Annual Report 2019

Institute of Systems Sciences, Innovation and Sustainability Research

University of Graz, Merangasse 18/1, A-8010 Graz
Tel: +43 (0) 316/380-3238, Fax: +43 (0) 316/380-9585
E-Mail: sis@uni-graz.at, Web: http://sis.uni-graz.at/de/

Institute of Systems Sciences,
Innovation & Sustainability Research
University of Graz

Merangasse 18/I,
8010 Graz, AUSTRIA

Editorial

Dear Reader!

The year 2019 passed by quickly and we have a lot to report of course. A great success was the opening of a Christian Doppler Laboratory for Sustainable Product Management enabling a Circular Economy in April - this lab is currently the only Christian Doppler Laboratory being active at the University of Graz. Co-funded by the companies iPoint and ARA AG this research laboratory provides a creative space for developing and conducting research in sustainable product management, the results of which will support the transition toward a circular economy. In combination with other third party funded project activities on circular economy issues (Cresting, Start Circles) this enables us to develop a strong research focus in this domain.

From a human resource perspective, the decisions of 2019 will enable continued development. First, Tobias Stern was appointed to move from his limited term endowed chair to an unlimited professorship on Innovation and Transition Research. Later on, Georg Jäger was appointed to fill a tenure track position (§99/5) on computer-based systems sciences. Hence, both colleagues have now the opportunity to work at the institute for a long time. Therefore, our institute can now rely on a steady personnel structure enhancing continued long-term development.

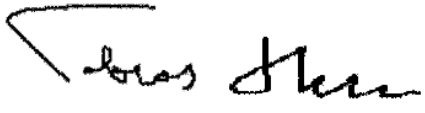
In contrast to these decisions towards continuity, the introduction of entry restrictions to the bachelor program Environmental Systems Sciences caused administrative struggles and uncertainties. However, while the total number of registered students lowered notably, the number of active students in the program remained almost constant. A development not self-evident when compared to many other study programs facing lower registration numbers.

As a measure to foster the attractiveness of our study programs we decided to renew the curricula of the Environmental Systems Science Sustainability-oriented Management master program. As most of our courses held in this program were already taught in English we decided to switch entirely. This should enable us not just to attract an increasing number of international students but also to facilitate the internationalization strategy of the University of Graz. Beside several new courses, reflecting the research foci of the institute the program also is renamed to Environmental Systems Science Sustainability and Innovation Management.

In an effort to sharpen the research profile, the University implemented five Fields of Excellence. We are happy to be strongly involved into two of them, i.e. Climate Change and Sustainable Transformation and Complexity of Life in Basic Research and Innovation (COLIBRI).

We also congratulate Michael Kriechbaum for the successful finalization of his doctoral studies and welcome Michael as PostDoc-researcher in our team.

All these achievements presented in this annual report are the result of our strong commitment to high quality in teaching and research in order to solve complex real-world problems. We thank all members of our excellent and highly motivated team and all national and international partners. And we hope that this annual report is of interest to our students, colleagues, partners and friends.



Prof. Dr. Rupert Baumgartner

Prof. Dr. Tobias Stern

Contents

1 THE INSTITUTE

1.1 Mission statement

The Institute of Systems Sciences, Innovation and Sustainability Research is investigating possibilities for the transition towards a more sustainable world. Therefore, we study transition, innovation, and adaptation processes within human-environment systems, with a focus on firms and regions. We base our research on systems sciences, innovation, and transition sciences as well as on sustainability science, and develop inter- and transdisciplinary methods to analyse and model human-environment systems, develop scenarios and transition pathways, and assess regulatory strategies.

The institute is characterized by the disciplinary diversity of its members. Highly motivated researchers originating from diverse fields of natural, social and formal sciences collaborate along real-world problems.

Our team

The institute is unique in several ways:

- Scientific work focuses on three central topics: systems sciences, innovation, and transition sciences, as well as sustainability science and management.
- It is open to external collaboration with scientists from social as well as natural sciences.
- The transdisciplinary research focus facilitates high-quality research and leads to strong collaborative ties with regional stakeholders and with business and industry.
- Research projects apply a mix of both qualitative and quantitative approaches.
- Offering one of the few curricula on Environmental Systems Sciences, the institute grew into additionally coordinating two international joint master's programmes.
- The institute is well embedded in international networks in both teaching and research.

The institute is a part of the Faculty of Environmental, Regional and Educational Sciences and features a broad interface within the faculty as well as beyond. Together with the "Wegener Center" it plays a central role within the university's research core area "Environment and Global Change" and in the new field of excellence area "Climate Change and Sustainable Transformation."

1.2 The Institute's Website

The institute's website with an up-to-date news section and plenty of information can be accessed via http://sis.uni-graz.at/ (English version: http://sis.uni-graz.at/en/).
While central information items like contact information, opening hours, news as well as important links can be found already on the start page, the rest of the website is organised in four categories:

- *Institute*: This category includes a mission statement, venue information including trip advisor and public transport planning tool, the annual reports since 2010 as well as further up-to-date information.
- *Studying*: This category involves information for both current and potential future students of our study programmes: Environmental Systems Sciences, Joint Degree Sustainable Development, CIRCLE and the recently founded doctoral school. A list of master theses and links to the alumni clubs can also be found there.
- *Research*: This section gives an overview of research aims and activities, ongoing projects, recent publications as well as existing cooperations with national and international partners. There is also a sub-category dedicated to the SIS science talk, which is a forum for invited (international) guests to present their research.
- *People*: Finally, one category is dedicated to introducing people who work (or worked) at the institute, including their research interests and publications. Open positions are also announced there.

Website http://sis.uni-graz.at/

1.3 Faculty and Staff members

Professors:

Univ.-Prof. Dr. **Rupert Baumgartner**
Phone: 3237 Email: rupert.baumgartner@uni-graz.at

Director of the Institute
Professor for Sustainability Management

Research Interests: Corporate Sustainability/CSR, Strategic Management, Life Cycle Assessment & Sustainability Assessment, Circular Economy, Management systems, Sustainable Supply Chain Management, Sustainable Business Models

Univ.-Prof. Dr. **Manfred Füllsack**
Phone: 3235 Email: manfred.fuellsack@uni-graz.at

Professor for Systems Sciences

Research Interests: Systems, Complexity, Networks, Games and Computational Theory, Work (History, Sociology, Economy, Philosophy), Computer-Based Modelling and Simulation

Univ.-Prof. Dr. **Tobias Stern**
Phone: 7344 Email: tobias.stern@uni-graz.at

Vice Director of the Institute
Professor for Energy and Resource Innovation

Research Interests: Biobased innovation, Product development (biobased products), Technology assessment and forecasting (biorefineries), Bioeconomy (bio-based economy) transition, Innovation management, Market analyses, potentials and marketing

Ao. Univ.-Prof. Dr. **Alfred Posch**
Phone: 3234 Email: alfred.posch@uni-graz.at

Dean for studies at the URBi Faculty

Research Interests: Environmental and Innovation Management, Eco-Controlling, Industrial Ecology, Inter- and Transdisciplinary Learning for Sustainable Development

Research and Teaching Staff:

Raphael Asada, MSc. BA
Phone: 7343 Email: raphael.asada@uni-graz.at

Research Interests: Transitions towards Bioeconomy, Social Metabolism, Integrated socio-ecological Modelling

Dr. **Ralf Aschemann**
Phone: 3232 Email: ralf.aschemann@uni-graz.at

Academic coordinator of the "Erasmus Mundus Master's Programme on Circular Economy"; coordinator of transdisciplinary case-study teaching; Erasmus advisor.
Research Interests: Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA), Env. Effects of Transport, Industrial Ecology, Circular Economy, Higher Education and Env. Assessment and Management, Health Impact Assessment (HIA)

Ass.-Prof. Dr. **Thomas Brudermann**
Phone: 7336 Email: thomas.brudermann@uni-graz.at
Academic coordinator Joint International Master's Programme in Sustainable Development

Research Interests: Human Decision Making, Choice Architecture and Nudges, Sustainable Development, Energy Transition, Complex Adaptive Systems, Diffusion of Green Technology, Collective Dynamics and Mass Psychology

Dr. **Ulrike Gelbmann**
Phone: 7333 Email: ulrike.gelbmann@uni-graz.at

Research Interests: Strategic Sustainability Management, Corporate Social Responsibility, Stakeholder Management, Sustainability Reporting, Social Sustainability, Resilience, Waste Management

Christian Hofer, Bakk. BSc. MSc.
Phone: 7347 Email: christian.hofer@uni-graz.at

Research Interests: Systems Sciences, Machine Learning, Systems Modeling

Dr. **Georg Jäger**, BSc. MSc.
Phone: 7348 Email: georg.jaeger@uni-graz.at

Research Interests: Computational Systems Science, Systems Modelling, Simulation of Complex Systems, Data Mining, Machine Learning, Network Science

Aisma Linda Kiesnere, BSc. MSc. (until April 2019)
Phone: 7337 Email: aisma.kiesnere@uni-graz.at

Research Interests: Sustainable Business Models, Transformations of Organizations for Sustainability, Sustainable Entrepreneurship, Decision Making and Change Management

Claudia Mair-Bauernfeind, BSc. MSc.
Phone: 7346 Email: claudia.mair@uni-graz.at

Research Interests: Environmental Assessment and Management, Sustainable Development, Sustainable Resource, and Waste Management, Innovations towards Bioeconomy

Miguel Moreno Torres, MSc.
Phone: 1521 Email: miguel.moreno-torres@uni-graz.at

Research Interests: Climate Change Vulnerability, Resilience and Adaptive capacity; Innovation Systems, Business Model Innovation; Sustainable Land and Natural Resource Management; Digitalization and Transition towards Industry 4.0

Arijit Paul, Ph.D. MSc.
Phone: 7337 Email: arijit.paul@uni-graz.at

Research Interests: Corporate sustainability, Corporate climate change strategy, Business Ethics, Sustainable Energy Strategies and Policies

Simon Plakolb, MSc. BSc.
Phone: 7347 Email: simon.plakolb@uni-graz.at

Research Interests: Traffic simulations, Computational Systems Science, Systems modelling, Functional programming

Ass.-Prof. Dr. **Romana Rauter**
Phone: 3236 Email: romana.rauter@uni-graz.at

Research Interests: Sustainability Innovation, Open Innovation, Innovation Management and Performance, New and Sustainable Business Models, Strategic Sustainability Management, Knowledge Transfer and Knowledge Management

Martina Zimek, BSc. MSc. (maternity leave since July 2019)

Phone: 7330 Email: martina.zimek@uni-graz.at

Research Interests: Corporate Social Responsibility, Sustainability Performance, Sustainability Assessment, Life Cycle Assessment, Sustainability, and Supply Chain Management, Waste Management, Strategic Management

Project Staff:

Anna Diaz Tena, MSc.
Phone: 1525 Email: anna.diaz-tena@uni-graz.at

Research Interests: Circular Economy, Product Lifecycle Management, Sustainable Product Design, Industry 4.0

Eva Fleiß, MA PhD
Phone: 1521 Email: eva.fleiss@uni-graz.at

Research Interests: Empirical Social Research, Validity of Survey Questions, Environmental Sociology/Sustainability, Renewable Energy, Photovoltaics

Mag. **Stefanie Hatzl**, PhD
Phone: 1521 Email: stefanie.hatzl@uni-graz.at

Research Interests: Energy Transition, Renewable Energy Technologies (PV), Empirical Social Research, Environmental Behaviour

Daniel Holzer, BA MA
Phone: 1520 Email: daniel.holzer@uni-graz.at

Research Interests: Transition towards Circular Economy, Circular Business Models, Empirical Social Research, Environmental Sociology

Anita Lerch, BSc.
Phone: 2163 Email: anita.lerch@uni-graz.at

Research Interests: Digital Innovation, Sustainable Innovation, Green IT, Acceptance and Diffusion of Technology

Christopher McKay, MSc.
Phone: 7340 Email: christopher.mckay@uni-graz.at

Research Interests: Circular economy, design for sustainability and circularity, circular systems

Tomas Santa Maria Gonzalez, MSc.
Phone: 1546 Email: tomas.santamaria@uni-graz.at

Research Interests: Circular Economy, Circular Business Models, Sustainable Business Models, Business Model Innovation, Corporate Sustainability, Strategic Management

Josef-Peter Schöggl, PhD. Bakk. MSc.
Phone: 7340 Email: josef.schoeggl@uni-graz.at

Research Interests: Design for Sustainability, Life Cycle Assessment, Corporate Social Responsibility, Sustainable Supply Chain Management

Lukas Stumpf, BA
Phone: 7332 Email: lukas.stumpf@uni-graz.at

Research Interests: Transition to a circular economy, operationalisation of sustainability in a circular economy, circular systems, design for sustainability and circularity

Julia Wenger, BSc. MSc. MSc.
Phone: 7331 Email: julia.wenger@uni-graz.at

Research Interests: Transitions towards Bio-Economy, Lignocellulosic Biorefineries, Techno-economic and Environmental Assessment

Doctoral Programme DK Climate Change:

Michael Kriechbaum, MSc.
Phone: 7348 Email: michael.kriechbaum@uni-graz.at

Research Interests: Environmental Innovation, Environmental Policy, Renewable Energy

Jyoti Prajapati, MSc.
Phone: 7427 Email: jyotil.prjapati@uni-graz.at

Research Interests: climate change mitigation strategies, low carbon sustainable mobility system and transitions, technological and non-technological innovations, business model innovations

Annina Thaller, BSc. MSc.
Phone: 7426 Email: annina.thaller@uni-graz.at

Research Interests: Climate Change Mitigation, Human Decision Making, and Behavior, Mobility Transitions, Carbon Lock-In

Rafia Zaman, MBA
Phone: 7425 Email: rafia.zaman@uni-graz.at

Research Interests: Sustainable energy transition (climate change mitigation and energy access), Energy governance, Energy service security, Impact evaluation of energy programs

Administration:

Klaudia Kramer
Phone: 1037 Email: klaudia.kramer@uni-graz.at

Tanja Untergrabner
Phone: 3238 Email: tanja.untergrabner@uni-graz.at

Student Assistants:

Gundula Allersdorfer	**Chiara Letter**	**Doris Prach**
Gregor Fallmann	**Angelika Meißl**	**Daniel Reisinger**
Julia Graf	**Yannick Oswald**	**Magdalena Rusch**
Verena Haas	**Michael Peer**	**Bernhard Schrempf**
Melanie Harrer	**Lukas Pertl**	**Bianca Steiner**
Tamara Janesch	**Martin Popowicz**	**Katrin Winkler**

1.4 Seminars and "SIS Science Talk"

For the "SIS Science Talk," the institute is inviting external experts to give a presentation on core research topics (i.e., systems sciences, innovation, 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.

The following talks were held in 2019:

- Dr. **Marat Karatayev** (Ernst mach Scholar), "The importance of nexus approach to water-energy-food security for transitional and resource-rich countries", May 14, 2019
- Prof. Dr. **Kua-ananTechato** (Prince of Songkhla University, Thailand), "Failure of MSW Management in Thailand and a Possible Solution", April 2, 2019
- Dr. **Michael Schaller** (sustainable – Agentur für Nachhaltigkeit), "Human Rights in the Supply Chain", March 12, 2019
- Prof. Dr. **Marzia Traverso** (University of Technology Aachen, Germany), "Life Cycle Sustainability Assessment", March 5, 2019

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

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

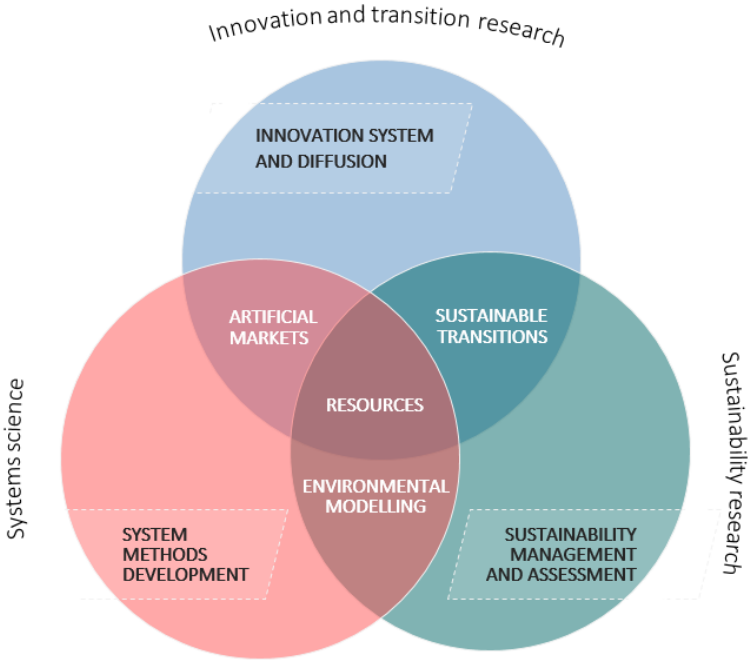
- USW Praxis Day – May 2019
- Introduction to Scientific English – June 2019
- USW Job Application Check – December 2019
- Orientation Event – September 2019
- Evaluation of IPs
- Evaluation of mathematics lectures
- Evaluation of the coordination office

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 systems sciences, innovation and sustainability research: systems research with a focus on methods development (Füllsack), innovation- and transition research with a focus on innovation systems and diffusion (Posch, Stern), and finally sustainability research with a focus on sustainability management (Baumgartner).



Research areas and foci at the Institute of System Sciences, Innovation and Sustainability Research

Systems Sciences

Within the framework of the three-pillar concept at the SIS and in the ESS study, the research area of system sciences is primarily responsible for the development and provision of key methodological components required in research and teaching. Current focuses are on systems scientific and network-based resilience research, on equation- and agent-based modeling and simulation as well as on computer-based acquisition, processing, and evaluation of data. With the appointment of the current position holder of the Systems Science Professorship, the application and development of digital methods have been put into the forefront of attention. In terms of staff, this entailed the hiring of suitably qualified experts with a strong focus on IT skills.

In more details, system scientific research and methods development at SIS focuses on the following core areas. This includes the investigation and development of means for predicting critical phase transitions in social dilemmata situations (e.g., the loss of cooperation). It further includes research on network-theoretic aspects that could work as drivers for the enhancement of contribution to common pool resources. It also includes the development of tools for automated evaluation of large amounts of data relevant for sustainability questions (data and text mining). And an additional research focus is currently directed towards the development of a large scale simulation model for urban transport optimization and emission reduction. Furthermore, there is strong activity in the development of IT-based teaching methods and materials, such as interactive online repositories.

Innovation and Transition Research

The terms *bioeconomy* and *bio-based economy* refer to one of the recently most prominent political-economic concepts in Europe postulating the substitution for fossil resources by bio-based ones (e.g., Aguilar et al., 2017[1]). It thereby addresses ecological targets, i.e., climate change mitigation, and reduction of environmental impacts (European Commission, 2012[2]). Studies support — at least conditionally — that an intensified use of biomass can lead to greenhouse gas emission savings (e.g., Braun et al., 2016[3]). Apart from ecological challenges, bioeconomy is also intended to have socioeconomic benefits such as fostering economies' competitiveness, meeting rising demand and counteract resource depletion (European Commission, 2012).

According to OECD (2006[4]), the concept of bioeconomy can be defined as "transforming life science knowledge into new, sustainable, eco-efficient and competitive products." Therefore, innovation plays a crucial role when realizing the vision of a bioeconomy. Bio-economic innovations aim at replacing fossil resources for energy, chemicals, and materials with renewable and bio-based feedstocks.

The adherent causes, dynamics and consequences bio-based innovation are in the focus of the 2016 newly introduced chair for energy and resource innovation at the Institute of Systems Sciences, Innovation and Sustainability Research. This focus group of this research area is led by Tobias Stern and consists of Claudia Mair, Raphael Asada (both research and teaching assistants) and Julia Wenger (project assistant).

In particular, the working group focuses on questions like, how to overcome the gap between technical maturity and practical implementation, what broader economic, environmental or social implications might derive from an intensified use of bioprocessing technologies or which transition pathways are most feasible for sustainable use of bio-based materials. The research is underpinned by analyzing the transition, diffusion and innovation processes between the three key systems of sustainability. Only through a holistic approach to the manifold interrelations between environmental, societal and economic dimensions of bio-based economies, long-lasting and feasible solutions can be generated. With the institutes focus on innovation, environment and global change, this new chair features a promising link and extension to the already existing research activities.

The second focus area of this working group addresses energy innovation and transition for a decarbonisation of our economy. Obviously, the use of fossil feedstock for energy generation is the main cause for GHG emissions and thus for climate change. The energy transition can be understood as "… a change in the state of an energy system as opposed to a change in individual energy technology or fuel source"[5], or more precisely as a shift from a system dominated by fossil-based energy towards a system using primarily renewable energy sources, also increasing energy efficiency and better managing energy demand. For this, the working group addresses following aspects: Firstly, the energy generation side, where a shift towards renewable energies – energy sources such as solar energy, wind energy, hydroelectric power, biomass, and

[1] Aguilar, A., Wohlgemuth, R., Twardowski, T., 2017. Perspectives on bioeconomy. New biotechnology. 10.1016/j.nbt.2017.06.012.

[2] European Commission, 2012. Innovating for Sustainable Growth. A Bioeconomy for Europe. European Commission, Brussels, 64 pp.

[3] Braun, M., et al., 2016. A holistic assessment of greenhouse gas dynamics from forests to the effects of wood products use in Austria. Carbon Management 7 (5-6), 271–283.

[4] OECD, 2006. The Bioeconomy to 2030: Designing a Policy Agenda. OECD, Paris.

[5] Grubler, A., Wilson, C., and G. Nemet (2016): Apples, oranges, and consistent comparisons of the temporal dynamics of energy transitions, Energy Research & Social Science 22, 18-25.

geothermal energy, is needed. Here, the working group focuses primarily on the use of solar energy in different settings. The decentralization of the electricity generation with photovoltaics directly impacts the power distribution system. Additionally, there will be an increasing need for solutions regarding the short-term and also seasonal storage of renewable energies.[6] Secondly, the consumption side, which needs to be managed in a way, that demand profile become better adjusted to possible energy provision profiles of energy systems which are based to a greater extent on fluctuating renewable sources. Moreover, the consumption patterns might be an effective trigger to save energy, and/or to increase overall energy efficiency. The working group focused in recent years on energy efficient behaviour in public buildings.

Sustainability Management

The central interest in this research area is to improve the understanding 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.

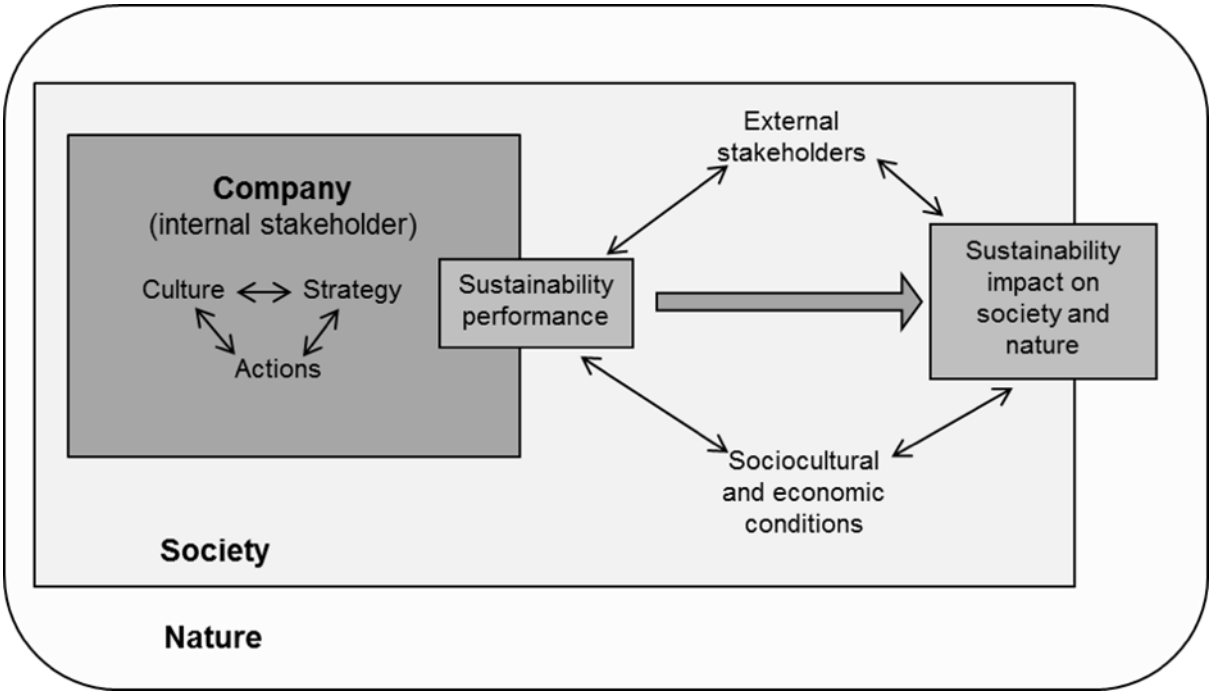
The figure below shows the basic research model, which combines factors within a company (i.e., relationships among organizational culture, strategy and actions) with the resulting sustainability performance of a company (and its products and services), as well as the final impact on society and the nature of this sustainability performance. Because a single company does not act alone within the economy and society, its relationships with other companies are also of interest.

Following topics characterize the research activities undertaken in this research area:

- **Corporate sustainability management:** Research in this field is conducted to determine the fundamental motivations of companies to act in more sustainable ways, examine organizational culture and corporate sustainability and develop frameworks for corporate sustainability management.
- **Corporate sustainability strategies and sustainable business models:** Research in this field is conducted to define and implement corporate sustainability strategies and identify the drivers, barriers, and impacts of sustainable business models.
- **Sustainability assessment**: Research in this field deals with environmental, economic and social impact assessments using qualitative and quantitative data (for example, by combining LCA with economic assessments).
- **Sustainable innovation:** Research in this field is conducted to identify innovation processes related to sustainability while placing a focus on open innovation.
- **Sustainability design:** Research is conducted to identify and develop frameworks and instruments that can be used to integrate sustainability issues into product design processes.

[6] Bruckner, T. et al. (2014): Energy Systems. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

- **Inter-organizational management, industrial ecology, and sustainable supply chain management:** Research in this field is conducted to examine how to coordinate actors in a network of companies with respect to sustainability issues (i.e., how to measure sustainability impacts in supply chains, coordinate industrial networks and supply chains and manage relevant data for inter-organizational management).



Sustainability impact chain,
from: Baumgartner, Rupert J.; Rauter, Romana (2017): Strategic perspectives of corporate sustainability management to develop a sustainable organization. In: Journal of Cleaner Production. Vol. 140, Part 1, pp. 81-92

2.2 Research Projects

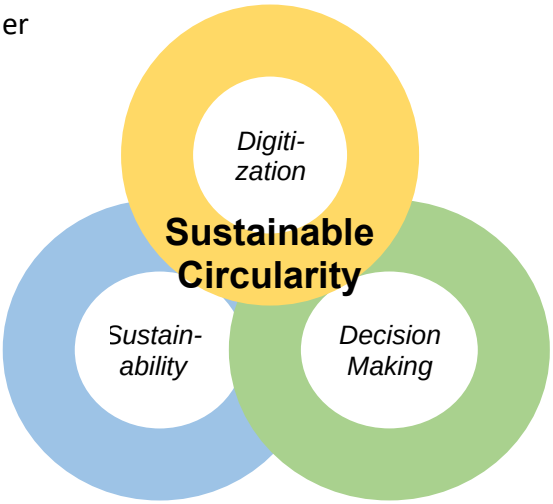
2.2.1 Christian Doppler Laboratory for Sustainable Product Management enabling a Circular Econmy

Sustainable Circularity

Christian Doppler Laboratory for Sustainable Product Management enabling a Circular Economy

Head of the Laboratory: Prof. Dr. Rupert Baumgartner
Project team:
Magdalena Rusch, BA MSc,
Josef Peter Schöggl, PhD
Lukas Stumpf, BA MSc,
Tanja Untergrabner
Duration: 2018 - 2025

Website: https://circular.uni-graz.at/en/



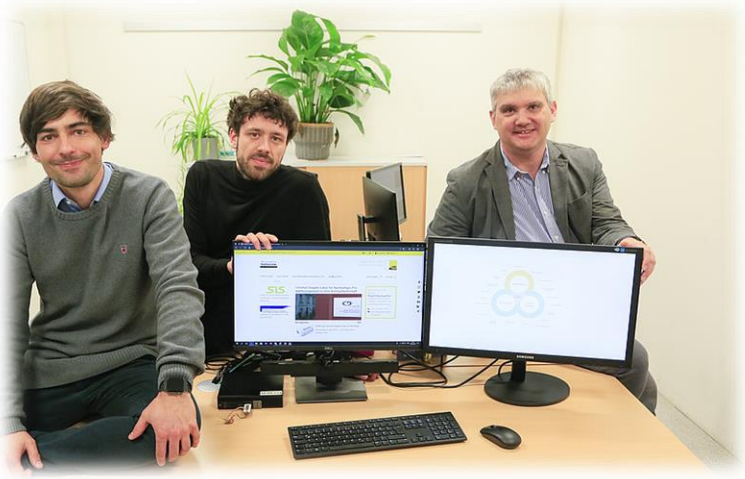
Introduction

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.

The goal of this research laboratory is to support companies with new and improved methods and frameworks in order to maximise the sustainability performance and circularity of their products and services. The research team is aiming to conduct 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 (e.g., reporting, compliance management).



Rupert Baumgartner (r.), Head of the CD-Lab with Josef Schöggl (post-doc) und Lukas Stumpf (PhD) (v.l.). Photo: Uni Graz/Tzivanopoulos

Unique Projectsetting

In Christian Doppler Laboratories, application-oriented basic research is pursued at a high level, and expert 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.

The CD-Lab for Sustainable Product Management enabling a Circular Economy started in November 2018 and is currently the only CD-Laboratory at the University of Graz. The application-oriented research is nurtured by a continuous exchange and close collaboration with the two innovative industry partners - ipoint and ARA. The official opening took place in April 2019 in the Meerscheinschlössl in Graz with eminent guests from research and practice. The video of the opening talks and the international scientific symposium, which was held in the following, can be accessed here: https://www.youtube.com/channel/UCZyDRrhGP2gA2B2fmC9oeSQ/playlists

From left to right: Reinhart Kögerler (President CDG), Barbara Eibinger-Miedl (Country Counselor Styria), Christa Neuper (Rector), Rupert Baumgartner (Head of CD-Laboratory), Jörg Walden (CEO ipoint), Barbara Gasteiger-Klicpera (URBI dean), Harald Hauke (CEO ARAplus & AGR), Peter Scherrer (Vice-rector)

Remarkable research output

The project is planned for 7 years with a detailed working plan for each year to achieve the objectives of the CD-Lab. So far the research team is quite good on track with the research output both in quantitative and qualitative terms and many activities in the scientific community as well as in forms of "science to public" events can be reported:

Scientific community:

- ✓ 4 submitted journal papers 4 submitted journal papers (1 Journal of Mechanical Design, 1 Resources Conservation Recycling, 2 Journal of Cleaner Production)
- ✓ 1 book chapter
- ✓ 5 peer reviewed conference papers (+2 submitted)
- ✓ 3 peer reviewed conference abstracts
- ✓ 6 presentations at scientific conferences
- ✓ 4 scientific awards

Science to public:

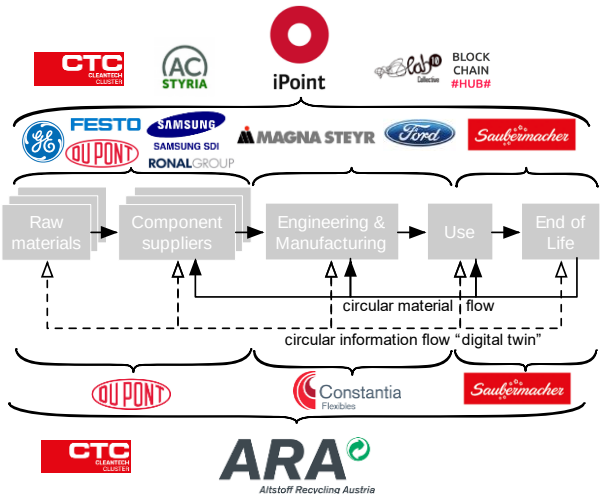
- ✓ 5 invited presentations at conferences or symposia
- ✓ 16 articles in newspapers , magazines and blogs about the CD Lab and it's researchers
- ✓ Organisation of scientific symposium as part of the opening event

Use cases

The new CD-Lab collects data on the entire life cycle of products and services and defines corresponding sustainability and circularity principles. Close cooperation with companies with a focus on the automotive and packaging industries that want to develop further in the direction of a Circular Economy form the basis. Two specific use cases are defined to test and further enhance theoretical concepts: Use case one inlcudes several companies in the automotive sector to answer the question: "How can sustainable circular economy practices be realized along a full value chain?" and for the packaging 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?

Use case 1: Automotive

Use case 2: Packaging



Graphical presentation of the two use cases and the involved industry partners

Exchange with industry partners

Continuous meetings with the (industry) partners of the CD-Lab are key to foster knowledge- and information exchange. In October 2019 the CD-Lab team invited their "Letter of intent" (LOI) partners to a first welcome meeting at the University of Graz. To ensure the practical relevance of the research in the CD-Lab, experts from different industries are involved in several research activities. Especially the data collection for the empirical research steps are organized together with the corporate partners iPoint and ARA AG and the LOI partners.

In a focus group workshop in October 2019 the CD-Lab team welcomed the LOI partners for a workshop about Sustainable Product Management in a Circular Economy context. The emphasis was on the exchange of experiences and current practices of the participants regarding sustainable and circular data management. The output was a collection of data sources, actors, barriers and enablers for data-driven sustainable product management and a deeper understanding how the data collection and exchange [for sustainable product management in a circular economy] could be improved (with new technologies) along the product life cycle.

Lively exchange with the (industry) network of the CD-Lab(l.) and members of the CD-Lab team (r.).

Scientific collaborations

The use-inspired basic research in the CD-Lab is highly interdisciplinary and it integrates aspects from sustainable product design and assessment, supply chain management and engineering, as well as from computational and systems sciences. To foster the exchange of knowledge and expertise between these field, the laboratory engages in several international research collaboration. Among these collaboration partners are the Center for ECO^2 Vehicle Design at the Department Engineering Mechanics of KTH - Royal Institute of Technology Stockholm/Sweden, the Institute for Interactive Systems and Data Science (ISDS) at Graz University of Technology (TU Graz), the Institute for Software Technology (IST) at TU Graz, the Department for Personnel Management, Work and Organizational Psychology at Ghent University/Belgium, LaRochelle Business School in France and the Jönköping International Business School at University of Jönköping/Sweden.

Project Partners and Funding: Austrian Federal Ministry for Digital and Economic Affairs, the National Foundation for Research, Technology and Development and the Christian Doppler Research Association; ipoint-systems GmbH, ARA AG

2.2.2 CRESTING: CiRcular Economy-SusTainability implications and guidING progress

CRESTING is an Innovative Training Network (ITN) funded as part of the Marie Skłodowska-Curie Actions (MSCA) programme. The project has recruited 15 Early Stage Researchers (ESRs) to train in cutting-edge systematic analysis of Circular Economy (CE) activities in a wide range of geographic and economic settings: a total of 8 universities belonging to 6 different countries are involved. CRESTING has been divided into 5 Work Packages lead by multidisciplinary and international supervisory teams including non-academic partners:

- WP1: Assessing CE practices and discourse
- WP2: Corporate engagement with the CE
- WP3: Public sector engagement with the CE
- WP4: Capturing the benefits of circularity
- WP5: Measuring the impacts of circularity

The University of Graz leads WP2 and is also involved in WP4, acting as host institution of ESR 2.1 and ESR 2.2 under the main supervision of Prof. Rupert Baumgartner. The SIS will also be the institution of secondment for ESR 2.3, ESR 4.1 and ESR 4.3.

ESR 2.1 - Business strategies and practices for a circular economy (Tomas Santa Maria)
The key role of firms in the transition to a more sustainable and circular system has been widely acknowledged, though the potential contribution is far from being achieved. In order to realize CE aspirations, companies need to look beyond incremental improvements in products and processes into radical transformations found in business model innovation (BMI), which can be a source of competitive advantage by itself. However, BMI towards the CE has been low in the practice, and the literature on the topic is in its early days. The present research will contribute to a deeper understanding of BMI towards the CE, its process and the available frameworks that can support it, knowledge that is fundamental to foster the implementation of Circular Business Models and accelerate the transition to a CE.

ESR 2.2. - Sustainable product lifecycle management in a circular economy (Anna Diaz)
Strategies embedding circularity at the product level hold a lot of potentials: it is estimated that 80% of a product´s environmental impact is determined during its design phase. Circular product design can benefit from the growth of digital connectivity in manufacturing environments, making it possible to foster data-driven decision-making. Product Lifecycle Management (PLM) could be leveraged, which has consisted of the main companies' strategy to manage products' lifecycle information from the cradle to the grave. This research aims at bridging the gap between existing data sources in PLM and the data demanded by eco-design tools needed to embed circularity principles during the design phase of products.

Project team: Univ.-Prof. Dr. Rupert Baumgartner; Tomas Santa Maria, MSc; Anna Diaz, MSc.

Project partners: University of Hull/UK (Coordinator), University of Technology of Troyes/France, Utrecht University/Netherlands, Universidade Nova de Lisboa/Portugal, University of Messina/Italy, Universidade Aberta/Portugal, University "G. D'Annunzio" of Chieti-Pescara/Italy

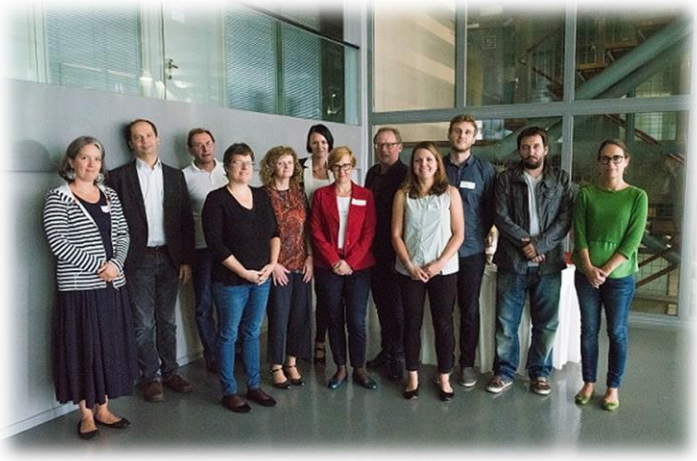
Duration: January 2018 - September 2021.

Funding: European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 765198.

2.2.3 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:

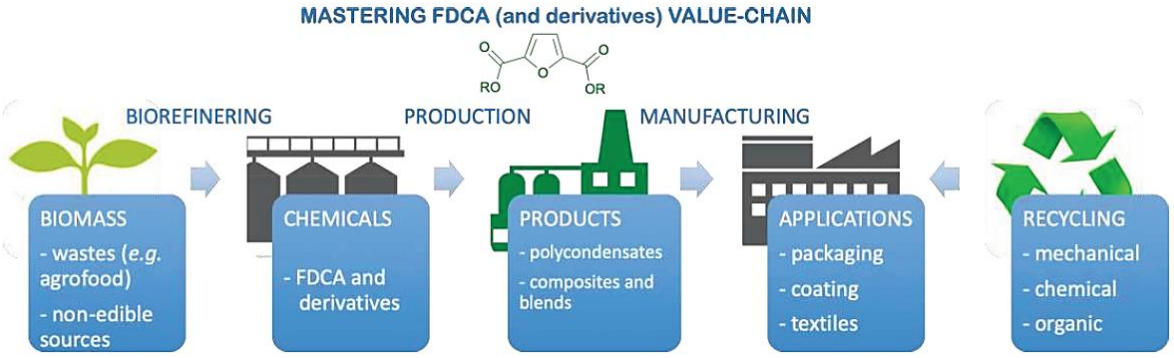
- documentation and utilization of RTD skills for the circular economy
- establishment of new cooperation models, especially regarding reuse-oriented value chains (training of mediators / facilitators)
- supporting SME in RTD networks
- support the launch of new products by developing new business models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

Further Information: http://www.si-at.eu/en2/start-circles/

Project team: Univ.-Prof. Dr. Tobias Stern, Ass.-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 – August 2021

2.2.4 "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

2.2.5 Wood for Automotive Applications – WoodC.A.R.

This COMET K-Project aims at gaining a more thorough and comprehensive understanding of wood as load-bearing and energy absorbing (crash and vibration) material in advanced applications is needed. WoodC.A.R. (Wood - **C**omputer **A**ided **R**esearch) will establish the knowledge and the requisites for integrating wood in virtual engineering and the industrial design process (e.g., vehicle design) in general. The Project will establish the needed knowledge base on the mechanical properties, the grading, the processing, the integration and the recycling of numerous wood species and wood composites in vehicle design. Moreover, WoodC.A.R. will evaluate and improve existing and develop advanced material models for use in computer-aided engineering (CAE). State-of-the-art production, joining and bonding technologies will be reviewed, analyzed, evaluated and integrated with the virtual engineering process. Application cases, not only from the automotive sector, will be selected. Based on meticulous specification sheets, the application cases will be developed by applying the initial virtual engineering process. In continuous feedback-loops, the process will be refined such that it is applicable in an industrial development process. Eventually, demonstrators will be built and tested, proofing the reliability of the virtual engineering process.

Photo: Mattro

Photo: MAGNA

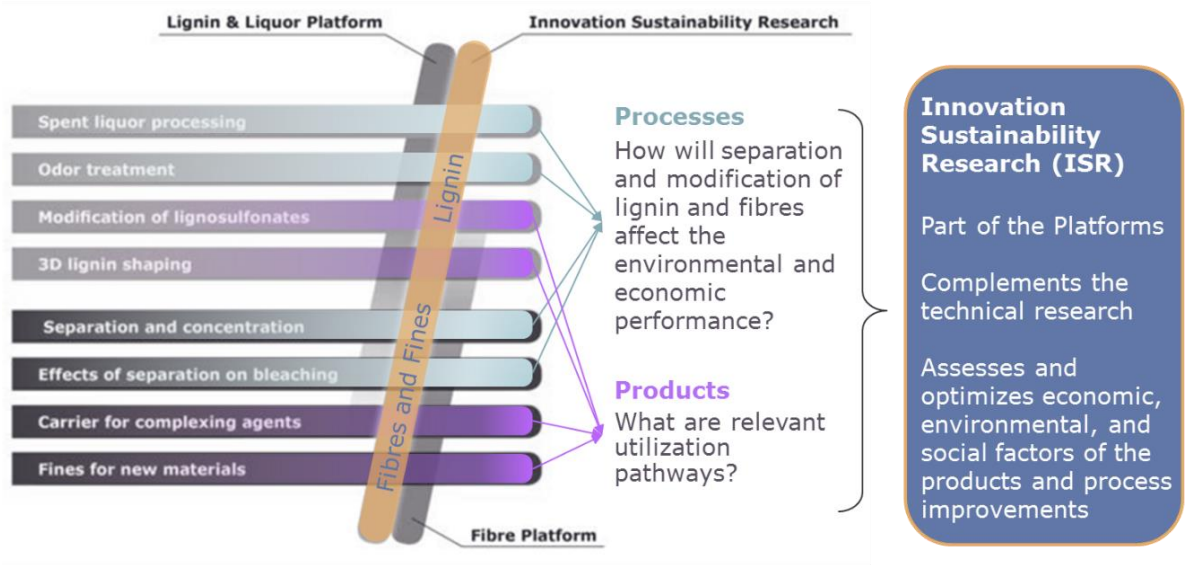
The Institute of Systems Sciences, Innovation and Sustainability Research is responsible for assessing the environmental and socio-economic impacts of wood in an automotive application. More precisely the institute will perform a Life Cycle Assessment (LCA) of the defined application cases in order to identify environmental and social substitution effects. Moreover, the socio-economic impacts of an increasing wood demand will be assessed by applying Input-Output analysis.
Further Information: http://www.woodcar.eu/index_de.html#

Project team:	Mag. Raphael Asada, Univ.-Prof. Dr. Rupert Baumgartner, Univ.-Prof. Dr. Tobias Stern, Claudia Mair, MSc., Martina Zimek, MSc
Lead Institution:	Innovationszentrum W.E.I.Z.
Company Partners:	MAGNA, MAN, MATTRO, Weitzer Parkett, DOKA, DYNAmore, EJOT, FHP – Forst Holz Papier, Holzcluster Steiermark, IB Steiner, LEAN MC, AC-Styria, Collano, Volkswagen,
Scientific Partners:	University of Natural Resources and Life Science, University of Graz (SIS), Graz University of Technology (VSI), Virtual Vehicle (Vif), University of Applied Science FH Joanneum, Innovationszentrum W.E.I.Z
Duration:	March 2016 - March 2020
Funding:	FFG, COMET K-Project

2.2.6 Flippr² - Future Lignin and Pulp Processing Research PROCESS INTEGRATION

This COMET K-Project is the follow-up project to FLIPPR⁰ (April 2013 – March 2017), where the University of Graz was already responsible for the area of sustainability research (e.g., LCA).

The efforts of the project are focused on integrated solutions to manufacture products from wood efficiently, specifically from spent liquor derived technical lignin and pulp derived specific short fibre fractions (fines). By tackling process integration issues associated with separation, fractionation and modification of bio-based materials in the pulp and paper industry, resulting products are expected to contribute towards a more sustainable knowledge-based bioeconomy, partly replacing fossil resources, and increasing value added.



Flippr² sub-projects and the innovation sustainability task

As illustrated in the figure above, SIS is responsible for the innovation and sustainability task. On the one hand, the respective technical sub-projects are complemented by (techno)-economic and environmental research: with a spectrum of methods at hand, tailor-made solutions are applied to support the decision-making process.
On the other hand, issues in a broader context such as bio-based innovations, (lignocellulosic) biorefinery developments and bioeconomy impacts are investigated.

Project Team:	Univ.-Prof. Dr. Tobias Stern, Ao.Univ.-Prof. Dr. Alfred Posch, Julia Wenger, MSc., Verena Haas, BSc., Mag.rer.nat. Raphael Asada
Lead Institution:	Papierholz Austria GmbH
Company Partners:	Sappi Gratkorn-Produktions GmbH & Co KG, Mondi Frantschach GmbH, Zellstoff Pöls AG
Scientific Partners:	University of Natural Resources and Life Sciences Vienna, Graz University of Technology, University of Graz
Duration:	April 2017 - March 2021
Funding:	FFG COMET K-Project (6th Call): BMDW, BMVIT, KWF, SFG

2.2.7 Using Digital Media at Work: Impacts and Potentials from Employees' and Employers' Perspective in the Context of the Styrian Economy

Digitalization is transforming workplaces with unequal consequences for companies and their employees. Increasing deployment and use of digital technologies promise opportunities such as productivity gains, greater flexibility, and furtherance of employees' innovativeness. However, digitalization is accompanied by challenges in the corporate context as well such as additional burdens and stress on employers and their workforce alike.

For the Province of Styria, as the center of production and innovation, the digitalization of the work sphere is deemed to be of major importance. In this context, the aim of this research project is to shed light on this multifaceted process of restructuring and change caused by digital technologies and to make a step towards understanding the effects of the digital transformation on companies within the Styrian economy. This requires applied research on 1) the general use of digital media within the corporate context; 2) the individual user behaviour and digital literacy; 3) the organizational culture and its interaction with the business environment; and 4) on opportunities and challenges related to the use of digital technologies at the workplace.

The intended exploration of the current situation represents a crucial pre-condition for creating practical knowledge and deriving concrete recommendations for action, in order to reinforce the competitiveness of the Styrian economy.

Further Information: https://digital-at-work.uni-graz.at/

Project team:	Ass.-Prof. Mag. Dr. Romana Rauter, Anita Lerch, BSc
Project partners:	University of Graz (Institute of Educational Sciences), University of Applied Science FH Joanneum, Know-Center GmbH, Styrian Chamber of Labour, x-sample
Duration:	May 2018 – May 2020
Funding:	Land Steiermark (Province of Styria)

2.2.8 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/

Project team:	Ao. Univ.-Prof. Dr. Alfred Posch, Univ.-Prof. Dipl.-Ing. Dr. Tobias Stern, Eva Fleiß, MA Ph.D., 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 - Oktober 2021
Funding:	2nd Call - Energy Model Region (FFG)

VORZEIGEREGION ENERGIE

powered by klima+ energie fonds

2.2.9 Quality – Qualitative change to close Austria's Paris gap: Shaping the pathway

Rapid and far-reaching changes are required in order to reach the 1.5° goal set in the Paris Agreement. Austria's total GHG emissions are again on the rise and above the 1990 level. The transport sector emissions in Austria have risen substantially since 1990, whereby passenger transport accounts for about 64% of transport GHG emissions.

Despite national plans to reduce Austria's total greenhouse gas emissions, those of personal transport did not seize to increase in the past years. QUALITY aims at counteracting this trend by considering not only incremental, but qualitative changes, i.e. substantial changes in the socioeconomic system for their potential to bring about substantial GHG emission reductions. Moreover, QUALITY identifies and evaluates policy packages and instruments to enable these qualitative changes and consequently aids a low-carbon transition.

Therefore, various aspects need to be considered and will consequently be addressed in course of the project, such as the potential for GHG emission reduction for respective qualitative change options for the passenger transport system in Austria. In order to find out how the behavioural shift must evolve to avoid carbon emissions, transportation modelling is applied. In addition, the total social costs for different modes of passenger transport are considered to elicit whether a reduction of GHG intensive modes of passenger transport could yield a reduction in total social costs.

These findings are considered together with legal aspects to develop effective and feasible policy instruments to achieve a low-carbon passenger transport system. Proposed policy packages that target a wide variety of possible measures, are discussed with stakeholders in order to ensure feasible policy design and to derive concrete policy recommendations for different levels, ranging from municipal to the European level.

Project team:	A.o. Univ.-Prof. Dr. Alfred Posch, Ass.-Prof. Dr. Georg Jäger, Simon Plakolb, BSc MSc, Thaller Annina, BSc, MSc, Eva Fleiß, MA Ph.D., Mag. Stefanie Hatzl, PhD, Raphaela Maier, BSc, MSc
Lead Institution:	University of Graz, Wegener Center for Climate and Global Change
Scientific partner:	University of Graz, Institute of Public Law and Political Science
Project partners:	TRAFFIX Verkehrsplanung GmbH, Environment Agency Austria
Duration:	November 2019 – October 2021
Funding:	ACRP, 11th Call

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 optimisation 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 EGC - Environment and Global Change

The University of Graz has defined seven "research core areas," four of them with inter-university-cooperation. One of them is the research core area „Environment and Global Change." Within this core area, global and regional climate and environmental changes are investigated and monitored. The role of humans contributing to this change, as well as possible ways for transformation towards a sustainable society through innovation, is the central theme of EGC. Researchers from climate and environmental physics, environmental chemistry, hydrogeology, environmental biology, environmental economics, sociology, geography and regional sciences, systems sciences and sustainability research and management, environmental ethics and law collaborate and cooperate in doing interdisciplinary research in this core area.

There are main research areas:

- GlobEOS (Global Earth Observation and Stewardship)
- RegIMOS (Regional and Local Integrated Modelling System and Studies)
- EnviSYS (Changing Ecosystems and Earth-external Environmental Systems)
- GreenPROTEC (Green Processes and Technologies)
- RegiKNOWS (Regional Changes and Knowledge Transfer for Sustainability)
- HDChange (Human Dimensions of Climate and Global Change)

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 2019, the 25th annual International Sustainable Development Research Conference was held in Nanjing, China. Rupert Baumgartner is a board member of the ISDR-Society.

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 Systems Sciences, Innovation, and Sustainability Research (SIS) 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. SIS, 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 Data Generation for Systems Scientific Approaches in Sustainability and Labor Market Research by Use of Text Mining

Economic growth and technological development induce a continuous transformation of the labor market. This transformation manifests for employees in altered labor conditions and education requirements. In labor market research these changes have been investigated on the microscopic and macroscopic scale separately. On the macroscopic scale, the research is based on employment statistics, whereas on the microscopic scale questionnaires and interviews are employed. Combining these approaches is not appropriate to gain a labor market analysis with both wide coverage and high resolution. That is due to the huge effort questionnaires, and interviews require especially for extensive investigations. However, data mining methods, which have been developed since the end of the twentieth century, provide capable instruments to describe the labor market. Such a representation can be created on both the macroscopic and microscopic scale by using an extensive collection of job announcements. Sources for suitable datasets are found on the internet and newspapers. While the internet allows real-time analysis, newspapers are appropriate to investigate historical developments and higher-level systemic correlations moreover. Those correlations are for example Job Polarization in the labor market context and Critical Transitions in general. Both concepts are part of current systems scientific research. The combination of information retrieved from newspapers and from the internet allows analyzing in particular the rise, development, presence, and quality of Green Jobs.

The research questions are:

- Does the usage of Text Mining allow to generate data suitable for systems scientific investigations?
- What can be revealed in the systems scientific context regarding economic development?
    - Can Text Mining in job announcements published via newspapers depict labor market parameters of past decades?
    - Is it possible to determine indicators for Critical Transitions in these datasets?
- Can real-time monitoring of the labor market be developed basing on the answers to the above questions? What can be concluded regarding the development of Green Jobs?
- Based on the data provided by the use of Text Mining, is it possible to develop alternative economic indicators?

Ph.D. student: Mag. Andreas Schober, Bakk.
Duration: 2014 – 2020

2.4.2 Complex Networks and Sustainability: Modeling Mobility, Resilience and Cooperation

Climate change and climate change related impacts are among the biggest challenges for current and future generations. The international community tries to address these challenges of climate change in the Sustainable Development Goals and the Paris Agreement. However, the estimation of the impact magnitude and the effect of planned mitigation and adaptation measures are hindered by temporal lag and geographical distance between cause and effect.

Models offer a possibility to address these uncertainties and predict possible outcomes. In this thesis models are based on methods from systems sciences, most notably network science, as networks are one fundamental way for understanding and analyzing complex systems, especially sustainability-related systems. To demonstrate the universal applicability multiple research objectives regarding different sustainability-related systems are chosen, which are not only connected by the application of the network scientific methods but also a different focus on the micro or the macro aspects of the analyzed system.

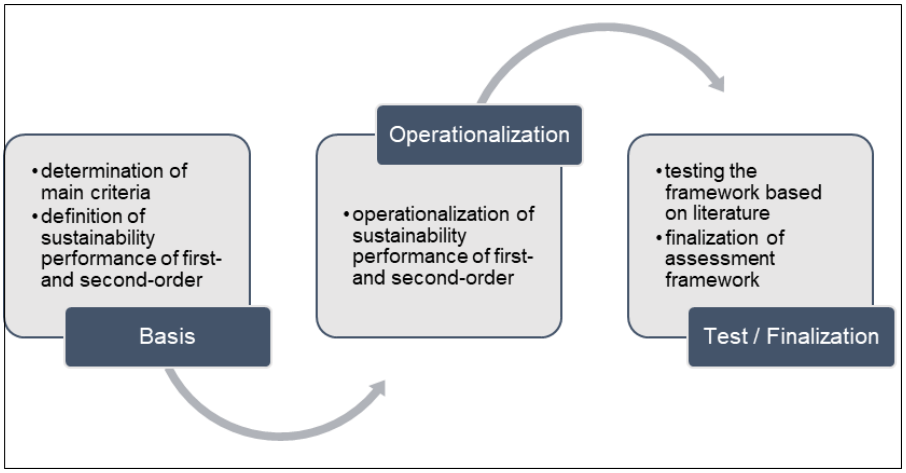
The first research objective focuses on the development of a generic opinion diffusion model that can include different forms of survey data that did not necessarily have to be adapted for the model.
In the second research objective critical transitions, sudden changes of a systems stable state, and the possible prediction of these are analyzed in bottom-up modeling approaches.
Research objective three focuses on models for decision– and policy makers. On the one hand the possibilities in emergency situations, where a model delivers decision support and feedback without endangering humans or the environment. On the other hand, a flexible model for estimating long-term climate impacts of different urban traffic scenarios.

Even though the different research objectives addressed distinct problems, the network scientific viewpoint proofed to be a viable way to gain new insights in every one of them.

Ph.D. student: Christian Hofer, Bakk. BSc. MSc.
Duration: 2015 – 2020

2.4.3 Operationalization of sustainability performance of first and second order

After the publication of the report "Our Common Future" by the World Commission on Environment and Development many milestones followed in defining sustainability. Most studies focus on sustainable development on a macro-level, rather than linking all affected levels (e.g., the company, market, society, and nature). It must be considered that sustainable development cannot be achieved by thinking within a firms' border. Everything is interconnected, and pollution doesn't stop at any (geographical or firms) boundary. A company is operating in a market system which is part of the society embedded in nature. The focus on the performance of a sub-system might potentially decrease the sustainability performance of society and nature in total. This means that whole system have to be studied, rather than focusing on single projects, processes, and activities. Thus, the dissertation focuses on the topic of sustainability performance in a systemic view. The goal is to operationalize sustainability performance of first- and second-order based on a definition of Baumgartner&Rauter (2017).
The first part of the dissertation is the development of a conceptual framework which includes essential dimensions to operationalize sustainability performance of first- and second-order. For testing the applicability of this framework, case studies will be conducted (e.g., sustainability performance of green chemistry processes). The figure below shows the methodological approach of the dissertation.



The methodological approach to operationalize first- and second-order sustainability performance

In the frame of the present dissertation the following main research questions will be studied:
Question 1: How can sustainability performance be operationalized if systemic impacts are integrated?
Question 2: Which dimensions are needed to operationalize sustainability performance of first- and second-order?
This dissertation is one of the first attempts to split sustainability performance into first- and second-order by identifying the degree of sustainability in a systemic way. This helps businesses to concentrate on major (sustainability management) activities to allow sustainable development, according to the Brundtland report 1987, to meet the needs for generations nowadays and in the future. Through this approach, companies can identify lack of sustainability performance. Based on this, improvements and targets can be set by implementing sustainable strategies. This is highly important as current situations show an urgent need to get companies to act in a more sustainable way.

PhD student: Martina Zimek, BSc. MSc.
Duration: 2016 – 2020

2.4.4 Eco-Innovations in Bioeconomy: The Role of Wood-based Composites in the Mobility Sector

The transition towards a bioeconomy can be described as an economy were the basic components of materials chemicals and energy are made out of bio-based resources (McCormick and Kautto 2013). For moving towards a bioeconomy, it is necessary to identify new applications and markets for bio-based materials.

The automotive sector is a possible marker for lighter materials. This sector faces growing pressure to reduce the greenhouse gas emissions of their fleet (EC 2014) and simultaneously increase the recyclability of its components (European Commission 2000). In order to cope with the emission targets, the mobility sector is in need to reduce the fuel consumption and the weight of their vehicles. For instance, bio-based materials have some advantages compared to traditional glass-fibers such as being renewable and available at a low cost, having a low weight, high strength and elasticity modulus (Bismarck et al. 2006). In general, bio-products are expected to be environmental friendlier compared to products based on petroleum (Hansen 2016). Depending on the component and the system under study, using wood as a substitute for other materials such as steel has the potential of reducing environmental impacts (Petersen and Solberg 2005).

The technical feasibility of introducing wood in automotive applications is currently getting more attention. However, substituting fossil-based resources with bio-based resources in certain applications will not necessarily lead to a reduction of environmental impacts. Therefore, the sustainability performance of bio-based products compared to other materials such as metals, carbon-fibres or aluminum needs to be analyzed as well.
The work at hand aims to gain more insight into the sustainability of bioeconomy innovations by focusing on the case of wood in automotive applications. More precisely, this work aims to analyze

- the end-of-life possibilities and issues of bioeconomy innovations in terms of resource efficiency
- the differences and similarities between different resource management concepts within the bio-based and non-bio-based economy, namely cascading utilization and circular economy and
- the environmental and social impacts when substituting of non-bio-based materials with bio-based materials in an automotive context

The PhD-project is partly embedded in the project WoodC.A.R.

PhD student: Claudia Mair-Bauernfeind, MSc
Duration: 2016 – 2020

2.4.5 Transition Towards Bioeconomy: Indicators, Determinants and Interventions from a Macro-level Perspective

The terms “bioeconomy” and “bio-based economy” are currently referring to one of the most prominent political-economic concepts in Europe focusing on ecological aspects, i.e., climate change mitigation and reducing environmental impacts. Furthermore, a bio-based economy is intended to have socioeconomic benefits such as fostering economies’ competitiveness, meeting rising demand and counteract resource depletion. Measuring and monitoring bioeconomic developments are important for future social, political and economic decisions. Previous studies on the state of bioeconomy were based on an initial decision, what bioeconomy is, i.e., which sectors of an economy are considered as bioeconomic. However, the literature shows that corresponding prioritization within bioeconomy strategies around the world differ considerably. Some countries rather focus on traditional biomass producing and transforming sectors (e.g., forestry sector, pulp, and paper industry) while others concentrate on high-tech industry (e.g., chemical and pharmaceutical industry). On the other hand, there is a broad consensus regarding the possible outcomes of a bioeconomic transition. These are, among others, reduced dependency on fossil fuels, mitigated global warming as well as avoided environmental damages caused by petrochemistry.

In order to overcome the problem of a lacking definition of bioeconomy, this project refrains from measuring the economic performance of a set of “bioeconomy sectors.” Instead, it focuses on the potential outcome of bioeconomic transitions, i.e., to quantify fossil fuels and biomass consumed by countries. Applying such a material-based approach, explanatory and controlled key variables expected to determine the fossil fuels and biomass shares in economies’ material inputs must be taken into account. In this context, economic growth, affluence or final demand, as well as population density and domestic per-capita extraction of raw materials have been discussed in the literature. However – at least for a subset of countries – models show unsatisfactory results, which leaves room for the inclusion of further/other explanations. Summarized, the question of raw material consumption determinants on macro level remains partly unresolved. For contributing to the discussion on the measurability of bioeconomic transitions, this project is built upon four consecutive objectives.

- Compare non-structural output growth of bio-based and non-biobased primary sectors across countries as a preparatory work and to get familiar with the data used in (2) (*constant market share decomposition*).
- Setting up a material-based indicator for bioeconomic transition that goes beyond the use of basic economic data; describing past developments and comparing the results with existing literature (*multi-regional input-output analysis*).
- To reassess (and add new) explanatory/controlling variables regarding the data from (2) in order to explain possible driving forces of bioeconomic transitions (*regression analysis*). Investigate, if model output is similar to the results of existing models based on other data sources.
- Conduct sensitivity analysis introducing variables from (3) as external factors, and observe resulting behavior of bioeconomy indicators (e.g., using *computable general equilibrium modelling*). Draw conclusions on possible interventions affecting the external factors investigated.

PhD student: Mag. Raphael Asada, BA
Duration: 2017 – 2020

2.4.6 Transition to Business Models for Sustainability: decision makers and decision-making systems supporting sustainable development of organizations

Many researchers have reached a consensus that sustainable development of economy and society at large is not likely without the sustainable development of organizations. Companies should not only decrease the negative impacts from carrying out their business activities, but these should also aim at creating positive value for the environment and society, while still creating sufficient economic value. Therefore, corporate management has an important role in contributing to sustainable development.

This dissertation explores decision-making for sustainability in companies in Austria. The focus of the research lies on identifying the (sustainability) decision makers and understanding the decision-making systems and structures that are shaping corporate sustainability management strategies. The goal of the research is to find out, what type of decision-making processes enable a more integrated approach to corporate sustainability management, thus, forming also more sustainable organizations/companies.

For reaching this goal, the following topics of interest are defined:

- Who is responsible for corporate sustainability management in companies in Austria, and where are these persons located in terms of the organizational structure?
- Which organization levels are involved in corporate sustainability management and in what form/to what extent?
- How companies/corporate sustainability managers reveal the sustainability topics of relevance for sustainability management?
- Which topics are reported as relevant for the companies in the selected sample in Austria, and can any trends be observed?
- How stakeholder requirements and various internal and external factors influence sustainability management practices? Etc.

For answering the research questions, a mixed methods approach is used. First, corporate sustainability survey was carried out from October-December 2017, addressing smaller large-sized companies in Austria. Second, persons responsible for sustainability management in these companies shared their insights on sustainability management processes and the main challenges in interviews carried out from May to July 2018.

PhD student: Aisma Linda Kiesnere, MSc.
Duration: 2016 – 2020

2.4.7 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 Flippr^2.

PhD student: Julia Wenger, BSc M.Sc. MSc.
Duration: 2018 – 2021

2.4.8 **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 analysed 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, transdisciplinarity 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 analysed (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, MSc
Duration: 2018 – 2021

2.4.9 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 in important in the context of CE and how are they perceive 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, BA, MA
Duration: 2018 – 2021

2.4.10 **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

2.4.11 Business Model Innovation for the Circular Economy: Understanding, Exploration and Guidance

Unsustainable patterns of production and consumption are pushing the economy beyond natural planetary boundaries, thus requiring an urgent shift towards a sustainable trajectory. In recent years, the Circular Economy (CE) paradigm has been promoted as an effective contributor to Sustainable Development and, even though there has been a broad interest on the concept, the business community has been slow in adopting its principles. Widespread adoption of circular business models is required to accelerate the transition, however, the literature supporting the process of business model innovation (BMI) for the CE -or Circular Business Model Innovation (CBMI)- is currently emerging. Though several publications on the topic have been published in the last five years, there is still a lack of understanding -and lack of guidelines- on the process of CBMI, particularly for incumbent firms; and, as the majority of the literature is theoretical, further empirical insights are required.

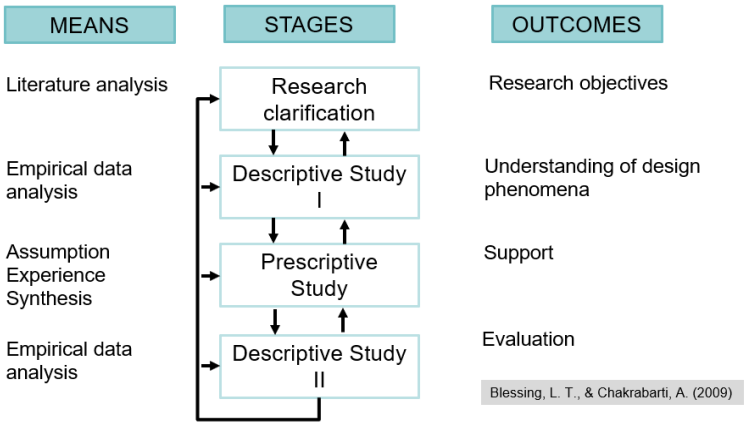
The goal of this thesis is to support the development of Business Models for the Circular Economy in incumbent firms, by compiling and assessing current knowledge on CBMI, exploring its occurrence in existing firms and providing guidelines to future innovation processes. This will be done through three interconnected research projects:

Research Question	Research Method	Expected Outcomes
RQ 1.1: What is known about Business Model Innovation for the Circular Economy (CBMI) and where should further research go?	Systematic literature review	(i) CBMI framework that summarizes the emergent field, built upon the structure of the BMI field; (ii) Identification of under and un-researched subtopics.
RQ 1.2: How can the emerging field of CBMI leverage on the maturing field of Business Model Innovation (BMI)?		
RQ 2: How does the process of CBMI happens in the practice in incumbent firms?	Multiple case study of CBMI on incumbent firms.	(i) Exploration of under-researched CBMI subtopics; (ii) Key elements and best practices of the CBMI process; (iii) Empirical review of drivers and barriers for CBMI
RQ 3: How could the process of CBMI be guided and facilitated using a Design Thinking approach?	Action research through specifically designed workshops and tools.	(i) Guidance through a CBMI process framework; (ii) Set of workshops and tools to facilitate specific stages of the CBMI process.

PhD student: Tomas Santa Maria Gonzalez, MSc
Duration: 2018 – 2021
Reference: CRESTING ITN MSCA Project

2.4.12 **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, MSc.
Duration: 2018 – 2021
Reference: CRESTING ITN MSCA Project

2.4.13 **Consumer decisions: The case of sustainable mobility behavior**

The transport sector is one of the biggest contributors of greenhouse gas emissions, where a significant share of emissions is caused by passenger transport. Drastic reductions will be necessary to stay in line with climate goals, therefore alternative ways of being mobile have to be increased, implying the need for a modal shift. This shift will not be easy to attain, as the current system is automobile dependent and suffering from carbon lock-in, where other, more sustainable modes of transport are locked out. As incremental solutions will not be sufficient, not only is it necessary to focus on a modal shift within the system, but rather on system-wide changes of the current passenger transport system.
Based on the outline presented above, my dissertation on the one side deals with the investigation of so-called disruptive policies, which have the potential to lead to a drastic decrease in transport-related emissions as well as a fundamental shift in the current system towards more sustainable and carbon-neutral urban mobility solutions. On the other side, the described problem of carbon lock-in in passenger transport, where the current emission-intensive system characteristics are unsustainable and prevent other, more sustainable choices from becoming dominant through a cycle of self-reinforcing factors, is addressed combining technological/infrastructural, institutional and behavioral components.
In my research I use both quantitative (such as surveys, statistical data analysis, hierarchical regression models) and qualitative methods (interviews, stakeholder workshops) from a social science perspective, where I am especially interested in individual decision making and behavior in times of climate change.

Regarding the progress of my dissertation project, have a look on my current paper plans:

- "The road towards sustainable mobility: Disruptive potential of urban transport policies"
  - Status: empirical research completed, paper draft in progress
  - Methods: systematic literature review, qualitative expert interviews, stakeholder workshop
  - Planned submission: April 2020
- "Acceptance is the road to all change - Public opinion on disruptive transport policies"
  - Status: in preparation
  - Methods: Quantitative survey, conjoint analysis
  - Planned submission: Summer 2020
- "About the interplay of carbon lock-in dimensions – the case of sustainable urban mobility behavior"
  - Status: in preparation
  - Methods: Quantitative survey, hierarchical regression models
  - Planned Submission: Autumn/winter 2020

PhD student: Annina Thaller, BSc. MSc.
Duration: 2018 – 2021

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

'Understanding transition' is the central feature of energy transition research; this implies, how to conceptualize transition framework and to explain why and how radical shifts take place in the established socio-technical systems. Transition in developing countries is challenging due to its unique characteristics of the electricity regimes. The transition process in such contexts is being debated.

The first project focuses on market perspective entitled; *Impact of market structure on solar home system diffusion in the off-grid rural areas.* Access to universal electrification is a pressing sustainable development goal for developing countries; the off-grid and difficult-to-reach rural areas are provided with energy services from traditional sources, e.g. kerosene lamps, diesel generators. In such contexts, supply push is inevitable to create new markets for promising solar home system (SHS) technology. The diffusion of technology is the outcome of market competitiveness which is determined by market structure, i.e. number of firms and their market share distribution size. Hence, evolving supply-side market structure and diffusion of technology in transition remains appealing for further research avenue. This study aims to describe how the market structure evolves over time and to assess the impact of market structure on the diffusion of solar home system technology in the off-grid rural markets.

The second project focuses on policy perspective entitled; *Solar home system prices are not what they seem: A critical analysis of transition in practice*. While renewable energy is advancing rural energy transition (SDG7.1) in developing South Asia, affordable access to off-grid SHS is a 'make or break' factor to eradicate persistent energy poverty. Development agencies and private entities offer flexible consumer financing to the rural poor by creating commercial markets for SHS. In the market based SHS program, SHSs are not subsidized or partially subsidized to some extent and rural customers pay for their systems availing micro energy loans from non-bank financial institutions, e.g. microfinance institutions. However, solar technology uptake in rural areas faces constraints in case of high upfront cost, inflexible periodic payments, high interest rates, and/or high service charges. The resulting unequal distribution of energy access runs counter to the notion of distributive justice. This study aims to investigate the relationship between pricing components of SHS and different market characteristics.

The third project focuses on technology regime perspective entitled, *Regime embedding mechanism for urban roof-top photovoltaics: A transition phase of dynamic structural interrelations*. Owing to cost-competitiveness and technology advancement, solar energy is progressively contributing to climate mitigation, particularly as a roll-out technology in carbon neutral electricity generation. Solar photovoltaic can reasonably be considered as 'alternative socio-technical regime' comprising required socio-technical arrangements including, political and investment support, infrastructural advancement, emerging business models, and institutionalized rules and practices. This implies new qualitative phenomena in the energy transition discourses – a shift in scholarly attention from 'emergence and exploration (early phase of diffusion)' to 'acceleration and embedding (next phase of diffusion)'. A finetuning of the existing frameworks or developing new theories, hence, is warranted. Building on the critical realist and system perspective, this study aims to conceptualize 'regime embedding mechanism'; abductive content analysis and interpretative structural modelling through energy expert judgments will be applied to investigate the order of structural interrelationships.

PhD student: Rafia Zaman, MBA
Duration: 2018 – 2021

2.5 Ph.D. Projects (finalized)

2.5.1 Social and Economic Uncertainties and Thresholds for the Diffusion and Adoption of Renewable Energy Systems

In my Ph.D. thesis, I deal with diffusion processes of emerging low-carbon technologies in the energy sector. More specifically, I focus on radical innovations (i.e., innovations that do not fit well into current energy regimes) by using primarily the example of solar photovoltaics (PV), a promising technology, which may contribute substantially to the de-carbonization of our society. Based on the insights of evolutionary economics and innovation theory, I conceptualize the diffusion of technologies as a dynamic and non-linear process, which depends on a range of different factors, including financial, technical, institutional, political and cultural factors.

There are two thematic blocks within the thesis. The first block is about social and economic uncertainties for solar PV technology and the associated emergence of collective expectations. Based on the sociology of expectations, I analyse the patterns of expectations for this type of technology over time and examine the actual contents of these expectations. Furthermore, I try to shed light on the question of how expectations might influence actual innovation activities. In one of my key projects, I focus on expectations for photovoltaic technology in Germany and Spain by analysing newspaper articles.

The second block is about social and economic thresholds. Within this block, I seek to identify and explain relevant tipping points in the context of the emergence of low-carbon technologies such as, for instance, a point in time at which the diffusion of a specific technology becomes self-sustaining. Here, I draw mainly on the technological innovation system (TIS) framework, which suggests that the successful diffusion and development of novel technologies depend on seven key functions that strongly interrelate. While these functions may accelerate each other and eventually cause a specific technology to 'take-off,' they also may block each other and prevent a technology's successful diffusion. To study the latter case, I, again focus on photovoltaic technology but use the Western Cape Province of South Africa as a case study.

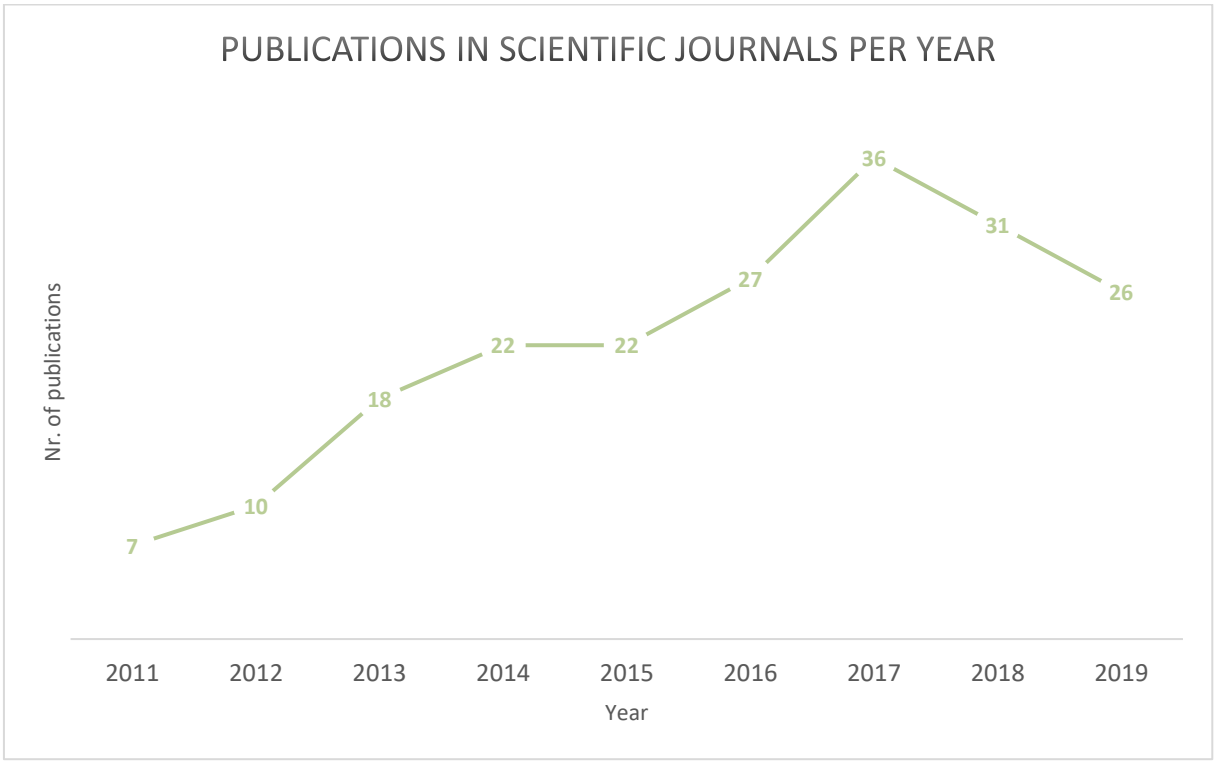
In the analyses, I primarily draw on the method of content analysis (qualitatively as well as quantitatively). I, however, also try to triangulate my data by conducting desk research or analysing secondary literature.

PhD student: Michael Kriechbaum, MSc. PhD
Duration: 2014 – 2019
Reference: Doctoral Programme DK Climate Change

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 following table:

Research activities and output	2015	2016	2017	2018	2019
Publications					
Publications in scientific journals	22	27	36	31	26
Contributions to an edited book or proceedings	16	22	12	16	17
Posters presented at scientific conferences	6	19	4	3	8



Number of publications in scientific journals over the last years

3.1 Publications

3.1.1 Edited book series/journal

Jäger, Georg; Letter, Chiara; Füllsack, Manfred: *Ohne System geht nix.* Graz: selfpublished 2019.

3.1.2 Contribution to peer-reviewed journal

Baumgartner, Rupert J.: *Sustainable Development Goals and the Forest Sector - A Complex Relationship,* in: Forests 10,152 (2019). DOI: 10.3390/f10020152

Brudermann, Thomas; Aschemann, Ralf; Füllsack, Manfred; Posch, Alfred: *Education for Sustainable Development 4.0: Lessons Learned from the University of Graz, Austria,* in: Sustainability 11,8 (2019), 2347. DOI: doi:doi.org/10.3390/su11082347

Brudermann, Thomas; Zaman, Rafia; Posch, Alfred: *Not in my hiking trail? Acceptance of wind farms in the Austrian Alps,* in: Clean Technologies and Environmental Policy 21,8 (2019), 1603–1616 . DOI: 10.1007/s10098-019-01734-9

Fleiß, Jürgen; Ackermann, Kurt A.; Fleiß, Eva; Murphy, Ryan O.; Posch, Alfred: *Social and environmental preferences: Measuring how people make tradeoffs among themselves, others, and collective goods,* in: Central European Journal of Operations Research forthcoming (2019), x. DOI: 10.1007/s10100-019-00619-y

Jäger, G., Zilian, L.S., Hofer, C., Füllsack, M.: *Crowdworking: working with or against the crowd?* in: Journal of Economic Interaction and Coordination 14,4 (2019), 761–788. DOI: 10.1007/s11403-019-00266-1

Jäger, Georg: *Replacing Rules by Neural Networks - A Framework for Agent-Based Modelling,* in: Big Data and Cognitive Computing 3,4 (2019), 51. DOI: 10.3390/bdcc3040051

Jäger, Georg; Füllsack, Manfred: *Systematically false positives in early warning signal analysis,* in: PLoS One 14,2 (2019), e0211072. DOI: https://doi.org/10.1371/journal.pone.0211072

Jäger, Georg; Hofer, Christian; Füllsack, Manfred: *The Benefits of Randomly Delayed Charging of Electric Vehicles,* in: Sustainability 11(13) (2019), 3722. DOI: 10.3390/su11133722

Kapeller, Marie L.; Füllsack, Manfred; Jäger, Georg: *Holiday Travel Behaviour and Correlated CO2 Emissions—Modelling Trend and Future Scenarios for Austrian Tourists,* in: Sustainability 11,22 (2019), 6418. DOI: https://doi.org/10.3390/su11226418

Kapeller, Marie Lisa; Jäger, Georg; Füllsack, Manfred: *Homophily in networked agent-based models: a method to generate homophilic attribute distributions to improve upon random distribution approaches,* in: Computational Social Networks 1,6 (2019), 9.

Kiesnere, Aisma L.; Baumgartner, Rupert J.: *Sustainability Management in Practice: Organizational Change for Sustainability in Smaller Large-Sized Companies in Austria,* in: Sustainability 11,12 (2019), 572-612. DOI: 10.3390/su11030572

Kiesnere, Aisma L.; Baumgartner, Rupert J.: *Sustainability management emergence and integration on different management levels in smaller large-sized companies in Austria,* in: Corporate Social Responsibility and Environmental Management Vol. 26, Issue 6 (2019), 1607-1626. DOI: doi.org/10.1002/csr.1854

Letter, Chiara; Jäger, Georg: *Simulating the potential of trees to reduce particulate matter pollution in urban areas throughout the year,* in: Environment, Development and Sustainability: a multidisciplinary approach to the theory and practice of sustainable development 21,4 (2019), 1-11. DOI: 10.1007/s10668-019-00385-6

Plakolb, Simon; Jäger, Georg; Hofer, Christian; Füllsack, Manfred: *Mesoscopic Urban-Traffic Simulation Based on Mobility Behavior to Calculate NOx Emissions Caused by Private Motorized Transport,* in: Atmosphere 10(6) (2019), 293. DOI: 10.3390/atmos10060293

Prieto-Sandoval, Vanessa; Jaca, Carmen; Santos, Javier; Baumgartner, Rupert J.; Ormazabal, Marta: *Key strategies, resources, and capabilities for implementing circular economy in industrial small and medium enterprises,* in: Corporate Social Responsibility and Environmental Management 26 (2019), 1473–1484. DOI: 10.1002/csr.1761

Rauter, Romana; Globocnik, Dietfried; Perl-Vorbach, Elke; Baumgartner, Rupert J.: *Open innovation and its effects on economic and sustainability innovation performance,* in: Journal of Innovation & Knowledge, Vol 8, Issue 4 (2019), 226-233. DOI: https://doi.org/10.1016/j.jik.2018.03.004

Riedner Lukas; Mair Claudia; Zimek Martina; Brudermann, Thomas; Stern Tobias: *E-mobility in agriculture: differences in perception between experienced and non-experienced electric vehicle users,* in: Clean Technologies and Environmental Policy 21,1 (2019), 55-67. DOI: doi.org/10.1007/s10098-018-1615-2

Rivotti, Pedro; Karatayev, Marat; Mourão, Zenaida; Shah, Nilay; Clarke, Michèle; Konadu, Dennis: *Impact of future energy policy on water resources in Kazakhstan,* in: Energy Strategy Reviews 24,1 (2019), 261-267. DOI: 10.1016/j.esr.2019.04.009

Schröck, Andrea Maria; Winiwarter, Wilfried; Gaube, Veronika; Haas, Edwin: *Estimating nitrogen flows of agricultural soils at a landscape level – A modelling study of the Upper Enns Valley, a long-term socio-ecological research region in Austria,* in: Science of the Total Environment 665 (2019), 275–289. DOI: 10.1016/j.scitotenv.2019.02.071

Schweiger, G.; Gomes, C.; Engel, G.; Hafner, I; Schoeggl, J.; Posch, A.; Nouidui, T.: *An empirical survey on co-simulation: Promising standards, challenges and research needs,* in: Simulation Modelling Practice and Theory 95 (2019), 148-163. DOI: 10.1016/j.simpat.2019.05.001

Schweiger, Gerald; Kuttin, Fabian; Posch, Alfred: *District Heating Systems: An Analysis of Strengths, Weaknesses, Opportunities, and Threats of the 4GDH,* in: Energies 12,24 (2019), -. DOI: 10.3390/en12244748

Šimunović, Nenad ; Stern, Tobias ; Hesser, Franziska: *Is sustainable forest management enough? Insights from a frame analysis of European environmental non-governmental organizations,* in: Austrian Journal of Forest Science 136,2 (2019), 87-140.

Valeyev, Adilet; Karatayev, Marat; Abitbayeva, Ainagul; Uxukbayeva, Saule; Bektursynova, Aruzhan; Sharapkhanova, Zhanerke: *Monitoring coastline dynamics of Alakol Lake in Kazakhstan using remote sensing data,* in: Geosciences 9,9 (2019), 1-11. DOI: 10.3390/geosciences9090404

Wenger, Julia; Stern, Tobias: *Reflection on the research on and implementation of biorefinery systems – a systematic literature review with a focus on feedstock,* in: Biofuels, Bioproducts and Biorefining 13,5 (2019), 1347-1364. DOI: 10.1002/bbb.2021

Zimek, Martina; Schober, Andreas; Mair, Claudia; Baumgartner, Rupert J.; Stern, Tobias; Füllsack, Manfred: *The Third Wave of LCA as the "Decade of Consolidation",* in: Sustainability 11 (2019), 3283. DOI: 10.3390/su11123283

3.1.3 Contribution to non-peer-reviewed journal

Melara, Fabiana; Macke, Janaina; Rauter, Romana: *Democratic workplaces and its linkages to new and sustainable business models: The case of Semco S.A.* in: Accountancy & Business 37 (2019), 23-37.

3.1.4 Contribution to an edited book or proceedings

Altendorfer, Michael; Pomberger, Roland; Gelbmann, Ulrike-Maria: *Weiterentwicklung der Kreislaufwirtschaft – welche Beschäftigungseffekte bringt die optimierte Restabfallbehandlung?* in: Stephanie Thiel, Olaf Holm, Elisabeth Thomé-Kozmiensky, Daniel Goldmann, Bernd Friedrich (Ed.), Recycling und Rohstoffe. Neuruppin: TK Verlag Karl Thomé-Kozmiensky 2019, 100-117.

Bouchouireb, H., O'Reilly, C., Göransson, Schöggl, J.-P., Baumgartner, R.J.: *Towards holistic energy-efficient vehicle product system design: The case for a penalized continuous end-of-life model in the life cycle energy optimisation methodology.,* in: The Design Society (Ed.), Proceedings of the 22nd International Conference on Engineering Design, ICED19. Delft, NL: The Design Society 2019, 2901-2910. DOI: https://doi.org/10.1017/dsi.2019.297

Delgadillo Jaime, Estephania E.; Reyes Carrillo, Tatiana; Baumgartner, Rupert J.: *Circular PSS strategies: an exploration of the integration of territorial resources,* in: Faculty of Industrial Design Engineering (Ed.), Proceedings of the 22nd International Conference on Engineering Design (ICED19), 5-8 August 2019. Delft: TU Delft 2019, pp. 3191-3200. DOI: 10.1017/dsi.2019.326

Diaz Tena, Anna; Schöggl, Josef-Peter; Baumgartner, Rupert: *Enabling a data-driven sustainable product development in a circular economy,* in: Nanjing University (Ed.), Sustaining Resources for the Future. Nanjing, China: Nanjing University 2019, 370-384.

Diaz Tena, Anna; Schöggl, Josef-Peter; Reyes, Tatiana; Baumgartner, Rupert: *Data-driven decision-making instruments to support circular product design,* in: N.F. Nissen; M. Jaeger-Erben (Ed.), PLATE Product Lifetimes And The Environment 2019 – Conference Proceedings. Berlin, Germany: TU Berlin University Press 2019, n/a.

Karatayev, Marat; Movkebayeva, Galiya; Bimagambetova, Zhibek: *Increasing utilisation of renewable energy sources: Comparative analysis of scenarios until 2050,* in: Nikolay, Mouraviev; Anastasia, Koulouri (Ed.), Energy security: policy challenges and solutions for resource efficiency. Palgrave Macmillan: Cham 2019, 37-68.

Kiesnere, Aisma L.; Baumgartner, Rupert J.: *Top Management Involvement and Role in Sustainable Development of Companies,* in: Leal Filho, W.; Azul, A.; Brandli, L.; Özuyar, P.; Wall, T. (Ed.), Responsible Consumption and Production, Encyclopedia of the UN SustainableDevelopment Goals. Cham: Springer 2019, 1-13. DOI: oi.org/10.1007/978-3-319-71062-4_11-1

Mair, Claudia; Asada, Raphael: *Efficient Use of Natural Resources,* in: Filho, Walter Leal; Azul, Anabela Marisa; Brandli, Luciana; Gökcin Özuyar, Pinar; Wall, Tony (Ed.), Responsible Consumption and Production. Encyclopedia of the UN Sustainable Development Goals. Cham: Springer 2019, 1-11.

Rauter, Romana; Globocnik, Dietfried; Baumgartner, Rupert J.: *Organizational Control, Sustainability Innovation Performance and Economic Innovation Performance,* in: Academy of Management Proceedings 1 (2019), 13680.

Rauter, Romana; Zimek, Martina; Baumgartner, Rupert J.; Schöggl, Josef-Peter: *Assessing the impact of sustainable business models: challenges, key issues and future research opportunities,* in: Nancy Bocken, Paavo Ritala, Laura Albareda, Robert Verburg (Ed.), Innovation for Sustainability - Business transformations towards a better world. Basingstoke, Hampshire, England: Palgrave Studies in Sustainable Business (in Association with Future Earth) 2019, 253-269.

Sajeev E.P.M., Mintz-Woo K., Damert M., Brunner L., Eise J. ; : *Blogging Climate Change: A Case Study,* in: Walter Leal Filho, ; Bettina Lackner, ; Henry McGhie; ; (Ed.), Addressing the Challenges in Communicating Climate Change Across Various Audiences. Cham: Springer 2019, 129-142. (in print)

Schöggl, Josef Peter; Fritz, Morgane; Saari, Ulla; Baumgartner, Rupert: *The effect of consumers´ environmental awareness on product expectations - the case of the Fairphone 1,* in: IAE Metz School of Management (Ed.), Proceedings of the 5th ProLog (Project Logistic) Conference 2019. Metz: Metz, School of Management 2019, -.

Schöggl, Josef-Peter; O'Reilly, Ciarán; Baumgartner, Rupert; Göransson, Peter: *A design-theoretic review of sustainable product development literature,* in: The Centre for Sustainable Design (Ed.), Proceedings of 22nd International Conference on Sustainable Innovation 2019 - Road to 2030: Sustainability, Business Models, Innovation and Design. Epsom, UK: University of Creative Arts (UCA) Epsom, Surrey, UK 2019, 188-196.

Schöggl, Josef-Peter; O'Reilly, Ciarán; Baumgartner, Rupert; Göransson, Peter: *Barriers for the implementation of design for sustainability in the European automotive industry: Empirical insights from an Analytic Hierarchy,* in: CPS (Ed.), Proceedings of the International Conference on Cleaner Production & Sustainability. Hong Kong: CPS 2019, N.A.

Stumpf, Lukas: *Circular Economy Business Strategies - A mixed methods analysis of 131 case studies,* in: Segalas, Jordí; Lazzarini, Boris (Ed.), Proceedings of the 19th European Roundtable for Sustainable Consumption and Production (ERSCP 2019). Barcelona: Institute for Sustainability Science and Technology, Universitat Politècnica de Catalunya - BarcelonaTech (ISST-UPC) 2019, 841-854.

Stumpf, Lukas: *Towards a fact-based circular economy – Exploring and Evaluating Business Showcases from the Circular Economy Industry Platform Abstract,* in: Deutsche Gesellschaft für Abfall- und Ressourcenwirtschaft (Ed.), 9. Wissenschaftskongress Abfall- und Ressourcenwirtschaft. Berlin: Deutsche Gesellschaft für Abfall- und Ressourcenwirtschaft 2019, 1-6.

Zimek, Martina; Baumgartner, Rupert J: *Sustainability Assessment and Reporting of Companies,* in: Walter Leal Filho, Anabela Marisa Azul, Luciana Brandli, Pinar Gökcin Özuyar, Tony Wall (Ed.), Responsible Consumption and Production. Encyclopedia of the UN Sustainable Development Goals. Cham.: Springer 2019, 1-13. DOI: 10.1007/978-3-319-71062-4_15-1

3.1.5 **Other Publications**

Brudermann, Thomas: *Grey energy transitions in South-East Asia – The case of Thailand. ASEA-UNINET - Annual Report Austrian Board of Trustees 2018, p. 90-96.* Vienna: ASEA-UninetASEA-Uninet 2019.

Brudermann, Thomas: *Humans and Climate: Why is it so difficult to behave climatefriendly? In: Humans in their surrounding world, p.19-22(Proceedings of the 4th EFPSA Conference, 21.-24.11.2019, ISBN 978-80-263-1554-4.* Prague: European Federation of Psychology Student's AssociationsEuropean Federation of Psychology Student's Associations 2019.

3.1.6 **Presentations**

Aschemann, Ralf: *Combining EIA and HIA - An Austrian Case Study,* for: Evolution or Revolution: Where next for impact assessment?, International Association for Impact Assessment, Brisbane (Australia), 01.05.2019.

Aschemann, Ralf: *Erasmus Mundus Master's Programme in Industrial Ecology: Analysis of its Master's Theses,* for: European Roundtable for Sustainable Consumption and Production (ERSCP), UPC Barcelona, Barcelona (Spain), 16.10.2019.

Aschemann, Ralf: *Interrelationships of Environmental Assessment and Industrial Ecology,* for: Evolution or Revolution: Where next for impact assessment?, International Association for Impact Assessment, Brisbane (Australia), 01.05.2019.

Aschemann, Ralf: *Some Basics of Circular Economy,* for: Orientation week CIRCLE, Erasmus Mundus CIRCLE-Programm, Hönö (Sweden), 05.08.2019.

Baumann, Georg; Feist, Florian; Stadlmann, Alexander; Müller, Ulrich; Mair-Bauernfeind, Claudia; Kurzböck, Christian: *Side Impact Beam: Wood instead of Ultra-High Strength Steel?,* for: CAE in Support of Sustainability and Durability, NAFEMS , Billund (Denmark), 26.11.2019.

Baumgartner, Rupert J.: *Circular disruption – the role of business models,* for: Workshop on Circular Business Models and Circular Disruption, University of Utrecht, Utrecht (Netherlands), 13.12.2019.

Baumgartner, Rupert J.: *Circular Economy as enabler for sustainable development of our societies: management challenges for the business sector,* for: Final Conference of the Project MOVECO (Mobilising Institutional Learning for Better Exploitation of Research and Innovation for the Circular Economy), Business Upper Austria – OÖ Wirtschaftsagentur GmbH, Linz (Austria), 14.05.2019.

Baumgartner, Rupert J.: *Nicht-Finanzielle Berichterstattung in Europa: Der Fall Österreich,* for: Webinar "Nicht-Finanzielle Berichterstattung in Europa: Der Fall Österreich", iPoint GmbH, (Germany), 27.11.2019.

Baumgartner, Rupert J.: *Regional oder global? Von regionalen Umweltfragen zur ganzheitlichen Herausforderung einer nachhaltigen Entwicklung,* for: Umweltinformation: Grundlage einer wirkungsvollen Umweltbildung, Amt der Steiermärkischen Landesregierung, Abteilung 15 - Energie, Wohnbau, Technik, Graz (Austria), 10.04.2019.

Baumgartner, Rupert J.: *Strategic corporate sustainability management,* for: Sustainability Performance Measurement, Research Institute of the University of Poitiers (CEREGE), Poitiers (France), 10.01.2019.

Baumgartner, Rupert J.: *Strategic sustainable development and corporate sustainability management,* for: Seminar Sustainability Concepts, University of Waterloo, University of Waterloo (Canada), 23.10.2019.

Baumgartner, Rupert; Schöggl, Josef-Peter: *Circular Design - Wie entsteht nachhaltige Innovation?,* for: UB Risikodialog - Chance Kreislaufwirtschaft, Umweltbundesamt , Wien (Austria), 03.10.2019.

Brudermann, Thomas: *Deine Entscheidung, unser Problem: Umweltrelevantes Entscheidungsverhalten verstehen und modellieren,* for: Schnupperuni 2019, University of Graz, Graz (Austria), 22.08.2019.

Brudermann, Thomas: *Green and Grey Energy Transitions,* for: The 430th IDEC Seminar, Graduate School for International Development and Cooperation, Hiroshima University, IDEC Large Conference Room, Hiroshima University (Japan), 17.09.2019.

Brudermann, Thomas: *Humans and Climate: Why is it so difficult to behave climate-friendly?,* for: EFPSA Conference 2019, European Federation of Psychology Student's Association (EFPSA) , Prague (Czechia), 22.11.2019.

Brudermann, Thomas: *Present and future energy transitions,* for: Global X-Network Annual Conference in Vienna October 26-28, 2019, Global X-Network, Vienna (Austria), 27.10.2019.

Diaz Tena, Anna: *Data-driven decision making instruments to support circular product design,* for: Product Lifetimes and The Environment (PLATE 2019), Technical University Berlin, Berlin, Germany (Germany), 18.09.2019.

Diaz Tena, Anna: *Enabling a data-driven sustainable product development in a circular economy,* for: Nanjing University, Nanjing, China (China), 26.06.2019.

Diaz Tena, Anna: *Product lifecycle management as an enabler of circular product design,* for: 10th International Conference on Industrial Ecology, Tsinghua University, Beijing, China (China), 11.07.2019.

Füllsack, Manfred: *Arbeit an der Arbeit – zu den Voraussetzungen der digitalen Rationalisierung,* for: Open Commons Kongress 2019, Open commons Linz, Linz (Austria), 14.06.2019.

Füllsack, Manfred: *Bifurcation Prediction in ABMs, on the example of Unemploymebnt Hysteresis and Tipping in Iterated Public Good Games,* for: Workshop zu Agent-based Economics, GSC, Graz (Austria), 30.10.2019.

Füllsack, Manfred: *Predicting Bifurcations,* for: COLIBRI-Day, COLIBRI, Graz (Austria), 30.09.2019.

Füllsack, Manfred: *Tipping Points,* for: Tipping Points, Volkswagen, Wolfsburg (Germany), 26.06.2019.

Gelbmann, Ulrike-Maria: *Erdgespräch: Plastikmythen,* for: Erdgespräche, Graz (Austria), 26.02.2019.

Gelbmann, Ulrike-Maria: *Moderation Thema Abfall,* for: Zukunftsworkshop für steirische Gemeinden Neue Projekte für eine nachhaltige Entwicklung in steirischen Gemeinden, TU Graz, Karl-Franzens-Universität, Land Steiermark, Gemeindebund Steiermark, Städtebund Steiermark, Steiermarkhof Graz (Austria), 19.09.2019.

Gelbmann, Ulrike-Maria: *Plastikmythen,* for: Österreichische Urania Graz, Urania Graz (Austria), 03.12.2019.

Holzer, Daniel: *Mind the gap: How can circularity in SMEs be increased?,* for: 4th International Conference on New Business Models, Chair for Corporate Sustainability of ESCP Berlin, Berlin (Germany), 03.07.2019.

Jäger, Georg: *Ohne System geht nix - ein Schnupperkurs in die Systemwissenschaften,* for: Tag der offenen Tür, Uni Graz, Graz (Austria), 25.04.2019.

Jäger, Georg: *Replacing Rules by Neural Networks,* for: International Microsimulation Association World Congress, NUI Galway, Galway, Ireland (Ireland), 19.06.2019.

Jäger, Georg; Plakolb, Simon; Füllsack, Manfred: *Traffic Modelling based on Mobility Behaviour,* for: KFU-AIT Cooperation Workshop on Mobility, Austrian Institute of Technology, Vienna (Austria), 28.05.2019.

Karatayev, Marat: *Regional energy collaborations to further energy security: a case of Eurasian Economic Union (EAEU) countries,* for: Research Network for Energy and Water in Central Asia, University of Edinburgh, Kazakh British Technical University, Remote Participant. Almaty, Kazakhstan (Kazakhstan), 23.05.2019.
Karatayev, Marat: *The importance of nexus approach to water-energy-food security for transitional and resource-rich countries,* for: Critical Issues in Science, Technology and Society Studies, Graz University of Technology, Graz, Austria (Austria), 06.05.2019.

Plakolb, Simon, Hofer, Christian, Jäger, Georg, Füllsack, Manfred: *The Effect of Urban and Rural Mobility Behaviour on Congestion and Emissions Resulting from Private Motorised Traffic,* for: Social Simulation Conference 2019, European Social Simulation Association (ESSA), Johannes Gutenberg University, Mainz (Germany), 26.09.2019.

Posch, Alfred: *Energieregionen der Zukunft,* for: Montagsakademie, Universität Graz, Graz (Austria), 06.05.2019.

Posch, Alfred: *Warum und wie Regionen globale Probleme lösen können,* for: Vorauer Klimaschutztage, Klima- und Energieregion Vorau, Vorau (Austria), 04.10.2019.

Rauter, Romana; Globocnik, Dietfried; Baumgartner, Rupert: *Organizational Control, Sustainability Innovation Performance and Economic Innovation Performance,* for: 79th Annual Meeting of the Academy of Management, Academy of Management, Boston (United States (USA)), 13.08.2019.

Schöggl, Josef-Peter: *Impulsvortrag Circular Economy,* for: Alpine Bioeconomy Workshop, Cleantech Cluster des Business Upper Austria, Linz (Austria), 17.10.2019.

Schöggl, Josef-Peter: *Klimawandelanpassung in der Gemeinde- und Regionalentwicklung - Das Zusammenspiel von Minderung und Anpassung,* for: Dialog über Klimawandelanpassung, Institut für Geographie und Raumforschung der Universität Graz, Allerheiligen bei Wildon (Austria), 14.11.2019.

Schöggl, Josef-Peter: *Sustainable Product Management enabling a Circular Economy,* for: fw: transparency 2019, iPoint Systems GmbH, Reutlingen (Germany), 26.06.2019.

Schöggl, Josef-Peter: *The narrative of sustainability and circular economy,* for: Symposium “Science and Research for Circular Economy", Circular economy coalition for Europe, Wien (Austria), 24.10.2019.

Schöggl, Josef-Peter; Magdalena, Rusch: *Towards data-based sustainability assessment and design,* for: Automotive Cluster Styria Business Lounge, Automotive Cluster Styria, Seggauberg (Austria), 05.11.2019.

Schütz, Marlies; Zilian, Stella Sophie; Zilian, Laura Samantha: *Perfect competition in the digital economy?,* for: Momentum Kongress, Momentum, Hallstatt (Austria), 12.10.2019.

Stern, Tobias: *Bioökonomie – Impuls und Chance für Wald- und Holzwirtschaft,* for: 15. Waldökonomisches Seminar "Bioökonomie", FH Bern/ Schweizer Forstverein, Murten/Münchenwieler (Switzerland), 05.11.2019.

Stern, Tobias: *Innovation and Transition Research in Context of the Bioeconomy Concept,* for: Marketing & Innovation Talks, Institut für Marketing & Innovation, BOKU Wien, Wien (Austria), 12.02.2019.

Stern, Tobias: *Innovation and TransitionResearch in Context of theBioeconomy Concept,* for: NOVA Summer School on Bioeconomy, University of Helsinki, Helsinki (Finland), 22.08.2019.

Stern, Tobias: *Wald als Rohstoff für die Bioökonomie,* for: Landnutzung und Klimawandel – Herausforderung Treibhausgasneutralität, Österreichische Akademie der Wissenschaften, Wien (Austria), 26.11.2019.

Stumpf, Lukas: *Circular Economy Business Strategies - A Mixed Methods Analysis of 131 Case Studies,* for: 19th ERSCP - Circular Europe for Sustainability: Design, Production and Consumption, Institute for Sustainability Science and Technology, Universitat Politècnica de Catalunya - BarcelonaTech, Barcelona (Spain), 16.10.2019.

Stumpf, Lukas: *Exploring and evaluating business showcases fromthe Circular Economy Industry Platform,* for: 9. Wissenschaftskongress „Abfall- und Ressourcenwirtschaft“, Ostbayerische Teschnische Hochschule Amberg, Amberg (Germany), 15.03.2019.

Stumpf, Lukas: *The narrative of sustainability and circular economy – a bibliometric, network, and semantic analysis,* for: 25th ISDRS Conference - Sustaining Resources for the Future, Nanjing University, Nanjing (China), 27.06.2019.

Tobias Stern, Martin Braun, Franziska Hesser & Peter Schwarzbauer: *EFFECTS OF CHANGING CONDITIONS FOR BIOMASS USE: RESULTS OF SYSTEM-DYNAMICS BASED SCENARIOS IN AUSTRIA,* for: 7th World Congress of the International Microsimulation Association, International Microsimulation Association, Galway (Ireland), 11.06.2019.

Wenger, Julia; Asada, Raphael; Stern, Tobias: *Towards a simulation-based understanding of biorefinery development,* for: 7th World Congress of the International Microsimulation Association, International Microsimulation Association; hosted by the National University of Ireland, Galway, Galway, Ireland (Ireland), 21.06.2019.

Wenger, Julia; Stern, Tobias: *Towards a simulation model to explore the economic framework conditions and challenges for novel lignin applications and innovative lignin-containing products,* for: PAPER & BIOREFINERY Conference, APV Akademischer Papieringenieur-Verein at Graz University of Technology, Graz, Austria (Austria), 06.06.2019.

Zilian, Laura Samantha; Zilian, Stella Sophie: *Skill mismatch in Austria,* for: 2nd EAYE Workshop, European Association of Young Economists, Paris (France), 04.10.2019.

3.1.7 **Posters**

Baumgartner, Rupert; Schöggl, Josef-Peter: *Data-based sustainability assessment and design in the context of the circular economy,* for: CCFLOW Open Days, Research Center Pharmaceutical Engineering, TU Graz (Austria), 2019.

Brudermann, Thomas; Hofer, Christian; Zaman, Rafia: *Energy in the global south: Green or grey transition?,* for: 18th Annual STS Conference, TU Graz, Graz (Austria), 2019.

Koshim, Asima; Karatayev, Marat: *Bioenergy in Kazakhstan in a water-land-energy nexus perspective,* for: Critical Issues in Science, Technology and Society Studies, Graz University of Technology, Graz, Austria (Austria), 2019.

Plakolb, Simon, Hofer, Christian, Jäger, Georg, Füllsack, Manfred: *Hybrid agent based network traffic model coupled with a macroscopic emissions model to investigate commuter impact on city traffic emissions of passenger cars,* for: The International Society for Ecological Modelling Global Conference 2019, The International Society for Ecological Modelling, Salzburg Congress Centre, Salzburg (Austria), 2019.

Thaller, Annina: *Towards a low carbon energy transition of urban mobility from a consumer perspective,* for: 18th Annual STS Conference Graz 2019 – Critical Issues in Science, Technology and Society Studies, Science Technology and Society Unit of the Institute of Interactive Systems and Data Science of the Technical University of Graz, the Inter-University Research Centre for Technology, Work and Culture (IFZ) and the Institute for Advanced Studies of Science, Technology and Society (IAS-STS), Graz, Österreich (Austria), 2019.

Thaller, Annina; Fleiß, Eva; Brudermann, Thomas: *What drives climate (in)action in the general public?,* for: Klimatag 2019, CCCA, Wien, Österreich (Austria), 2019.

Thaller, Annina; Posch, Alfred: *About the interplay of CARbon lock in dimensions - the case of sustainable urban mobility behavior,* for: European Roundtable for Sustainable Consumption and Production (ERSCP), Institute for Sustainability Science and Technology of the Universitat Politècnica de Catalunya - BarcelonaTech, Barcelona, Spanien (Spain), 2019.

Valeyev, Adilet; Karatayev, Marat; Abitbayeva, Ainagul; Uxukbayeva, Saule; Bektursynova, Aruzhan; Sharapkhanova, Zhanerke: *Monitoring coastline dynamics of Alakol Lake in Kazakhstan using remote sensing data,* for: European Geosciences Union (EGU) General Assembly, European Geosciences Union, Vienna, Austria (Austria), 2019.

3.1.8 **Science to Public**

Media article

Fateme Zare; Victoria Evia; Kriechbaum, Michael: *Skills for Sustainability Research,* Pathways to Sustainability (Blog - Steps Centre University of Sussex), internet, 02.01.2019.

Gelbmann, Ulrike-Maria: *Punkt 1 Radiolivesendung Die weltweiten Wege des Mülls,* ORF Radio Ö1, radio, 12.11.2019.

Kröpfl, Cornelia; Brudermann, Thomas: *Gewohnheiten ändern: Zu faul, um etwas Neues auszuprobieren? Interview mit Thomas Brudermann, Universität Graz,* Magazin Rohstoff, print, internet, 06.11.2019.

Mentioned in media

Baumgartner, Rupert in: *Forschungszentrum zu Kreislaufwirtschaft,* Kleine Zeitung, print , 05.04.2019.

Baumgartner, Rupert; Schöggl, Josef-Peter in: APA, *Kreislaufwirtschaft digital: Neues Doppler Labor an Universität Graz,* Austria Presse Agentur, internet, 04.04.2019.

Baumgartner, Rupert; Schöggl, Josef-Peter in: APA/red, *Kreislaufwirtschaft digital: Neues Doppler Labor an Universität Graz,* Studium.at, internet, 04.04.2019.

Baumgartner, Rupert; Schöggl, Josef-Peter in: *Eröffnung des Christian Doppler Labors für Nachhaltiges Produktmanagement in einer Kreislaufwirtschaft an der Universität Graz,* Ausseer Regionalfernsehen, internet, 04.04.2019.

Baumgartner, Rupert; Schöggl, Josef-Peter in: *Kreislaufwirtschaft digital: Neues Doppler Labor an Universität Graz,* Tiroler Tageszeitung, internet, 04.04.2019.

Baumgartner, Rupert; Schöggl, Josef-Peter in: science.orf.at/APA, *Neues Doppler-Labor widmet sich Nachhaltigkeit,* science.orf.at, internet, 04.04.2019.

Baumgartner, Rupert; Schöggl, Josef-Peter; in: Doris Griesser, *Plastikflaschen und Importobst sind nicht immer Ökosünden - Wer umweltfreundliche Produkte kaufen will, kommt mit Bauchentscheidungen nicht weit. Ein Grazer Labor entwickelt eine Nachhaltigkeitsbewertung,* Der Standard, print, internet, 09.06.2019.

Baumgartner, Rupert; Lukas, Stumpf; Schöggl, Josef-Peter; in: Gudrun Pichler, *Gut für heute und morgen,* Universität Graz, internet, 04.04.2019.

Baumgartner, Rupert; Schöggl, Josef-Peter; Stumpf, Lukas in: Gudrun Pichler, *Christian Doppler Labor für Nachhaltiges Produktmanagement in einer Kreislaufwirtschaft eröffnet,* idw - Informationsdienst Wissenschaft, internet, 04.04.2019.

Brudermann, Thomas in: Claudia Dabringer, *Schnittstelle zwischen Umwelt und Wirtschaft,* Die Presse, print, internet, 15.06.2019.

Brudermann, Thomas in: Sophie Mono, *Mode oder Magie,* Mallorca Zeitung Nr. 991, print, 02.05.2019.

Diaz Tena, Anna in: *3 Fragen an Umweltsystemwissenschaftlerin Anna Diaz,* Kleine Zeitung, print, 28.11.2019.

Gelbmann, Ulrike-Maria in: Daniela Brescacovic, *Einweg ist keine Alternative,* Kleine Zeitung online, internet, 10.07.2019.

Gelbmann, Ulrike-Maria in: Marlene Nowotny, *Mittagsjournal: Uni Graz Musi4Sustainability,* Ö1, radio, 26.11.2019.

Gelbmann, Ulrike-Maria; Peter Probst in: Daniela Brescacovic, *Fair Styria Day. Nachhaltigkeitsprojekt in Graz: Kindern mit Musik Werte vermitteln,* Kleine Zeitung, print, 22.06.2019.

Rusch, Magdalena in: *WKO vergibt 19 Forschungsstipendien,* News.WKO.at, internet, 05.12.2019.

Schöggl, Josef-Peter in: APA, *Wissenschaftspreise für Digitalisierung vergeben,* Der Standard, internet, 28.05.2019.

Schöggl, Josef-Peter in: APA, *Wissenschaftspreise für Digitalisierung vergeben,* Der Standard, print, internet, 28.05.2019.

Schöggl, Josef-Peter in: Cornelia Grobner, *Handys und Autos ohne Makel,* Die Presse, print, internet, 28.06.2019.

Schöggl, Josef-Peter in: *Der ganze Blick auf den Produktzyklus,* Green Tech Magazine, print , 09.12.2019.

Schöggl, Josef-Peter in: Eva Heinrich, *Das Stiefingtal als Vorzeigeregion bei der Klimawandelanpassung,* meinbezirk.at, internet, 21.11.2019.

Schöggl, Josef-Peter in: JUST Redaktion, *Wissenschaftspreise des Landes Steiermark verliehen,* JUST - Online Magazin, internet, 28.05.2019.

Schöggl, Josef-Peter in: *Risikodialog Kreislaufwirtschaft: Gemeinsam für Circular Design,* Altstoff Recycling Austria - News, internet, 07.10.2019.

Schöggl, Josef-Peter in: *Wissenschaftspreise des Landes Steiermark feierlich verliehen,* Steirische Wirtschaft, print , 03.06.2019.

Schöggl, Josef-Peter in: *Wissenschaftspreise des Landes Steiermark verliehen,* politik.steiermark.at, internet, 29.05.2019.

Schöggl, Josef-Peter in: *Wissenschaftspreise des Landes Steiermark verliehen,* Klipp Magazin, internet, 28.05.2019.

Schöggl, Josef-Peter in: *Wissenschaftspreise des Landes Steiermark verliehen,* Ausseer Regionalfernsehen - ARF, internet, 28.05.2019.

Schöggl, Josef-Peter in: *Wissenschaftspreise für Digitalisierung in der Steiermark vergeben,* Kleine Zeitung, print, internet, 27.05.2019.

3.2 External Scientific Functions

Reviews were undertaken for following journals:

- 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 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

3.3 Institute of Systems Sciences, Innovation, and Sustainability Research Report

In 2012 the institute decided to issue a report series of its own, called "Institute of Systems Sciences, Innovation, and Sustainability Research 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.

Published reports:

- SIS Report #1: Florian Hold, Informelle Abfallwirtschaft in Österreich – Chancen, Risiken und Praxis. Graz, October 2012 (in German).
- SIS 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).
- SIS Report #3: Manfred Füllsack (Ed.): Networking Networks. Graz, May 2013 (in English).
- SIS 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).
- SIS Report #5: Gastinger, B.: Biologische Abfallbehandlung in der Steiermark und ihr Beitrag zum Klimaschutz. Graz, December 2013 (in German).
- SIS 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).
- SIS 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).
- SIS 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.
- SIS Report #9: Baumgartner, R.J., Damert, M., Fritz, M.M.C., Schöggl, 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.

3.4 Prices and Awards

3.4.1 Styrian Science Price

The Styrian Science Prize 2019 honored pioneering research and teaching on the subject of "Digitalization in Science". In the category "Production and Sustainability", the SIS-member Josef-Peter Schöggl received the award. In his award-winning dissertation, he developed methods, tools and indicators for a complete life cycle assessment of products. This is a prerequisite for the sustainability assessment of supply chains and product development. Taking advantage of the new opportunities offered by digitisation and at the same time counteracting risks and dangers are urgent tasks to which the University of Graz is particularly dedicated. "The two papers awarded the Styrian Science Prize are showcase examples of how research creates the basis for meeting these challenges and helps shape the future", underlines Rector Christa Neuper.

Styrian Science Prize 2019

Aspects of ecological and social sustainability are becoming increasingly important in consumer decisions and consequently also for companies. Companies are expanding their focus more and more along the entire value chain. Digitalization can make the collection and exchange of the necessary data much easier. However, this requires methods with which the entire product life cycle can be analyzed. In his doctoral thesis, Josef Schöggl provides the theoretical and methodological basis for a digital sustainability assessment along supply chains. On this basis, he surveyed ecological, economic and social aspects in supply chains for the electronics and automotive industries and developed corresponding indicators. Finally, together with an automobile manufacturer, he developed and tested a method for optimizing the sustainability performance of components. The results of his dissertation were also used to develop a software platform for the exchange of sustainability data along the value chain.

3.4.2 **WKO Scholarship**

Many consumers now think carefully when shopping: Is the product regional? Is it seasonal? Ecologically compatible? Less frequently, on the other hand, the question arises as to what social and societal effects the purchased product will have. "Social sustainability includes, for example, the local conditions, such as the salaries, rights and environment of the employees," says Magdalena Rusch, a graduate of Environmental Systems Science (majoring in Business Administration) at the University of Graz, summarizing the term.
In her final thesis, she analyzed the Social Life Cycle Assessment (SLCA) - a method used to determine the positive and negative effects of a product - for its application in connection with a recycling economy. For this work, Rusch was recently awarded a 2100 Euro scholarship from the Chamber of Commerce (WKO). 500 euros were awarded to the Institute for Systems Science, Innovation and Sustainability Research. Under the title "Business Meets Science", the WKO awarded a total of 19 research scholarships from Styrian entrepreneurs for business-related diploma and master's theses.

WKO Scholarship

In her master's thesis, Magdalena Rusch concludes that SLCA does not always work as effectively as it should. "Unfortunately, there is no clear definition here of what is actually meant by social impacts," she explains. The woolly formulation leaves too much room for interpretation, the environmental systems scientist believes. Consequently, there are no binding standards that can be used for comparisons. For this reason, SLCA is currently used mostly informally, in very different areas and mainly on a voluntary basis. "If we want to make the economy more sustainable, however, it would be absolutely necessary to create a uniform basis on which different players can be compared in their ecological and social actions," explains the young researcher.

3.4.3 ERSCP 2019 Best Conference Paper Award

The European Roundtable for Sustainable Consumption and Production (ERSCP), founded in 1994, supports the development of a European (but also worldwide) community of research and practice in sustainable consumption and production. The main goal of the ERSCP is to encourage discussion amongst stakeholders such as businesses, public institutions, universities, institutes and research centres, NGOs, SMEs, professional associations, decision-makers, etc. involved in such areas.

Lukas Stumpf at the ERSCP 2019

In 2019, the ERSCP was hosted by the polytechnic University of Barcelona and was dedicated to the topic 'Circular Europe for Sustainability'. This year's award was given to CDLab researcher Lukas Stumpf for the best research submitted and presented at the ERSCP by PhD students. He contributed to the conference with an analysis of 131 circular economy business cases from a scientific and policy perspective.

3.4.4 DGAW scholarship

At the 9th science congress of the German association for waste management (DGAW e.V.), CD Lab member Lukas Stumpf was given a scholarship to support the acquisition of a real time Delphi software. The software will be used for a study on organizational requirements for circular practices in the packaging industry across the whole supply chain. A more detailed understanding of how organizations need to structure their resources for a circular transition is an expected outcome of the study, which will be carried out early 2020.

3.4.5 **USW Awards**

With the USW Award, the University of Graz honours outstanding master's theses from the studies Environmental Systems Science, Sustainable Development and Industrial Ecology. "The award should help to make visible the social relevance as well as the range of international professional fields that these studies open up", explains Ralf Aschemann, coordinator of the award. The criteria for the award are, in addition to the grade of the work, the authenticity of the topic, a reference to social, ecological and economic aspects of sustainability, interdisciplinarity and technological significance. A jury of eight scientists selected the best five from 17 submitted master's theses for the award:

- Yasmine Zaki Abdelaziz: Life Cycle Assessment of phosphorous management for Recirculating Aquaculture System Sludge
- Michael Peer: Towards the assessment of sustainable business Models- Prospects of utilizing existing sustainability assessment methods from a business model perspective
- Enrique Alejandro Perdomo: Contribution of musical education on sustainability. The study case of "El Sistema" musical education for underprivileged children in Venezuela
- Leonard Röser: Sustainable Tourism among Young Adults - A Survey about the Presence of Sustainable Tourism among Young Adults in Austria and Germany
- Laura Wallnöfer: Transitions to Sustainable Development, focusing on lifestyles - The role of young citizens for capacity building and disseminating good practices

4 TEACHING

4.1 Study Programmes

4.1.1 Environmental Systems Sciences

In teaching, our institute is the focal institute for the bachelor and master study programmes 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 programme 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 focussing 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 programmes 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 programmes 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 programmes in October 2003 which are still unique in its conception in Europe. Now, about 1,300 students are enrolled in the bachelor and master programmes in Environmental Systems Sciences; the bachelor programmes comprise 180 ECTS credit points which equals a study period of six semesters, and the consecutive master programmes 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 transdisciplinarity 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.umweltsystemwissenschafen.at.

4.1.2 Joint International Master's Programme in Sustainable Development

In 2008, a curriculum for the International Joint Master's Programme in Sustainable Development was designed and approved by six partner universities, with the University of Graz (Austria) as co-ordinating university, Ca' Foscari University of Venice (Italy), Leipzig University (Germany), and Utrecht University (The Netherlands) as degree-awarding consortium members, and Basel University (Switzerland) and Hiroshima University (Japan) as associated mobility partners. In 2013, University of Stellenbosch (South Africa) and TERI University in New Delhi (India) joined the consortium as further mobility partners.

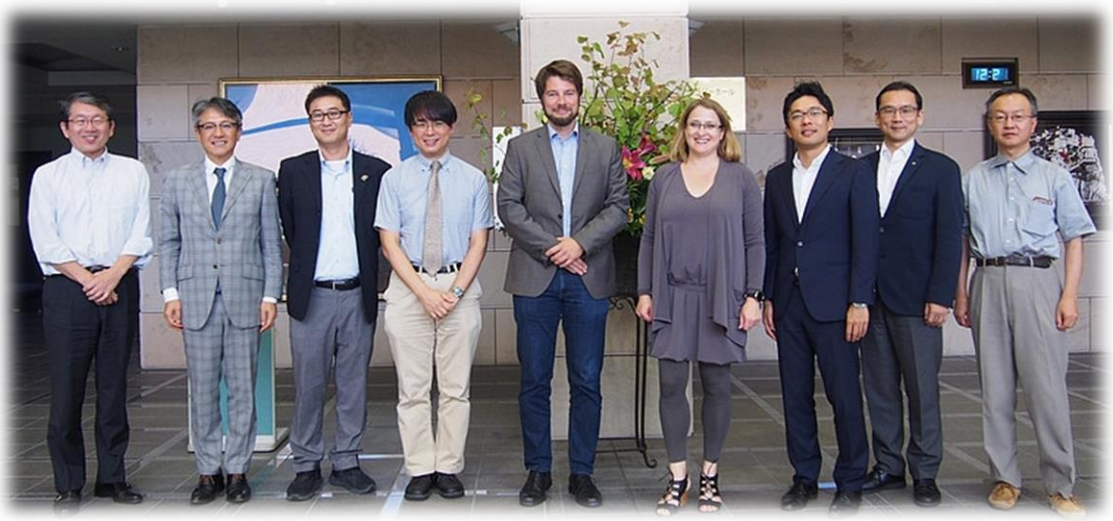
Welcome meeting for the 2019 generation in September. 18 students from 8 countries started the programme in Graz.

In this master's programme sustainability issues are approached from an international as well as inter- and transdisciplinary perspective. The focus is set on applying the competences to the question of sustainable development and the needs and possibilities of societal transformation. It combines the strengths and specializations in teaching and top research of six partner universities, thereby offering the students a programme recognized in the countries of the consortium partners and the possibility of going on to PhD-studies as well as increasing the employability in the private, public and semi-public sector.

Admission to this Master's Programme 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 Master's Programme comprises 120 ECTS credits corresponding to a period of study of at least four semesters or two years. 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 academic coordination, our institute offers courses for the first semester in basics in Sustainable Development, for the integration module in the third semester, and one specialization track (second semester) in Sustainable Business Management. Master theses are generally supervised by two teachers of two different partner universities.

New degree awarding member: Hiroshima University

After approval by the Japanese Ministry for Education, Hiroshima University will become a degree-awarding university in the winter term 2020. A delegation from Hiroshima University, led by Vice-President Prof. Yasushi Maruyama, visited Graz in February 2019. To support the necessary procedures for accreditation and implementation in Japan, Prof. Maruyama invited Thomas Brudermann (academic coordinator of the programme) and Ulrike Krawagna (Joint Programme Administration at the International Office) to attend a respective workshop at Hiroshima University on September 16-18, 2019. In this workshop, challenges for the implementation were identified and possible solutions were drafted in cooperation with representatives of Hiroshima University, Kyoto University, Waseda University (Tokyo) and the Japanese Ministry of Education (MEXT).



Workshop in Hiroshima with Prof. Hajime Nishitani, Prof. Akimasa Fujiwara, Prof. Shinji Kaneko, Prof. Kazuo Kuroda (Waseda & MEXT), Ass.-Prof. Dr. Thomas Brudermann, Mag. Ulrike Krawagna, Mr. Hiroshi Ando (Kyoto), Prof. Yashushi Maruyama, Prof. Jun Oba

The Institute of Systems Sciences, Innovation and Sustainability Research is happy to welcome Hiroshima University as a full partner to the programme. A limited number of Sustainable Development students will have the unique possibility to pursue a joint/double-degree issued by Hiroshima and Graz.

Comprehensive information on the Joint International Master's Programme in Sustainable Development can be found at www.jointdegree.eu/sd. The students of the program also operate a blog with many interesting posts – see sustainersmagazine.wordpress.com.

4.1.3 Erasmus Mundus Master's Programme on Circular Economy

Beside the International Joint Master's Programme in Sustainable Development and the 2017 completed "Erasmus Mundus Master's Programme in Industrial Ecology", the "Erasmus Mundus Master's Programme on Circular Economy (CIRCLE)" is already the third Joint Master Programme co-ordinated 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 start 2019, 2020, 2021 or 2022, respectively), which have to be selected by the CIRCLE consortium.
The curriculum of CIRCLE is designed as "Erasmus Mundus Joint Master Degree", thus its students have to study at least at two different European universities from the consortium and will be awarded with a double degree from those.

Dr. Ralf Aschemann is co-ordinating the CIRCLE programme and Vanja Novak, MA from the Office for International Relations is serving as its administrative co-ordinator. Partners in the consortium are Leiden University and Delft University of Technology (Netherlands); Chalmers University of Technology Gothenburg (Sweden); Norwegian University of Science and Technology (Norway); Curtin University (Australia); Waseda University (Japan) and Tsinghua University (China).

From 4 to 9 August 2019, CIRCLE has started with the orientation week for the first intake of selected students, organized in Hönö/Sweden. 16 out of the first 18 CIRCLE students (see photo) participated and gained detailed information on the "urban mining" method, which they applied to the case of Hönö (a small island close to Gothenburg) for four selected materials (aluminium, steel, copper and wood). After this orientation week, the CIRCLE students travelled to their European university (Trondheim or Leiden/Delft or Gothenburg or Graz), where they will spend their first study year.

For more information on CIRCLE please cf. https://www.emcircle.eu!

4.1.4 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 programme 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.

4.1.5 Doctoral Programme DK Climate Change

In the winter semester 2014, the interdisciplinary doctoral programme **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 programme and Univ.-Prof. Dr. Gottfried Kirchengast (Wegener Center for Climate and Global Change) serves as co-speaker. Three of the eleven board members are affiliated with our institute: Univ.-Prof. Dr. Rupert Baumgartner, Ao.Univ.-Prof. Dr. Alfred Posch and Univ.-Prof. Dr. Wilfried Winiwarter. The programme is supported by Dr. Bettina Lackner and Mag. Regina Brunnhofer.

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 programme's partner universities.

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

4.2 Teaching Activities

4.2.1 Systems Sciences E-Textbook

The rise of tablet computers and smartphones is accompanied by new possibilities for students as well as professors. It allows providing eBooks and especially electronic textbooks with interactive elements. Besides the incorporation of audio and video material, educational examples like dynamic models and simulations can be made accessible out of the text, giving the students the possibility to understand better and comprehend the teaching subject.

Interactive E-Textbook

For these reasons, Manfred Füllsack, Professor for Systems Sciences, created an interactive electronic textbook for systems sciences based on software applications for tablet computers. This project is still in progress. A first version of the interactive textbook is available at http://systems-sciences.uni-graz.at/etextbook/. We are proud to announce that the E-Textbook had more than 20000 visitors in 2017.

The aims of the project are:

- To allow active learning with the help of significant examples where dynamics are not presented statically as graphics, but simulated directly via software applications.
- To give students the possibility to learn and try out the characteristic behaviour of specific impacts (for example the consequences of changing parameters) on their own, but at the same time under the guidance of the text.
- To test eBooks on their applicability for the special requirements of textbooks generally and to find a convenient, cross-platform and non-proprietary presentation method.

4.2.2 Future Lecture 2019 on Music4Sustainability

Sustainability in a Different Way: Future Lecture 2019 by SIS, Uni Graz Master`s Program Global Studies and the University of Music and Performing Arts (KUG) on Music4Sustainability

"Us children, all of us, ... we dream that all people live and love in peace and are friends" These words, sung by the SUPERAR choir, opened the Future Lecture 2019 Music4Sustainability at the KUG MUMUTH musical theater. The integrative choir project SUPERAR consists of primary school students from Graz from a wide variety of social and cultural backgrounds. Intensive choir training allows them to experience music as a universal language, learn German and increase their chances of social participation. The Future Lecture 2019 Music4Sustainability in Graz, organized by the SIS and Master program Global Studies at the University of Graz and the KUG, supported by the Forum Environmental Education, asked about the connection between music and sustainability.

The event built on an interdisciplinary training project held during summer term 2019, in which students explored sustainability effects of El Sistema and related projects like SUPERAR all over Europe. The Venezuelan music school project "El Sistema" gathers children, especially from poor and educationally disadvantaged classes, into making music together in order to protect them from abuse and violence and to teach them positive values. The most famous graduate is the internationally renowned conductor Gustavo Dudamel. Today, projects inspired by "El Sistema involve children from all walks of life worldwide and use music to overcome barriers, dissolve prejudices and make a lasting mark on the community. At the Future Lecture, students and teachers, SUPERAR, Fair Styria and Klangforum Wien presented their views on the topic in a colorful collage of contributions.

Afterwards, various musical workshops (percussion, singing, making musical instruments out of garbage) as well as social science workshops (World Cafe on Music4Sustainability, SDGs Workshop) provided practical and theoretical insights: Music shapes human and social development and has a positive influence on it. It contributes to the 17 SDGs of the UN: Education, health, reducing inequality, sustainable communities, peace and partnership to achieve the goals.

The event reached a diverse audience of more than 100 people and ended with a delicious vegetarian buffet provided by the Graz social project "Heidenspaß". In conclusion, there remains a creative Future Lecture 2019 with the task for all participants to work emphatically for a better world, among other things by using the means of music!

4.3 Completed theses (master and doctoral)

In 2019 36 **master** students completed their thesis within one of the study programs Environmental Systems Sciences, Global Studies, Sustainable Development, and Industrial ecology. The list is in alphabetical order.

Binggl, Peter: Energieeffizienz in der Produktion - IT-basierte Unterstützung zur Analyse von Produktionsprozessen
Supervisor: Posch Alfred

Budiaková, Monika: Adoption of photovoltaics on residential buildings in Slovakia
Supervisor: Posch Alfred

Denegre, Nicholas: A study of regulatory and policy instruments in global energy markets associated with energy trading and prosumer concepts
Supervisor: Posch Alfred

Dörhöfer, Jannis: Criteria influencing the siting of future charging infrastructure for battery electric vehicles
Supervisor: Rauter Romana

Friedl, Larissa: Prosumer als Stakeholder in der Energiewirtschaft - Ein empirischer Beitrag zum Wandel am Energiemarkt
Supervisor: Posch Alfred

Gamsjäger, Gernot: Geschäftsorientierte Prozessklassifikation und Detailbetrachtung im Produktentstehungsprozess: Fallbeispiel eines Automobilzulieferers
Supervisor: Baumgartner Rupert

Hausner, Corinna Franziska: Assessing the GHG emission savings potential of different wood-based innovations compared to their conventional substitutes
Supervisor: Stern Tobias

Heidel, David: Produktionskostenabschätzung und Ressourcenplanung in der Frühphase der Produktentwicklung am Beispiel von Holzkomponenten
Supervisor: Stern Tobias

Heidinger, Julia: Heizen in Graz - Ein empirischer Beitrag zur Wärmewende in Graz
Supervisor: Posch Alfred

Henkes, Angelina Maria: Exploring the concept of maturity models for sustainable innovations: a literature review
Supervisor: Rauter Romana

Katholnig, Anna: Assessing Market Requirements for new Nonwoven Materials by Importance-Performance Analysis: A Feasibility Study
Supervisor: Stern Tobias

Kittel, Christopher Emanuel: Ensuring fairness and accountability in opaque, algorithmic decision-making systems. An evaluation of consistency, comprehensiveness and comparability across individual-level and group-level metrics
Supervisor: Füllsack Manfred

Klein, Laura: Empowering women through entrepreneurial trainings - The effect of an entrepreneurial training on the economic situation of female students in Mexico
Supervisor: Posch Alfred

Lerch, Anita: Die Akzeptanz Sozialer Technologien am Arbeitsplatz: eine empirische Analyse am Beispiel eines Sozialdienstleistungsunternehmens unter besonderer Berücksichtigung der Persönlichkeitsmerkmale
Supervisor: Rauter Romana

List, Sandra: Heat adaptation and carbon lock-in: Analysis of systemic barriers and facilitators for the diffusion of passive cooling technologies in Austria
Supervisor: Posch Alfred

Lonsing, Matthias: End of Life Issues: assessing options when using wood-based components in the mobility sector
Supervisor: Stern Tobias

Maier, Raphaela Hemma: Highly innovative solar reactor concepts in industry
Supervisor: Posch Alfred

Maier, Ricarda: Environmental impact of selected fruits and vegetables. Evaluation of the impacts per calorie content and comparison to weight
Supervisor: Aschemann Ralf

Marjanovic, Dario: Resiliente Wertschöpfungsketten in Zeiten des Klimawandels - Über die Bedeutung biogener und nicht biogener Rohstoffe als Maßnahme des betrieblichen Kontinuitätsmanagements
Supervisor: Stern Tobias

Mayer, David: Quantitative Untersuchung der Einstellung zur Agro-Gentechnik im Kontext der Bioökonomie
Supervisor: Stern Tobias

Mertineit, Janne Lina: Environmental technologies for development - An assessment of factors promoting and hindering the transfer of environmental technologies to small- and medium-sized enterprises in developing countries
Supervisor: Aschemann Ralf

Pammer, Dimitri: The role of consumers within an analysis of the systemic sustainability performance of use-oriented Product Service Systems
Supervisor: Rauter Romana

Pansy, Christoph: Vergleichende Lebenszyklusanalyse von Schalungselementen - Anwendung einer ökologischen Bewertung in der Produktentwicklung
Supervisor: Stern Tobias

Pichler, Stefan: Influencing factors on allocation method preferences in biorefineries on the example of lignin and fiber fines of the pulping process - An analytic hierarchy process
Supervisor: Stern Tobias

Plakolb, Simon: Towards Sustainable City Traffic - Agent based simulation of commuter impact on urban traffic emissions
Supervisor: Füllsack Manfred

Pölzl, Andrea: Sustainable energy transition in industry: An Empirical Analysis in the Austrian food- and beverage industry
Supervisor: Posch Alfred

Rammel, Benjamin: Ansprüche an Nachhaltigkeit: Ein Stakeholdervergleich in der Elektronikindustrie
Supervisor: Rauter Romana

Rammel, Benjamin: Group-Laddering - A methodological innovation for sustainability research?
Supervisor: Stern Tobias

Reindl, Raffaela: Präzisionslandwirtschaft als Zukunftsmodell für österreichische Kartoffelbauern? Eine SWOT - Analyse
Supervisor: Aschemann Ralf

Rusch, Magdalena: Social Life Cycle Assessment in a Circular Economy context - A systematic literature review of Social Life Cycle Assessment studies and analysis of its potential connections to Circular Economy strategies
Supervisor: Baumgartner Rupert

Serdoner, Ana: European Environmental Advocacy Coalitions: Environmental Non-governmental Perceptions of Carbon Capture and Storage in Energy Intensive Industries
Supervisor: Posch Alfred

Sietsma, Anne Jelmar: Exploring the Measurement, Reporting and Verification Needs of Developing Countries - An Interdisciplinary Qualitative Analysis
Supervisor: Brudermann Thomas

Steiner, Thomas Michael: Ökologische Bewertung einer solarthermischen Prototypenanlage zur Stromerzeugung
Supervisor: Posch Alfred

Theißl, Tina: Milieuorientierte Kommunikationsmechanismen - zur Förderung einer bewussten Müllvermeidung; Mülltrennung im urbanen und ruralen Raum
Supervisor: Gelbmann Ulrike-Maria

Zeller, Thomas: Verwendungsmöglichkeiten von Überschussstrom aus Photovoltaikanlagen als Alternative zur Netzeinspeisung
Supervisor: Posch Alfred

Zenker, Martin: Cherry picking and multidimensionalism in Austrian corporate bioeconomy perceptions. Exploring differences and similarities in bioeconomy perceptions across industrial sectors and feedstock types using a mixed-method approach
Supervisor: Stern Tobias

In addition, two **doctoral theses** have been completed within the doctoral school for Environmental System Sciences which was founded in October 2011.

Brunnhofer, Magdalena: The future starts now: Strategies of the Pulp and Paper Industry towards a low-carbon economy
Supervisor: Posch Alfred

Kriechbaum, Michael: Institutional dynamics in renewable energy diffusion: Beyond the boundaries of organisational fields
Supervisor: Posch Alfred

4.4 Course list

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 2019			
Type	**Course**	**Contact hours**	**Lecturers**
SE	Annual Workshop DK Climate Change	2	Baumgartner R, Bednar-Friedl B, Birk S, Foelsche U, Kirchengast G, Maraun D, Meyer L, Posch A, Schulev-Steindl E, Steiner A, Steininger K
PS	Applied Systems Sciences 1	2	Jäger G, Kapeller M, Schober A
PS	Applied Systems Sciences 2	2	Truhetz H
VU	Calculus for Systems and Environment Sciences	3	Hötzl E, Keeling S
KS	Eco-Controlling	2	Baumgartner R, Paul A
PS	Economic Technology Assessment and Foresight	2	Stern T
KS	Environmental Decision Making	2	Brudermann T
SE	How to write a Bachelor Thesis	2	Baumgartner R, Füllsack M, Posch A, Stern T
VO	Human Beings and Environment: Biosphere and Eco-Systems	2	Raspotnig G, Tschernatsch M
VO	Human Beings and Environment: Geosphere	2	Fischer W, Kellerer-Pirklbauer-Eulenstein A, Schöner W
AG	Interdisciplinary Practical Training	4	Gelbmann U, Peskoller A, Schober A, Zimek M
AG	Interdisciplinary Practical Training	4	Dullnig K, Reiter K, Seebacher U
AG	Interdisciplinary Practical Training	4	Grothusen R, Hasler A, Steinwender D
AG	Interdisciplinary Practical Training	6	Baumgartner R, Hofer D, Mair-Bauernfeind C, Reindl S, Schlesinger A, Zimek M

PS	Introductory Seminar - Elementary Statistical Concepts and Methods, Examples and Practice	1	Feit T
AG	IP - Bio-fuels and their environmental and social consequences	6	Aschemann R, Friedrich A, Mittelbach M, Schweitzer S
AG	IP Circular Economy	4	Aschemann R, Baumgartner R, Klampfl-Pernold H
AG	IP SDGs at the University of Graz	4	Aschemann R, Ninaus J, Zettl R
SE	Kolloquium DK Climate Change: Transition to low carbon and climate resilient society	2	Baumgartner R, Birk S, Foelsche U, Kirchengast G, Maraun D, Meyer L, Posch A, Schulev-Steindl E, Steiner A, Steininger K
SE	Life Cycle Assessment: Theoretical and Practical Insights	2	Traverso M
VU	Linear Algebra for USW	2	Batzel J, Fripertinger H, Prager W
PS	Management of Sustainable Development 2 Environmental Management	2	Baumgartner R
SE	Master Seminar	2	Baumgartner R, Füllsack M, Posch A, Stern T
AG	CIRCLE Summer School	2	Aschemann R
PS	MSD 2 Corporate Social Responsibility	2	Ulz A
DQ	PhD Doctoral Colloquium II	2	Baumgartner R, Füllsack M, Posch A, Stern T
UE	Practical Exercises: USW Computational Basics	1	Kapeller M
KS	Product and Service Development	2	Globocnik D
PS	Project Management	2	Posch A
AG	Research Project Sustainability Management	4	Brudermann T, Crockett S, Posch A
PS	Selected Topics of Sustainability and Innovation Management (Bachelor Seminar)	2	Mair-Bauernfeind C, Stern T
SE	Seminar for Data in System Sciences	2	Füllsack M
SE	Seminar for Postgraduates	2	Baumgartner R, Füllsack M, Posch A, Stern T
SE	Seminar for Research Methods	2	Asada R, Stern T

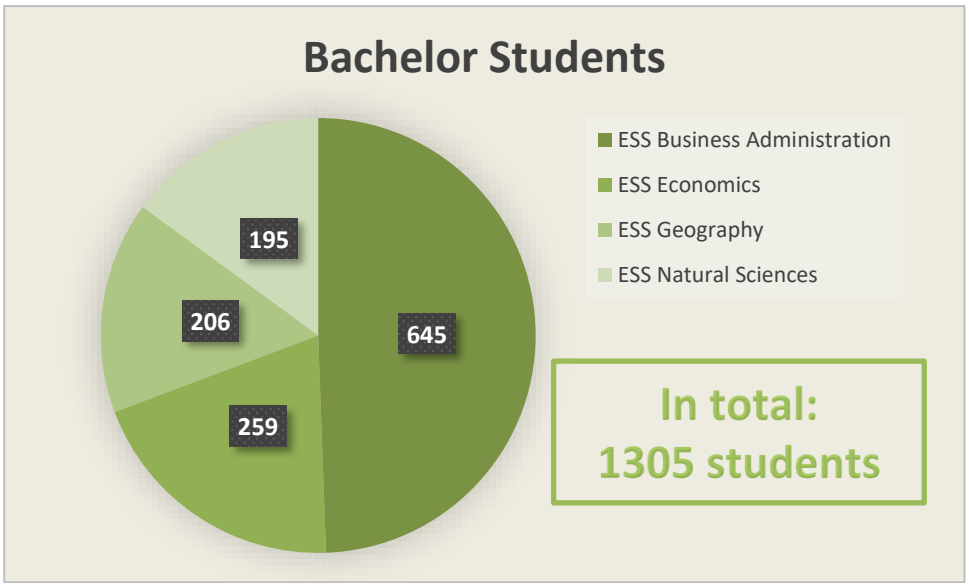
SE	Seminar for System-Modelling and System-Analysis	2	Schmickl T
SE	Seminar on Multilevel Analysis Methods	2	Füllsack M, Lechner G
KS	Strategic Sustainability Management	2	Gelbmann U
SE	Sustainability and Environmental Management	2	Posch A
KS	Sustainability Entrepreneurship	2	Paul A, Stern T
KS	Sustainable Innovation	2	Rauter R
VO	System-Modelling and System-Analysis	2	Jäger G
VO	Systems Sciences 2	2	Propst G
VU	Systems Sciences 3	2	Granigg W
KS	Value Chain Management	2	Aschemann R
KS	Waste and Recycling	2	Gelbmann U, Schmidt G

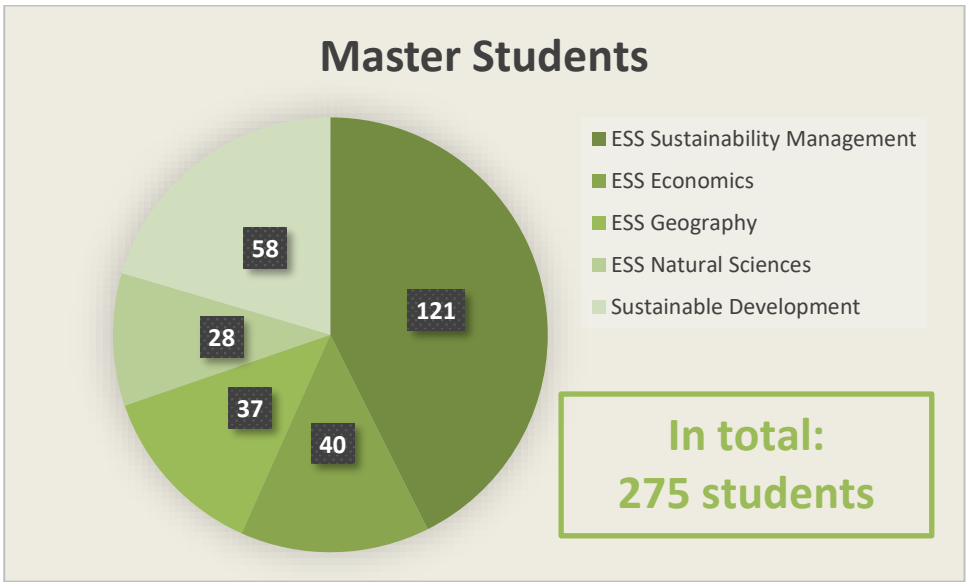
Winter Term 2019/2020			
Type	**Course**	**Contact hours**	**Lecturers**
PS	Applied Systems Sciences 1	2	Jäger G
PS	Applied Systems Sciences 2	2	Plakolb S, Schober A
VU	Calculus for Systems and Environment Sciences	3	Hötzl E, Keeling S, Schiffer C
VO	Data in System Sciences	2	Füllsack M
KS	Eco-Controlling	2	Baumgartner R, Mair-Bauernfeind C, Paul A
KS	Environmental and Technology Assessment	2	Aschemann R
KS	Environmental Decision Making	2	Brudermann T
VO	Environmentally Oriented Innovation and Technology Management	2	Rauter R, Stern T
SE	Fundamentals of Circular Economy and Industrial Ecology	2	Aschemann R
VO	Human Beings and Environment: Anthroposphere	2	Posch A, Steininger K

KS	Integrated Management Systems	2	Ulz A
AG	Inter- and Transdisciplinary Case Study on Sustainable Development	6	Brudermann T, Crockett S, Fleiß E, Kriechbaum M, Posch A
AG	IP – Awareness for Waste Reduction	4	Gelbmann U, Kabosch U, Mair-Bauernfeind C, Pirker C
AG	IP – BIOHAVIOR	4	Asada R, Mair-Bauernfeind C, Stern T, Wenger J
AG	IP – Cutting your C02 Budget in half	4	Aschemann R, Steinwender D, Wrentschur M
AG	IP – Sustainable Urban Water Management	4	Krebs G, Regelsberger M, Weiss S
VO	Interdisciplinary Scientific Approaches at the URBI Faculty	2	Aschemann R, Payer G, Pölzl-Stefanec E, Wlasak P
VO	Interdisciplinary Working Methods	2	Aschemann R
PS	Introductory Seminar - Elementary Statistical Concepts and Methods, Examples and Practice	1	Fleiß E, Holzer D, Schweighart M, Wenger J
AG	IP - Global Climate Strategies: An International Roadmap for Mitigation, Adaptation, Geoengineering	6	Finus M, Pölzler T, Scharler M, Schulev-Steindl E, Steiner A
AG	IP - Human Rights in Supply Chains - The case of fruits/vegetables and aluminium	6	Aschemann R, Baumgartner R, Schaller M
SE	Kolloquium DK Climate Change	2	Baumgartner R, Bednar-Friedl B, Birk S, Foelsche U, Kirchengast G, Maraun D, Meyer L, Posch A, Schulev-Steindl E, Steiner A, Steininger K
VU	Linear Algebra for USW	2	Prager W
SE	Master Seminar	2	Baumgartner R, Füllsack M, Posch A, Stern T
KS	Methods for inter- and transdisciplinary problem-solving	2	Aschemann R
PS	MSD 2 (Reportage of Sustainability)	2	Resel K
PS	MSD 2 Corporate Social Responsibility	2	Ulz A
UE	Practical Exercises: USW Computational Basics	1	Fernandez Mendoza F, Fuchsberger J, Thaller A
KS	Product and Service Development	2	Globocnik D

AG	Research Project Innovation Management	4	Rauter R, Stern T
KS	Selected Topics of Sustainability and Innovation Management	2	Moreno Torres M, Stern T
SE	Seminar for Data in System Sciences	2	Füllsack M
SE	Seminar for Research Methods	2	Asada R, Fleiß E
SE	Seminar for System-Modelling and System-Analysis (Equation Based Modeling)	2	Füllsack M, Schmickl T
SE	Seminar on Multilevel Analysis Methods (Future State Maximization)	2	Füllsack M
SE	Social competences for managing sustainable development	2	Seebacher U
SE	Social Competences for Working in Inter- and Transdisciplinary Teams	2	Seebacher U
VO	Statistics	2	Fleiß E
KS	Strategic Sustainability Management	2	Gelbmann U
VO	Sustainability and Environmental Management	2	Baumgartner R
KS	Sustainability Entrepreneurship	2	Paul A, Stern T
AG	Sustainable Development - Integrating Perspectives	6	Brudermann T, Posch A, Steiner A, Winkler T
KS	Sustainable Innovation	2	Rauter R
VO	Systems Sciences 1	2	Füllsack M
VU	Systems Sciences 3	2	Granigg W
SE	The Sustainability Challenge	2	Posch A
PV	Tutorial for Postgraduates	2	Baumgartner R, Füllsack M, Posch A, Stern T
TT	Tutorium Integral- und Differenzialrechnungen für USW	4	
VO	USW Computational Basics	2	Jäger G
KS	Waste and Recycling	2	Gelbmann U, Schmidt G

4.5 Student Statistics





Number of registered students in 2019 (source: student statistics from UniGrazOnline)

Institute of Systems Sciences,
Innovation & Sustainability Research
University of Graz

Merangasse 18/I,
8010 Graz, AUSTRIA