ulrike-Maria: *Recycling von Plastik*, Ö1 Mittagsjournal, radio, 14.04.2022.

3.3.2 Mentioned in media

Baumgartner, Rupert J.; Schöggel, Josef-Peter in: Steffen Roos, Prof. Baumgartner: *Produktentwicklungsprozesse sind zu selten strategisch aufgesetzt*, Detecon Journal, internet, social media, 31.01.2022.

Brudermann, Thomas in: *Buchtipp: Moderne Selbsttäuschung*, WALDDÖRFER UMWELTZEITUNG, internet, 12.08.2022.

Brudermann, Thomas in: Christine Mayrhofer, *Klimaschutz? Um keine Ausrede verlegen*, Die Presse, print, internet, 18.09.2022.

Brudermann, Thomas in: Christine Mayrhofer, *Klimaschutz? Um keine Ausrede verlegen*, MSN, internet, 16.09.2022.

Brudermann, Thomas in: Gerlinde Pölsler, *Neue Bücher*, Falter 51-52/22, print, internet, 21.12.2022.

Brudermann, Thomas in: Haarmann, Tim, *So schlimm wird es schon nicht*, Spektrum der Wissenschaft, print, internet, 09.11.2022.

Brudermann, Thomas in: Hanno Settele (Moderation); BFilm (Redaktion, Produktion), ORF DOK1 – *Das Ende der Wende?*, ORF 1, television, 02.11.2022.

Brudermann, Thomas in: Jochen Stadler, *Psychologe entblößt in Buch Ausreden für klimaschädliches Verhalten*, Austria Presse Agentur, internet, 08.09.2022.

Brudermann, Thomas in: *Kreislaufwirtschaft für eine nachhaltige Zukunft?*, Murtalinfo.at, internet, 12.12.2022.

Brudermann, Thomas in: McCain, *Knowledge about buildings and materials for a sustainable future was exchanged at the conference*, Slovenia Posts English, internet, 21.11.2022.

Brudermann, Thomas in: *Na konferenci izmenjali znanja o stavbah in materialih za trajnostno prihodnost*, Sta Znanost, internet, 21.11.2022.

Brudermann, Thomas in: Neu: *“Die Kunst der Ausrede”*, Der Grazer, print, 18.09.2022.

Brudermann, Thomas in: Ralf Julke, *Die Kunst der Ausrede: Wie unser Gehirn uns mit Ausreden austrickst, damit es seine Routinen nicht ändern muss*, Leipziger Zeitung, print, internet, 25.11.2022.

Brudermann, Thomas in: Reinhold Gruber, *“Wir wollen das Klimathema aufs Land holen”*, OÖ Nachrichten, print, internet, 20.11.2022.

Brudermann, Thomas in: Reinhold Gruber, *In Haslach wird über das Klima geredet*, OÖ Nachrichten, print, internet, 21.11.2022.

Brudermann, Thomas in: Sabine Bretschneider, *Alles fast nur halb so schlimm*, Medianet News, print, internet, 09.09.2022.

Brudermann, Thomas in: *Thomas Brudermann: Die Kunst der Ausrede*, Oberösterreichisches Volksbaltt, print, internet, 17.09.2022.

Brudermann, Thomas in: *V raziskovalnem inštitutu InnoRenew CoE uspešno organizirali mednarodno konferenco o stavbah in materialih za trajnostno prihodnost*, SI24 News, internet, 21.11.2022.

Brudermann, Thomas; Hoeben, Annechien in: Bayer, Lukas, *Richtig über die Klimakrise reden: Wie du mit Familie und Freund:innen übers Klima sprechen solltest*, moment.at, internet, 05.09.2022.

Brudermann, Thomas; Hoeben, Annechien in: Carolina Kucher, *Warum schaffen wir es oft nicht, klimafreundlich zu leben?*, 5Minuten.at, internet, 13.09.2022.

Posch, Alfred; Rauter, Romana in: Elisabeth Zöckl, Wolfgang Tropf, *ABTA: Der ökologische Fußabdruck wird zum Maß aller Dinge*, travel management austriaDas österreichische Fachmedium für Business Travel & MICE, internet, 24.11.2022.

Posch, Alfred; Rauter, Romana in: Zöckl, Elisabeth, *Wirksame CO2-Maßnahmen statt Greenwashing wird zur Realität*, T.A.I. Tourist Austria International, print, 16.12.2022.

Posch, Alfred; Steininger, Karl in: Julia Beirer, *Mehr Wandel fürs Klima*, Der Standard, print, 16.12.2022.

3.4 Events

3.4.1 Organization of an academic event

Baumgartner, Rupert J.; Cabezas, Heriberto; Deák, Csaba; Diwekar, Urmila: *Trans-Atlantic Research and Development Interchange on Sustainability: Sustainability and Resilience in the Face of Emergent Threats*, Miskolc, Hungary, 14.09.2022 – 16.09.2022.

Paul, Arijit and Mintz-Woo, Kian: *Moral judgment and climatechange*, Online, Austria, 03.02.2022 – 04.02.2022.

Posch, Alfred: *Stakeholderworkshop "Die Zukunft des Flugverkehrs"*, Online, Austria, 20.09.2022 – 20.09.2022.

Posch, Alfred: *Vernetzungstreffen WEGBEREITER*, St. Ruprecht an der Raab, Austria, 12.10.2022.

Stern, Tobias: *17. Waldökonomisches Seminar«Effizienz – Ein geeignetes Konzept für die Waldwirtschaft?»*, Münchenwieler, Switzerland, 14.11.2022 – 16.11.2022.

3.4.2 Participation in an academic event

Aschemann Ralf: *Policy Making or Policy Faking?*, Oikos Graz, Graz, Austria, 23.04.2022. (continuing education)

Aschemann Ralf: *Urban Future 22*, UFCC GmbH, citychangers.org, Helsingborg, Sweden, 01.06.2022 – 03.06.2023.

Gelbmann Ulrike-Maria: *Öffentlichkeitsarbeit als Chance*, URBI Fakultät, Graz, online, Austria, 13.01.2022. (continuing education)

Gelbmann Ulrike-Maria: *Symposion Sozialpädagogik*, Institut für Erziehungs- und BildungswissenschaftArbeitsbereich Sozialpädagogik, Graz, Austria, 23.06.2022.

Malin Christine Dagmar, Polzer Anna, Zeiringer Johannes, Königstorfer Florian, Zenkl Thomas, Adam Raven, Krusic Lucija, Thalmann Stefan, Staudegger Elisabeth: *6th International PhD Conference – Digitalization in Science and Society*, University of Ljubljana, Ljubljana, Slovenia, 27.10.2022 – 28.10.2022.

Posch Alfred, Rauter Romana: Business Travel Lounge Wien, Austrian Business Travel Association, Wien, Austria, 23.11.2022.

Posch Alfred: 15. Klimaforum: "Mehr Power für den Klimaschutz – Bürger*innenbeteiligung: wenn die Basis mitbestimmt"., CCCA, Graz, Austria, 26.09.2022.

Rusch Magdalena: Arqus Workshop on Service Learning: Teaching a service-learning course: Introduction, benefits, practical guidelines, Arqus (European University Alliance) & University of Graz (Department of Academic Services), Graz/online, Austria, 05.07.2022. (continuing education)

Rusch Magdalena: How do we innovate beyond what we know and can imagine!, UNICORN – Start-up & Innovation Hub & Emergent Futures Lab, Graz, Austria, 28.06.2022. (continuing education)

Rusch Magdalena: oikos International Chapter Conference Graz 2022, oikos Graz, Graz, Austria, 22.04.2022 – 24.04.2022. (continuing education)

Rusch Magdalena: Verständlichkeitstraining für WissenschaftlerInnen, Universität Graz; Sonja Burger, Graz/online, Austria, 12.04.2022. (continuing education)

Rusch Magdalena: Workshop: Profitability & Circularity through Data, Know-Center Graz, online, Austria, 15.11.2022.

Schreuer Anna: Erste österreichische Social Economy Konferenz, RCE Graz-Styria – Zentrum für nachhaltige Gesellschaftstransformation, Graz, Austria, 24.11.2022 – 24.11.2022. (academic, continuing education)

Stumpf Lukas: Sustainability Encounters Vol. 1, PlanA, Berlin, Germany, 07.07.2022 – 07.07.2022. (continuing education)

Vogrin Michael, Schmickl Thomas, Reisinger Daniel, Maia de Oliveira Wood Guilherme: Social Simulation Conference 2022, European Social Simulation Association (ESSA), Milan, Italy, 12.09.2022 – 12.09.2022.

3.4.3 Holding an academic event

Jäger Georg; Savanovic Milica; Göberndorfer Lisa: Lange Nacht der Forschung, Universität Graz, 20.05.2022.

Posch, Alfred: Co-Evaluation Stakeholder-Workshop APCC Special Report: Strukturen für ein klimafreundliches Leben, CoChairs: Christoph Görg, Verena Madner, Andreas Muhar, Andreas Novy, Alfred Posch und Karl Steininger Koordination: Ernest Aigner, 06.04.2022 – 06.04.2022.

3.5 External Scientific Functions

Reviews were undertaken for the following journals.

- Applied Sciences
- Biomass and Bioenergy
- Business and Society
- Business Strategy and Development
- Business Strategy and the Environment
- California Management Review
- Computational and Mathematical Organization Theory
- Corporate Social Responsibility and Environmental Management

- Ecological Indicators
- Energies
- Energy Efficiency
- Energy Policy
- European Journal of Forest Research
- European Journal of Wood and Wood Products
- Forest Products Journal
- Gaia: oekologische Perspektiven in Natur-, Geistes- und Wirtschaftswissenschaften
- International Journal of Environmental Research and Public Health
- International Journal of Transitions and Innovation Systems
- International Wood Products Journal
- Journal of Business Ethics
- Journal of Cleaner Production
- Journal of Computational Methods in Sciences and Engineering
- Journal of Economic Psychology
- Journal of Industrial Ecology
- Longe Range Planning
- Scandinavian Journal of Management
- Science and Public Policy
- Sustainability
- Sustainable Development
- Sustainable Production and Consumption
- Systems Research and Behavioral Science
- Technovation
- Urban Forestry and Urban Greening
- Utilities Policy

3.6 Institute of Environmental Systems Sciences Reports

In 2012 the institute decided to issue a report series of its own, called "Institute of Environmental Systems Sciences Report." The series is dedicated to disseminating interesting scientific results from institute members and their colleagues as well as from excellent students. The aim is to provide a means of publication that works more quickly than journals would and an opportunity to publish excellent research work that has not been published in other ways. This includes research reports, excellent master's or Ph.D. theses as well as collections of papers from conferences (conference proceedings) or excellent reports from teaching projects. The series appears at irregular intervals. It bears an ISSN number and is available in the form of hard copies and especially as a pdf online on our website. The language of publication is German or English.

3.6.1 Published reports

- ESS Report #1: Florian Hold, Informelle Abfallwirtschaft in Österreich – Chancen, Risiken und Praxis. Graz, October 2012 (in German).

- ESS Report #2: Maximilian Mrotzek, Andreas Kreuzeder, Walter Gössler (Eds): Phosphorus: Papers of an Interdisciplinary Practical Training at the University of Graz. Graz, January 2013 (in English).
- ESS Report #3: Manfred Füllsack (Ed.): Networking Networks. Graz, May 2013 (in English).
- ESS Report #4: Rauter, R., Gsodam, P., Nguyen, T. D., Stabauer, P., Baumgartner, R. J.: New Business Models in Austria -Forerunners in Sustainable Economics. Graz, October 2013 (in English).
- ESS Report #5: Gastinger, B.: Biologische Abfallbehandlung in der Steiermark und ihr Beitrag zum Klimaschutz. Graz, December 2013 (in German).
- ESS Report #6: Baumgartner, R.J., Gelbmann, U., Rauter, R. (eds.): Making the Number of Options Grow. Contributions to the Corporate Responsibility Research Conference 2013. Graz, January 2014 (in English).
- ESS Report #7: Rauter, R., Globocnik, D., Perl-Vorbach, E., Baumgartner, R. J.: Open Innovation und Nachhaltigkeit. Bedeutung von Kooperationen und formalen Managementpraktiken zur Steigerung des nachhaltigkeitsorientierten und wirtschaftlichen Innovationserfolgs. Graz, November 2015 (in German).
- ESS Report #8: Rauter, R., Zimek, M., Kiesnere, A. L., Baumgartner, R. J.: Exploring a changing view on organizing value creation: Developing New Business Models. Graz, June 2017.
- ESS Report #9: Baumgartner, R.J., Damert, M., Fritz, M.M.C., Schöggel, J.-P.: IP Sustainability in Global Supply Chains: A stakeholder perspective. Graz, September 2017.
- Report #10: Rauter, R., Stern, T.: Research Project Innovation Management: Die Digitalisierung der Arbeitswelt. Graz, September 2019.

3.7 Prices and Awards

3.7.1 Hans Roth Environmental Award

Nora Kober, MA (Global Studies) received the Hans Roth Environmental Award 2022 for her master thesis, in which she developed an evaluation tool for innovation projects as a decision support for companies.

<https://ess.uni-graz.at/de/neuigkeiten/detail/article/nora-kober-wurde-mit-dem-hans-roth-umweltpreis-ausgezeichnet/>

4 Teaching

4.1 Study Programs

4.1.1 Environmental Systems Sciences

In teaching, our institute is the focal institute for the bachelor and master study programs in Environmental Systems Sciences (USW – Umweltsystemwissenschaften) with its four subject foci: business administration (respectively sustainability oriented management), economics, geography, and NAWI-Tech.

NAWI-Tech is the newest of all subject foci and was established in 2012. This unique study program is provided by University Graz (KFUG) and Graz University of Technology (TUG) in their joint activity Natural Sciences. This study (USW Nawi-Tech) replaces the former subject foci physics and chemistry and is focusing predominantly on the aspects of natural sciences in the discussion of sustainability (for further information, please see: <http://www.nawigraz.at/>).

The main idea of these study programs is to generate interdisciplinary trained academics that are able to handle complex problems that are related to environmental protection and/or to the broader concept of sustainable development of different systems. Here, the capability to apply formal methods of systems sciences, in-depth knowledge in the respective subject focus and profound competencies for working in interdisciplinary teams are the most important cornerstones of the profile of graduates in Environmental Systems Sciences.

The roots of the study programs in Environmental Systems Sciences go back to 1991 when the first individual diploma studies were developed. Continuously increasing interests by students and high dedication of some professors finally led to the implementation of regular bachelor and master study programs in October 2003 which are still unique in its conception in Europe. Now, about 1,000 students are enrolled in the bachelor and master programs in Environmental Systems Sciences; the bachelor programs comprise 180 ECTS credit points which equals a study period of six semesters, and the consecutive master programs 120 ECTS credit points, or four semesters.



Our institute is responsible for the education in formal methods of systems sciences, mathematics and statistics, interdisciplinary education for basics in human-environment systems, for parts of the teaching subject business administration (bachelor level), for the teaching subject sustainability-oriented management (master level), and last but not least for the interdisciplinary practical courses. The latter is a special and unique course type where an interdisciplinary team of teachers and students with different subject foci work together on a

complex real-world problem for sustainable development of a certain system. Interdisciplinarity and transdisciplinary are part of the teaching concept, aiming at the integration of stakeholders from outside the University in order to initiate a mutual learning process between academics and practitioners.

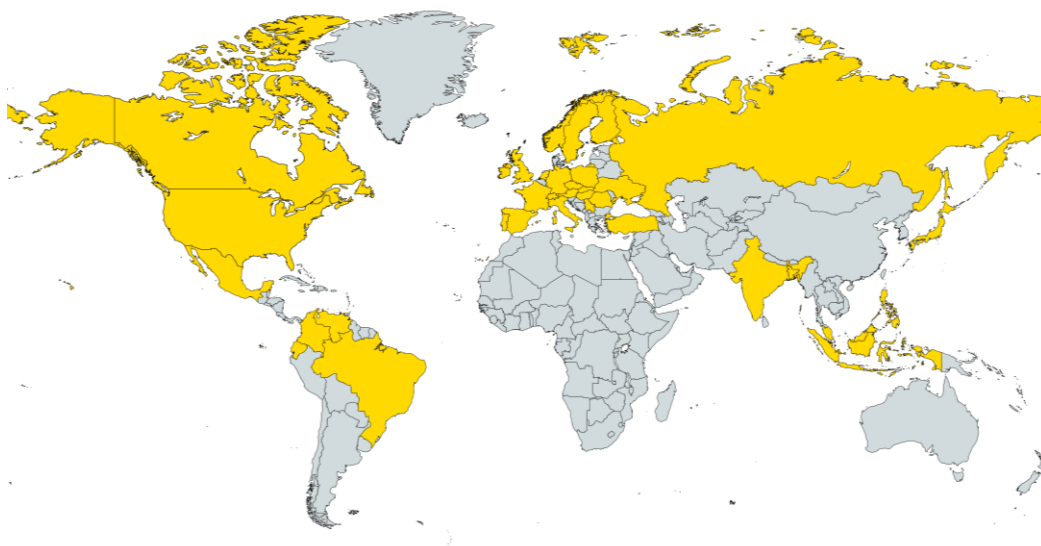
Comprehensive information on Environmental Systems Sciences can be found at <http://umweltsystemwissenschaften.uni-graz.at> or www.umweltsystemwissenschaften.at.

4.1.2 Joint International Master's Program in Sustainable Development

In this Master, sustainability issues are approached from an international as well as inter- and transdisciplinary perspective. The program combines the strengths of six partner universities: Graz, Leipzig, Venice and Hiroshima are possible entrance universities, University of Basel and Utrecht University are mobility partners.

One unique feature of the program is that one specialization track is completed during a mandatory mobility semester at one of the other entrance universities or one of the mobility partners. Students therefore profit from a wide range of perspectives on sustainable development and the specific focus offered by at least two universities. Alumni of the program usually work as sustainability experts in the private, public and semi-public sectors, or head for an academic career by pursuing a PhD related to sustainable development.

In 2022, 16 students from nine different countries started the program in Graz. We were happy to extend the geographical range of our community by welcoming our first students from the Philippines, Singapore and Japan.



The map shows the nationalities of the students in the last 10 years. Nationalities of incoming students from the partner universities are not included in this map.



Left: Welcome meeting for new students in September 2022. Right: Imke, Rahel and Amra with greetings from their mobility semester at Hiroshima University.

Admission to this Master is granted to students who have completed at least the equivalent of a Bachelor's or Diploma degree, and can demonstrate their research skills, their basic knowledge of the natural and/or social sciences, and a general insight in the subject of sustainable development and intervention strategies. The program comprises 120 ECTS credits corresponding to a period of study of at least four semesters or two years. At least 60 ECTS credits have to be earned at the home university. Students are required to complete at least 30 ECTS credits at one of the partner universities. Besides the consortium coordination, our institute offers basic and advanced courses related to Sustainable Development, as well as courses related to corporate sustainability management and innovation research.

For students of our partner universities we provide two specialization tracks: *Corporate Sustainability Management*, and *Innovation and Transition Management*. Master theses are generally assessed by two professors of two different partner universities.

Comprehensive information on the Joint International Master's Program in Sustainable Development can be found at www.jointdegree.eu/sd. The students of the program also operate a website – see <https://sustainers-graz.weebly.com/>.

4.1.3 Erasmus Mundus “International Master’s Program on Circular Economy”

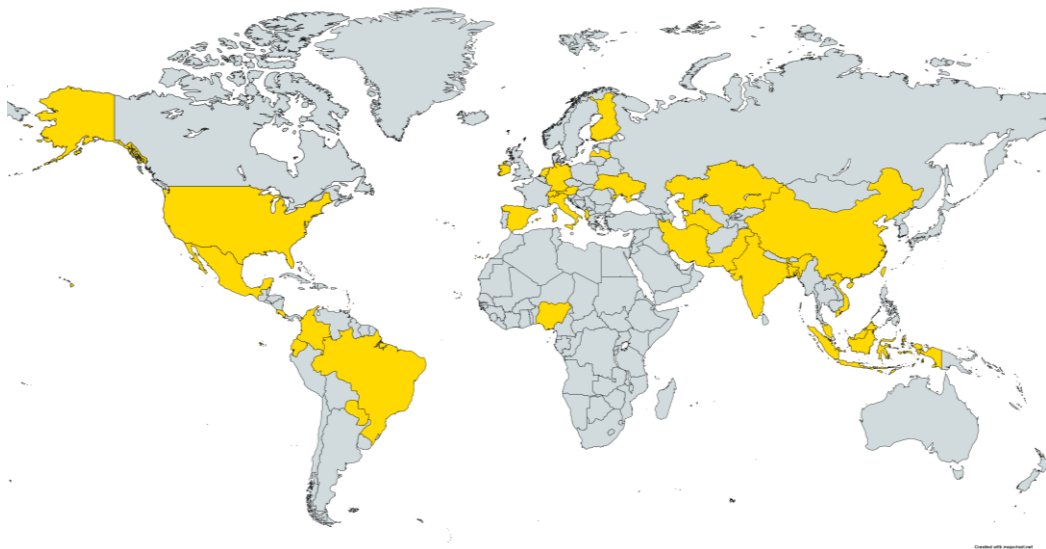


Beside the International Joint Master's Program in Sustainable Development and the 2017 completed “Erasmus Mundus Master's Program in Industrial Ecology”, the Erasmus Mundus “International Master's Program on Circular Economy (CIRCLE)” is already the third Joint Master Program coordinated by our institute. At first, the funding of the European Commission lasts until 2024 and consists of 62 scholarships for four intakes of students (which have started 2019, 2020, 2021 or 2022, respectively), which have to be selected by the CIRCLE consortium. As the curriculum of CIRCLE is designed as “Erasmus Mundus Double Master Degree”, its students have to study at two different European universities from the consortium and will then be awarded with a double degree from those.



Fresh graduates of the second CIRCLE intake.

Dr. Ralf Aschemann is coordinating the CIRCLE program and Ulrike Krawagna and Anja Hoffmann from the Office for International Relations support all its administrative issues. Partners in the consortium are Leiden University and Delft University of Technology (Netherlands); Chalmers University of Technology Gothenburg (Sweden); and Norwegian University of Science and Technology (Norway). Moreover, three universities outside Europe are partners for an additional mobility, namely Curtin University (Australia); Waseda University (Japan) and Tsinghua University (China).



The map shows the nationalities of the students (all generations).

From 7 to 12 August 2022, three intakes of CIRCLE students (the second, third and fourth generation) met face-to-face for their orientation week, summer school and graduation ceremony, organized in Kamerik in the Netherlands. The fresh graduates of the second CIRCLE intake are pictured in the photo!

For more information on CIRCLE, please browse to <https://www.emcircle.eu>.

4.1.4 Global Studies

ESS, together with the dean's office, has overseen managing the three master programs "Global Studies" at the University of Graz since 2020. The program consists of three comprehensive and diverse curricula that source their courses from all six of the university's faculties and an additional six interfaculty centers. Global Studies have developed since 2010 in a growth process supported by the commitment and interest of researchers, lecturers, and students at our university in cooperation with external organizations. The KoBü Coordination Office for Environmental Systems Sciences and now Global Studies has been taking care of about 350 master's students from the three programs contained in the Global Studies 2022.

On June 22nd 2022, we celebrated "10 plus 2 years" of Global Studies in a fine event at the main auditory with some 120 people in attendance, enjoying nice food, great music, and celebrating our students, lecturers, and our partnerships.

The programs bundle the professional expertise of the University of Graz in the fields of globalization and (sustainable) development. Fighting poverty, world hunger, education, environmental protection, human rights, worldwide production and working conditions, diversity and gender, peace, and justice etc. are central contents, which also corresponds to the "Sustainable Development Goals" of the United Nations. Global Studies prepare students to think and act holistically in an increasingly complex, dynamic globalized world.

To this end, Global Studies are inter- and multidisciplinary. The knowledge and competences achieved enable graduates to professionally analyze the numerous international and intercultural challenges that society is currently facing due to globalization. In their studies, students develop the sensitivity and integrated way of thinking required in a wide variety of multicultural settings.

The three programs build on different preceding bachelor programs and offer a respective focus on either Economics, Business and Environment or Law and Politics or Society and Culture. In October 2022, new curricula were launched, basically continuing the preceding ones, but smoothing out existing "rough spots". Still, in each of the three programs students can choose from several disciplinary specializations and additionally from interdisciplinary modules designed to broaden mindsets and guarantee for an outside the box perception. To this end, the "master modules plus" were fully integrated as another option. Furthermore, all students have a to organize a compulsory internship for themselves in Austria or abroad and they have to partake in a supervised Interdisciplinary Practical Training IP.

Our alumni find their jobs in governmental and non-governmental organizations, enterprises, educational institutions or quite often make their own way in self-employment of founding companies themselves.

4.1.5 Doctoral School for Environmental Systems Sciences

In October 2011, the new Doctoral School for Environmental Systems Sciences was founded. The main goal is to provide high-quality education for our PhD-students in the field of environmental systems sciences. The study program is based either on the curriculum for

interdisciplinary environmental systems sciences or on the curriculum for environmental systems sciences focused on natural science. The thesis has to be cumulative based on three peer-reviewed journal publications instead of writing a monograph. This form of a dissertation complies with international scientific standards and ensures that the valuable results achieved by our PhD-students are presented to an international audience.

4.1.6 Doctoral Program DK Climate Change

In the winter semester 2014, the interdisciplinary doctoral program *DK Climate Change* has been launched. The program is a joint effort of researchers associated with the University of Graz's research core area "Environment and Global Change." Univ.-Prof. Lukas Meyer (Department of Philosophy) serves as a speaker for the program and Univ.-Prof. Dr. Gottfried Kirchengast (Wegener Center for Climate and Global Change) serves as co-speaker. Two faculty members are affiliated with our institute: Univ.-Prof. Dr. Rupert Baumgartner and Univ.-Prof. Dr. Alfred Posch. The program is supported by Mag. Karin Osibow. The selected postgraduate students will be employed for 3 years in pre-doc research positions with the option to extend their employment by half a year if they choose to spend at least 6 months at one of the program's partner universities.

The program is funded by the Austrian Science Fund (FWF). Detailed information on the aims of the program, as well as information on all projects and involved researchers, can be found on the following website: <http://dk-climate-change.uni-graz.at/en/>.

4.2 Completed and submitted theses

4.2.1 Doctoral theses

In 2022, six doctoral theses have been completed within the doctoral school for Environmental Systems Sciences, which was founded in October 2011. They are listed in alphabetical order.

Derler, Hartmut (2022): We are what we eat: inter- and transdisciplinary research toward the establishment of sustainable food systems

Supervisor: Posch Alfred

Hornischer, Hannes (2022): Self-Organization and Maximizing Options – An investigation of a general modeling approach applied to decentralized robotic swarms.

Supervisor: Füllsack Manfred

Plakolb, Simon (2022): Model based decision support for low carbon transport. Leveraging large scale network research with parallel computing

Supervisor: Füllsack Manfred

Santa Maria Gonzalez, Tomas (2022): Business Model Innovation for the Circular Economy: What is known, how it happens and how to facilitate

Supervisor: Baumgartner Rupert

Thaller, Annina Elisa (2022): Decarbonizing passenger transport through policy-driven behavior change

Supervisor: Posch Alfred

Zaman, Rafia (2022): Sustainable electricity access in rural areas: An empirical investigation of institutional arrangements and distributional (in)equality

Supervisor: Posch Alfred

4.2.2 Master theses

In 2022, 52 master students completed or submitted their thesis within one of the study programs Environmental Systems Sciences, Global Studies, Sustainable Development, and Industrial ecology. They are listed in alphabetical order.

Antensteiner, Sabine (2022): Der Einfluss von gesetzlichen, unternehmensspezifischen, technologie- und marktbezogenen Barrieren auf die Implementierung von nachhaltigen Innovationen – Analyse eines Unternehmens in der Automobilindustrie

Supervisor: Rauter Romana

Bause, Isabelle (2022): Analyzing urban grey and green infrastructure and its contribution to personal exposure to environmental influences, exemplified for Leipzig, Germany

Supervisor: Bruderermann Thomas

Beck, Sophia (2022): Das Spannungsfeld Felsklettern und Naturschutz – Ein Ansatz zur Entwicklung nachhaltiger Besucherlenkungsstrategien am Beispiel Naturpark Karwendel

Supervisor: Aschemann Ralf

Böhm, Laura (2022): Comparing methods and combining COVID-19 network models: The SIR model, percolation and beyond

Supervisor: Füllsack Manfred

Bruschi Villarroel, Nattaly Isabella (2022): Identifying Drivers and Barriers for the Diffusion of Cargo Bikes in medium-sized European Cities – a Comparative case study

Supervisor: Posch Alfred

Edlinger, Julia Christina (2022): Bewusstseinsbildungsmaßnahmen zur Abfallvermeidung

Supervisor: Gelbmann Ulrike-Maria

Freiherr von Eickstedt, Frederik Vollrad Oskar (2022): Predicting companies' innovation performance: A sector analysis based on a machine learning algorithm

Supervisor: Rauter Romana

Friedl, Katja (2022): Bildung für nachhaltige Entwicklung: Eine Analyse von Schulen in Österreich

Supervisor: Posch Alfred

Gollegger, Martin (2022): Sustainability-Oriented Business Model Assessment – Examination of the Practical Suitability and Expected Properties

Supervisor: Rauter Romana

Haab, Teresa (2022): Culture and Sustainability: A Case Study of Museums in Austria

Supervisor: Rauter Romana

Hackl, Bettina (2022): The provision of a battery electric based car-sharing model in suburban areas to reduce CO₂-eq emissions

Supervisor: Posch Alfred

- Heel, Gabriel (2022): The Future of the Austrian Electricity Storage System – The Role of Lignin-Based Redox-Flow Batteries
Supervisor: Stern Tobias
- Hegde, Suhas Shreepad (2022): Techno-economic feasibility study on Fuel-Cell and Battery Electric Buses – Austria
Supervisor: Bachhiesl Udo
- Hölzl, Michael (2022): Guiding principles in a carbon footprint accounting scheme to support the fulfilment of regulations, policies and programs regarding battery electric vehicles for the markets Europe and China
Supervisor: Baumgartner Rupert
- Jochum, Klara (2022): The Social Dimension of Sustainability in Alpine Tourism: A Case Study of the Mountaineering Villages
Supervisor: Rauter Romana
- Karnassnigg, Magdalena (2022): Corporate Sustainability Practices amongst micro-enterprises in the coffee shop sector in Europe
Supervisor: Rauter Romana
- Kerner, Christoph Matthias (2022): Bioenergy with Carbon Capture and Storage and Direct Air Carbon Capture and Storage as climate solutions? An analysis of Carbon Dioxide Removal from the perspective of experts and the precautionary principle
Supervisor: Bruderermann Thomas
- Keßler, Luisa (2022): Gender Sensitivity in Water-Energy-Food Nexus Governance? An exploratory study of local governing actors' perceptions and attitudes toward gender mainstreaming in South Africa
Supervisor: Posch Alfred
- Kirbisser, Veronika (2022): Sustainable Business Models in the Alpine Region: A Case Study Analysis of Coworking Spaces
Supervisor: Rauter Romana
- Klassen, Sunny Marie (2022): Biodiversity Footprint of the Fashion Industry – Evaluating the Applicability of LCA to Depict the Biodiversity Impact of Plant Derived Fiber Raw Materials
Supervisor: Stern Tobias
- Kober, Nora (2022): Strategisches Innovationsmanagement am Front End des Innovationsprozesses: Eine Fallstudie
Supervisor: Rauter Romana
- König, Marco (2022): Circular Economy Scan Eine Analyse der Webauftritte von Unternehmen in Bezug auf Kreislaufwirtschaft mithilfe von Web-Scraping und Topic modelling
Supervisor: Baumgartner Rupert
- Kramer, Lena Maria (2022): Framing the Limits to Growth: Narratives by Sustainable Entrepreneurs in the Fashion Industry
Supervisor: Stern Tobias
- Kramer, Rosamaria (2022): Can Giveaway Shops Help Advance the Circular Economy and Influence Slow Fashion in a City?
Supervisor: Aschemann Ralf
- Lemesch, Verena (2022): Corporate sustainability disclosure performance of Austrian Traded Index companies
Supervisor: Baumgartner Rupert

- Letter, Chiara (2022): Coping with Pandemics: How Different Governmental Measures Affect the Disease Spread as well as Greenhouse Gas Emissions
Supervisor: Jäger Georg
- Löckner, Claudia (2022): Sustainable food packaging in Austria – A multi-criteria mapping of potential implementation options
Supervisor: Stern Tobias
- Modl, Sebastian (2022): The Effects of Meditation on Life Satisfaction and Climate-Friendly Behavior
Supervisor: Brudermann Thomas
- Mraja, Amela (2022): Die ökonomischen und ökologischen Auswirkungen der Digitalisierung von Geschäftsprozessen
Supervisor: Posch Alfred
- Ortner, Michael (2022): Die Zukunft des Carsharings als integrativer Bestandteil der Mobilitätsoptionen außerhalb urbaner Strukturen – Eine Szenarioanalyse für die Steiermark
Supervisor: Posch Alfred
- Ott, Julius (2022): Input-Output based Decomposition Analysis to evaluate the drivers of Resource Efficiency in countries with higher and lower levels of development
Supervisor: Stern Tobias
- Plöschberger, Jennifer Marlen (2022): Values of actors at different stages of innovation diffusion in the field of animal product substitutes in Austrian gastronomy. – A comparison
Supervisor: Stern Tobias
- Preston, Kees Micheel (2022): Early Lifecycle Data Needs and Availability for Circularity of Automotive Traction Batteries
Supervisor: Baumgartner Rupert
- Rauter, Iris (2022): Greening the Austrian gas sector? A multi-criteria appraisal of decarbonization options
Supervisor: Stern Tobias
- Resmann, Julian Sebastian (2022): Renewable energy demand for a decarbonised Transport sector in Austria
Supervisor: Jäger Georg
- Roy, Papon (2022): Environmental Life Cycle Assessment of family/cargo E-bike: A cleaner solution for urban mobility
Supervisor: Baumgartner Rupert
- Salami, Aishat (2022): The Potential Contribution of Circular Economy to Strategic Sustainable Development Framework within the Fashion Industry – A Case Study of Fashion SMEs in Nigeria
Supervisor: Aschemann Ralf
- Schett, Viktoria (2022): Nachhaltige Geschäftsmodelle durch entwicklungspolitische Bildung? Der Einfluss von Nachhaltigkeitsbildung auf Unternehmensgründungen und Unternehmensideen
Supervisor: Gelbmann Ulrike-Maria
- Schlatte, Fabian (2022): Smart Product Service Systems – An Assessment of Properties, regarding their Potentials, Limitations, and Risks
Supervisor: Posch Alfred

- Schopp, Philipp (2022): Role and Potential of Emerging Technologies in Industrial Decarbonization: Case Study of the PVC Industry
Supervisor: Posch Alfred
- Schwarzl, Nadine (2022): The Carbon Footprint of Shoes: Assessing the Need to include the Durability of Materials in LCA
Supervisor: Aschemann Ralf
- Serfas, Katharina Nicola (2022): Nachhaltigkeitsmanagement in der deutschen Chemiebranche. Eine Benchmark-Analyse ausgewählter DAX40 Chemiekonzerne
Supervisor: Rauter Romana
- Stich, Simone (2022): Sustainable Business Model Innovation: Exploring processes and practices among incumbent firms
Supervisor: Aschemann Ralf
- Strebl, Simone (2022): Schweinefleischkonsum der steirischen Bevölkerung – Quantitative Analyse des Kaufverhaltens
Supervisor: Aschemann Ralf
- Tansek, Christina (2022): Einsatz regionaler Schafwolle im Pflegebereich: Eine Stakeholderanalyse
Supervisor: Posch Alfred
- Thaller, Carola Elisabeth (2022): Vergleich landwirtschaftlicher Biodiversitätsbewertungsinstrumente in den DACH-Staaten mit Fokus auf FarmLife Biodiversität
Supervisor: Aschemann Ralf
- Thiermeyer, Lynn Elisabeth (2022): Knowledge Development in the Field of Smart Energy Systems: A Systematic Analysis of Citation Functions
Supervisor: Posch Alfred
- Tolnai, Reka (2022): The Limits and Possibilities of Sustainable Tourism: How Much More Are Customers Willing to Pay for Green Services at Hotels?
Supervisor: Aschemann Ralf
- Tschofenig, Fabian (2022): Agent-based modeling on a microscopic level: a novel approach to model the electric power grid
Supervisor: Jäger Georg
- Vogler, Amelie (2022): Schools Transitioning Towards More Climate Awareness – A Multi-Level Analysis of Climate Protection Projects in the German School System
Supervisor: Bruderermann Thomas
- Vorast, Maximilian (2022): Challenges for Agrivoltaics in the International Context
Supervisor: Bruderermann Thomas
- Wimmer, Lisa (2022): The potential of municipalities for the implementation of circular economy – a case study of the Styrian central area
Supervisor: Gelbmann Ulrike-Maria
- Zenz, Nikolaus (2022): Sustainability Impact Assessment for the Implications of the EU's Carbon Border Adjustment Mechanism on the Austrian Agriculture
Supervisor: Aschemann Ralf

4.3 Course list

Course types legend

AG	Work group	PV	Privatissimum
DQ	Doctoral Colloquium	SE	Seminar
KS	Course	UE	Exercises
OL	Orientation lecture	VO	Lecture
PS	Introductory seminar	VU	Lecture with exercises

Summer Term 2022

Type	Course	Contact	
		hours	Lecturers
SE	Orientierungstutoring	0.5	Hummel S
VO	Human Beings and Environment: Geosphere	2	Mergili M, Schöner W
VO	Human Beings and Environment: Biosphere and Eco-Systems	2	Raspotnig G, Tschernatsch M
VO	Systems Sciences 2	2	Jäger G
VU	Systems Sciences 3	2	Granigg W, Güsser-Fachbach I
PS	Applied Systems Sciences 1	2	Lechner G, Plakolb S, Schober A
PS	Applied Systems Sciences 2	2	Ringsmuth A, Truhetz H
UE	Practical Exercises: USW Computational Basics	1	Reisinger D
VU	Calculus for Systems and Environment Sciences	3	Adam R, Kogler M
PS	Introductory Seminar – Elementary Statistical Concepts and Methods, Examples and Practice	1	Fleiß E
VU	Linear Algebra for USW	2	Kogler M, Lendl S, Waniek K
AG	IP Circular Economy	4	Aschemann R, Baumgartner R, Klampfl-Pernold H
AG	Interdisciplinary Practical Training	4	Hasler A, Senger M, Vlk T
AG	Interdisciplinary Practical Training	4	Krassnitzer P, Mair-Bauernfeind C, Stern T
AG	Interdisciplinary Practical Training	4	Liebmann-Holzmann J, Schöggel J, Vötsch G
AG	Interdisciplinary Practical Training	4	Höflehner T, Kunze I, Seitz V, Steinwender D
AG	Interdisciplinary Practical Training	4	Kozina-Voit C, Posch K, Schwab E
VO	Systems-Modelling and Systems-Analysis	2	Corominas Murtra B
SE	Data in Systems Sciences	2	Füllsack M
SE	Systems-Modelling and SystemsAnalysis (Agent based modelling)	2	Füllsack M, Jäger G
KS	Sustainability Controlling and Management	2	Baumgartner R, Roche K
AG	IP Rapid sociotechnical transitions	6	Everall J, Kriechbaum M, Otto I, Ringsmuth A
AG	IP Social preferences and pro- environmental behaviours: Experimental investigations	6	Baumgartner R, Fleiß J, Paul A
TU	Tutorium Lineare Algebra für USW	4	
SE	Kolloquium Climate Change	2	Baumgartner R, Bednar-Friedl B, Birk S, Foelsche U, Maraun D, Meyer L, Posch A, Steiner A, Steininger K
SE	ARQUS Winter School 2022: DIVERSITY, INTERDISCIPLINARITY AND SOCIETAL CHALLENGES	2	Stelzer H

AG	Cross-university collaboration: Sustainability Challenge	2	Rusch M, Tschuchnik M, Waniek K
AG	CIRCLE Summer School	2	Aschemann R
KS	Challenges and Opportunities of Sustainable Development	2	Posch A, Steininger K
KS	Climate Ethics and Climate Psychology: Principles, Expectations, Attitudes, Behavior	2	Brudermann T, Meyer L
PS	Management of Sustainable Development 2 Environmental Management	2	Kettele M, Ulz A
PS	Economic Technology Assessment and Foresight	2	Boiger T, Stern T
PS	Selected Topics of Sustainability and Innovation Management (Bachelor Seminar)	2	Mair-Bauernfeind C, Roche K
PS	Project Management	2	Posch A
SE	How to write a Bachelor Thesis	2	Baumgartner R, Füllsack M, Rauter R
KS	Strategic Sustainability Management	2	Gelbmann U
KS	Change Management and Learning for Sustainability	2	Gelbmann U, Pirker C
KS	Transition Management	2	Kriechbaum M, Stern T
KS	Product and Service Development	2	Globocnik D
KS	Sustainable Innovation	2	Rauter R
KS	Value Chain Management	2	Aschemann R
KS	Sustainable Product Management	2	Baumgartner R, Diaz Tena A, Roche K
KS	Environmental Decision Making	2	Brudermann T
KS	Systems Sciences in Innovation and Transition Research	2	Füllsack M, Stern T
KS	Human Factors in Transitions	2	Brudermann T
KS	Quantitative Methods of Social Research	2	Fleiß E
AG	Research Project Sustainability and Innovation Management	4	Brudermann T, Crockett S, Everall J, Otto I, Thaller A
SE	Fundamentals of Circular Economy and Industrial Ecology	2	Aschemann R
SE	Seminar in Research Methodology	2	Asada R, Fleiß E, Stern T
SE	Master Seminar	2	Baumgartner R, Brudermann T, Füllsack M, Posch A, Rauter R, Stern T
SE	Sustainability and Environmental Management	2	Posch A
DQ	PhD Doctoral Colloquium I	2	Baumgartner R, Brudermann T, Füllsack M, Posch A, Rauter R, Stern T
VU	Inter- and Transdisciplinary Methods	2	Aschemann R, Höflehner T
AG	Interdisciplinary Practical Training (Buen Vivir)	4	Elßer M, Gelbmann U, Pirker C, Schreyer C
AG	Interdisciplinary Practical Training (Transformative Wirtschaft)	4	Gelbmann U, Höflehner T, Steinwender D
AG	Interdisciplinary Practice Reflection (for students shifted to W18 from W17)	3	Gelbmann U, Pirker C, Weichsler L

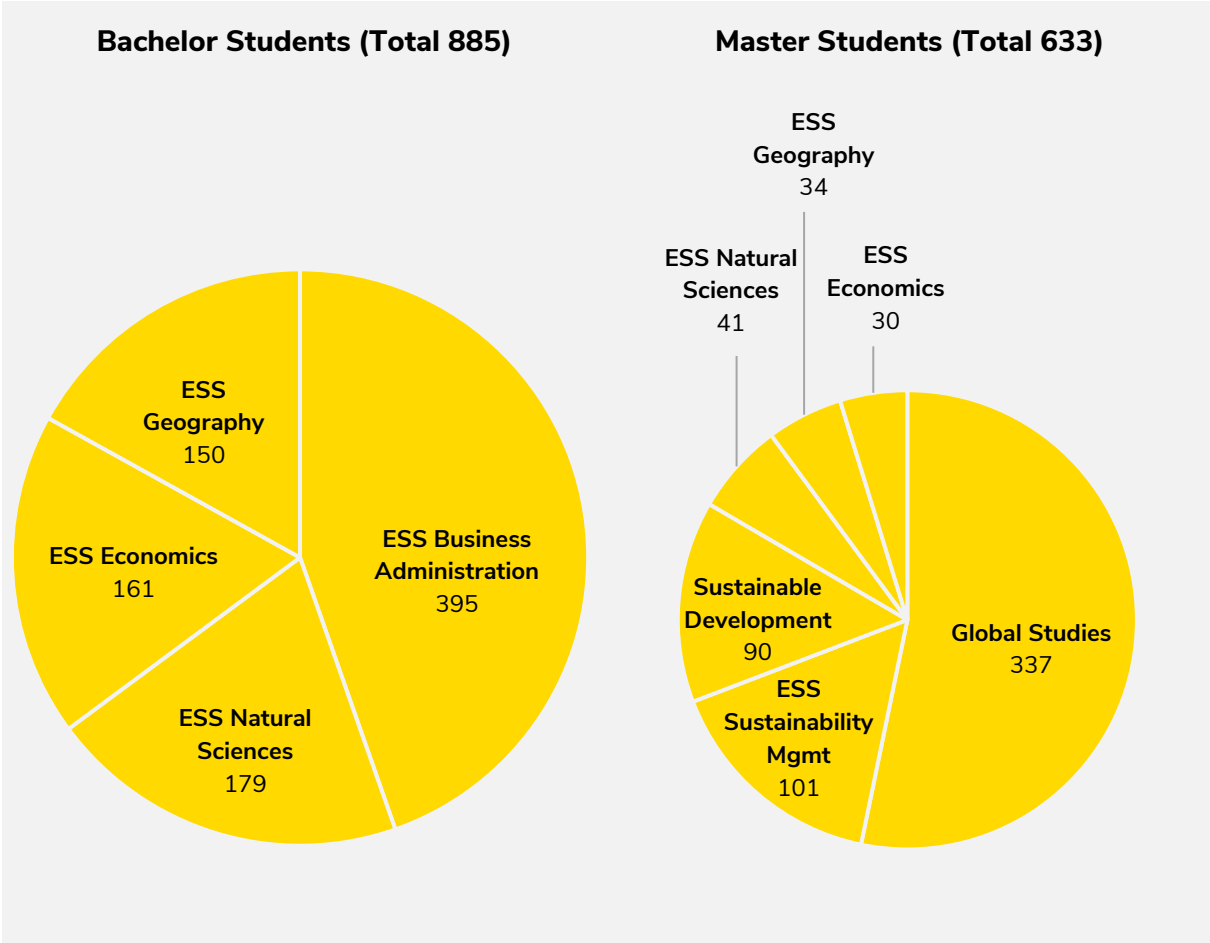
Winter Term 2022/2023

Type	Course	Contact hours	Lecturers
SE	Orientierungstutoring	2	Hummel S

VO	Human Beings and Environment: Anthroposphere	2	Posch A, Steininger K
VO	Interdisciplinary Working Methods	2	Aschemann R
VO	Systems Sciences 1	2	Lechner G
VU	Systems Sciences 3	2	Granigg W, Güsser-Fachbach I
PS	Applied Systems Sciences 1	2	Jäger G, Mellacher P
PS	Applied Systems Sciences 2	2	Bachner G, Rodriguez Amor D, Truhetz H
VO	USW Computational Basics	2	Jäger G
UE	Practical Exercises: USW Computational Basics	1	Reisinger D
VU	Calculus for Systems and Environment Sciences	3	Adam R, Kogler M, Steiner E
VO	Statistics	2	Fleiß E
PS	Introductory Seminar – Elementary Statistical Concepts and Methods, Examples and Practice	1	Schweighart M, Thaller A
VU	Linear Algebra for USW	2	Kogler M
AG	Interdisciplinary Practical Training	4	Baumgartner R, Kettele M, Reisinger D, Rusch M
AG	Interdisciplinary Practical Training	4	Asada R, Mair-Bauernfeind C, Stern T
AG	Interdisciplinary Practical Training	4	Schöggel J, Vötsch G, Wusser M
VO	Data in Systems Sciences	2	Rovenskaya E
SE	Data in Systems Sciences	2	Rovenskaya E
SE	Systems-Modelling and Systems-Analysis	2	Everall J, Otto I
AG	IP – Applied ethics in action: Identifying the (un)ethical dimensions of corporate social (ir)responsibility	6	Baumgartner R, Berger K, Paul A, Roche K
AG	IP Shaping Graz into a Doughnut: Transforming our City!	6	Aschemann R, Kozina-Voit C, Posch A, Steinwender D, Wilfinger P
TU	Tutorium Integral- und Differenzialrechnungen für USW	4	
VO	Interdisciplinary Scientific Approaches at the URBI Faculty	2	Aschemann R, Kruse A, Sattler M, Wächter N, Wlasak P
AG	Cross-university collaboration: Sustainability Challenge	2	Hoff H, Rusch M
KS	Methods for inter- and transdisciplinary problem-solving	2	Aschemann R
SE	Social Competences for Working in Inter- and Transdisciplinary Teams	2	Neuburger-Hillmayer B
SE	Social competences for managing sustainable development	2	Neuburger-Hillmayer B
AG	Case study on climate change and sustainable transformation	4	Meyer L, Posch A, Steiner A, Steininger K
VO	Environmentally Oriented Innovation and Technology Management	2	Rauter R, Stern T
VO	Sustainability and Environmental Management	2	Baumgartner R
PS	MSD 2 (Reportage of Sustainability)	2	Resel K
PS	MSD 2 Corporate Social Responsibility	2	Ulz A
SE	How to write a Bachelor Thesis	2	Rauter R, Stern T, Thaller A

KS	Strategic Sustainability Management	2	Gelbmann U, Paul A
KS	Change Management and Learning for Sustainability	2	Gelbmann U, Pirker C
KS	Sustainability Controlling and Management	2	Baumgartner R, Kettele M
KS	Transition Management	2	Kriechbaum M, Stern T
KS	Sustainable Innovation	2	Rauter R
KS	Waste and Recycling	2	Gelbmann U, Schmidt G
KS	Decision Making for Sustainable Development	2	Brudermann T
KS	Selected Topics of Innovation Management	2	Moreno Torres M
KS	Quantitative Methods of Social Research	2	Fleiß E
AG	Research Project Sustainability and Innovation Management	4	Boiger T, Crockett S, Mair-Bauernfeind C, Stern T
KS	Sustainable Business Models	2	Rauter R
KS	Environmental and Technology Assessment	2	Aschemann R
SE	Fundamentals of Circular Economy and Industrial Ecology	2	Aschemann R
SE	The Sustainability Challenge	2	Crockett S, Posch A
AG	Sustainable Development – Integrating Perspectives	6	Brudermann T, Fischer J, Posch A, Steiner A, Winkler T
SE	Seminar in Research Methodology	2	Asada R, Fleiß E, Stern T
SE	Master Seminar	2	Baumgartner R, Brudermann T, Posch A, Rauter R, Stern T
AG	Inter- and Transdisciplinary Case Study on Sustainable Development	6	Brudermann T, Hechenberger R, Posch A, Thaller A
SE	Fall School: Transformation to Climate Neutrality	4	Bednar-Friedl B, Brudermann T, Corcoran K, Finus M, Hadler M, Kirchengast G, Meyer L, Posch A, Rauter R, Steininger K, Stern T
PV	Tutorial for Postgraduates	2	Baumgartner R, Brudermann T, Posch A, Rauter R, Stern T
SE	Seminar for Postgraduates	2	Baumgartner R, Brudermann T, Posch A, Rauter R, Stern T
SE	Industrial ecology methods for a sustainable future	2	Van der Voet E
VU	Introduction to Global Studies	1	Gelbmann U, Weichsler L
VO	Law and Economics of Globalization and Development	2	Kleinert J, Werther-Pietsch U
VO	Sustainability Dimensions in Globalization and Development	2	Rauter R, Steininger K
VO	Ethical and sociocultural dimensions of globalization	2	Ayata B, Ungericht B
VU	Inter- and Transdisciplinary Methods	2	Höflehner T, Lakitsch M
AG	Interdisciplinary Practical Training (Globale Lieferketten)	4	Gelbmann U, Pirker C, Schöggel J, Weichsler L

4.4 Student statistics



Number of registered students in 2022 (source: student statistics from UniGrazOnline)

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