Annual Report 2018

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

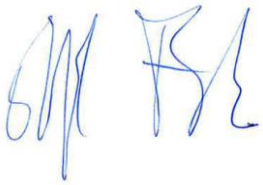
Merangasse 18/I,
8010 Graz, AUSTRIA

Editorial

Dear Reader!

We are pleased to inform you about the results of our work, which are summarized in this annual report for 2018. The high number of 31 publications in scientific journals, the great success in winning third-party funded projects and the significant growth of the scientific staff at the institute are our landmarks this year - and therefore mentioned right at the beginning. To a large extent, these achievements are due to the success in launching new projects allowing us to carry out up-to-date and internationally relevant research. Examples are Prof. Baumgartner's new “Cresting: CiRcular Economy-SusTainability Implications and guidING progress” project, Prof. Posch's new "Green Energy Lab" project and Prof. Stern's "Supporting TrAnsition from lineaR To CIRCuLar valuE chainS" project.
We are also proud to participate in the doctoral programme "Climate Change - Uncertainties, Thresholds and Coping Strategies," which is carried out together with colleagues from five different faculties of the University of Graz and is financed by the Austrian Science Fund. It is now going into its second phase of successful and productive research. In addition, the field of excellence "Climate Change Graz," in which Prof. Posch and Prof. Baumgartner are involved, has taken up and expanded its activities. And the prospective field of excellence "COLIBRI - Complexity of Life in Basic Research and Innovation" as well as the research network "Human Factor in Digital Transitions", in both of which Prof. Füllsack is involved, have gained considerable momentum. In teaching, we were able to start an Erasmus Mundus Master's Programme on Circular Economy, to offer a series of Doctoral study programs about Digitalization and to attract highly qualified international students for our joint Master's programmes "Sustainable Development" and "Industrial Ecology."
We also congratulate the following (former) colleagues for the successful finalization of their doctoral studies: Philipp Babcicky, for his work on “Flood preparedness of private households: Determinants of protective behaviour and insights into collective action”; Matthias Damert, for his work on “Corporate strategies in response to climate change - An empirical analysis of characteristics, drivers and outcomes with a focus on the global automotive industry”, Sajeev Erangu Purath Mohankumar, for his work on “Rethinking the manure management chain: An investigation of climate, air quality and animal welfare impacts; Eva Fleiß, for her work on “I shine, not burn. Empirical studies on citizen participation initiatives in the field of photovoltaics.”; Stefanie Hatzl, for her work on “Adoption – Diffusion – System Change: Empirical insights into demand-side aspects of transition towards a sustainable energy system”; and Arijit Paul, for his work on “Strategic and ethical dimensions of business responses to climate change.”

We wish them all the best for their future careers!



Univ.-Prof. Dipl.-Ing. Dr. Rupert Baumgartner

Univ.-Prof. Dr. Manfred Füllsack

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 profile-building 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, Master Industrial Ecology (MIND) 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, Vice Dean at the URBi Faculty
Professor for Sustainability Management

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

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

Vice Director of the Institute
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

Professor for Energy and Resource Innovation

Research Interests: Energy and Resource Innovation, Transition towards Bio-economy, Technology Valuation and Impact Assessment, Innovation Barriers and Diffusion Processes, Harvested Wood Products and Climate Policy

Ao. Univ.-Prof. Mag. 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:

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

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

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

Academic coordinator of the "Erasmus Mundus Master's Programme in Industrial Ecology"; 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, Higher Education and Env. Assessment and Management, Health Impact Assessment (HIA)

Ass.-Prof. DI 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

Mag. 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.
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, 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

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

Ass.-Prof. Mag. 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

Mag. **Andreas Schober**, Bakk. (until Nov. 2018)
Phone: 7341 Email: andreas.schober@uni-graz.at

Research Interests: Systems Sciences, Data Mining, Text Mining, Green Economy

Martina Zimek, BSc. MSc.
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. (since September 2018)
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
Phone: 1521 Email: eva.fleiss@uni-graz.at

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

Patrick Hart, BA (until April 2018)
Phone: 1520 Email: patrick.hart@uni-graz.at

Research Interests: Modelling Social Interactions, Gamification Approaches to Energy Savings, Renewable Energy Uses in Urban Environments

Mag. **Stefanie Hatzl**
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

Ursula Ploll, MSc (until August 2018)
Phone: 7331 Email: ursula.ploll@uni-graz.at

Research Interests: Stakeholder impact, Consumer acceptance, Biotechnology & biostimulants

Tomas Santa Maria Gonzalez, MSc (since September 2018)
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. (since November 2018)
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 (since November 2018)
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:

Matthias Damert, PhD. MSc
Phone: 7348 Email: matthias.damert@uni-graz.at

Research Interests: Corporate Social Responsibility (CSR), Corporate Climate Change Strategies, Sustainability Management in the Automotive Industry, Environmental Policy and Management

Sajeev Erangu Purath Mohankumar, PhD. MSc. Eng.
Phone: 7403 Email: em.sajeev@uni-graz.at

Research Interests: Climate Change Adaptation and Mitigation, Renewable Fuels, Low Carbon Scenarios

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

Research Interests: Environmental Innovation, Environmental Policy, Renewable Energy

Annina Thaller, BSc MSc. (since September 2018)
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 (since September 2018)
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:

Dr. **Katharina Deman** (since November 2018)
Phone: 2286 Email: katharina.deman@uni-graz.at

Sabina Grobbauer, MBA
Phone: 3238 Email: sabina.grobbauer@uni-graz.at

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

Student Assistants:

Gundula Allersdorfer	**Angelika Meißl**	**Magdalena Rusch**
Gregor Fallmann	**Yannick Oswald**	**Bernhard Schrempf**
Julia Graf	**Michael Peer**	**Bianca Steiner**
Verena Haas	**Simon Plakolb**	**Melanie Troppe**
Melanie Harrer	**Benjamin Rammel**	

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 2018:

- **Prof. Dr. Maria Rosário Partidário** (the University of Lisbon and University of Aalborg), "Impact Assessment as an Instrument of Governance for Strategic Change – Enabling the SDGs," October 16, 2018.
- **Dr. Mateja Dovjak** (University of Ljubljana), "Deteriorated Environmental Quality as a Collateral Damage of Energy Efficiency: Barriers and Challenges for Sustainable Buildings," October 9, 2018.
- **Prof. Dr. Ulli Vilsmaier** (Leuphana University of Lueneburg), "Transdisciplinary Research as Transformative Praxis," June 26, 2018.
- **Dr. Weena Gera** (University of the Philippines Cebu), "Rethinking Scales in Urban Disaster Management for Local Sustainability: Insights from the Philippines' Flood Risk Governance," June 8, 2018.
- **Dr. Annukka Näyhä** (Jyväskylä University), "Drivers and resources of Finnish forest-based companies in transition to the circular bio-economy," May 15, 2018.
- **Prof. Dr. Jonatan Pinkse** (University of Manchester), "Corporate Sustainability: Topics, theories and methods," April 17, 2018.
- **Prof. Dr. Anne Toppinen** (University of Helsinki), "Future pathways of fiber-based packaging in the circular bio-economy," April 10, 2018.
- **Prof. Dr. Marina Fischer-Kowalski** (University of Klagenfurt), "The Anthropocene: Humans lock-in with Fossil Fuels, and their Lock-out," January 30, 2018.

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):

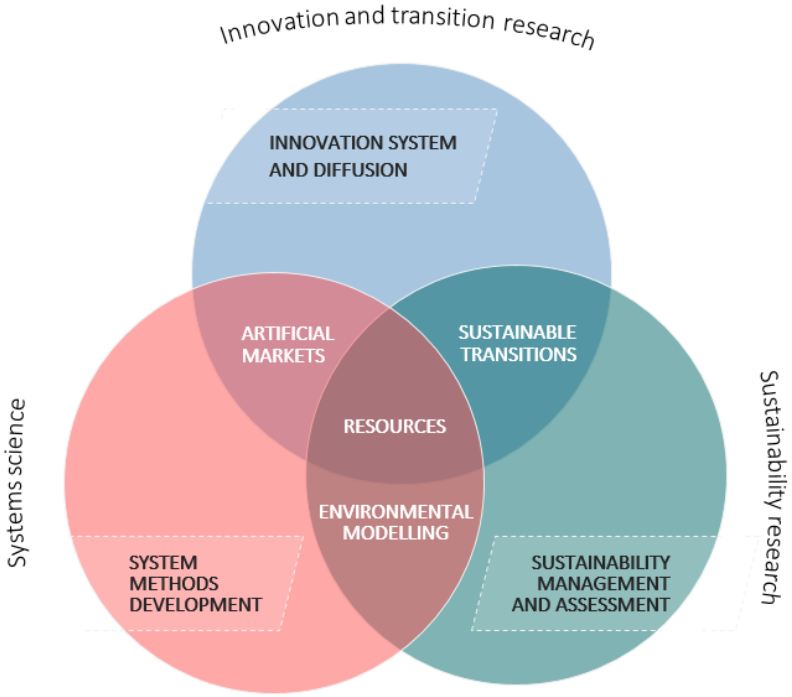
- USW Praxis Day – May 2018
- Introduction to Scientific English – June 2018
- USW Job Application Check – December 2018
- Orientation Event – September 2018
- Evaluation of IPs
- Evaluation of mathematics lectures
- Evaluation of the coordination office

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. Currently, the team consists of one post-doc assistant, Georg Jäger, and two pre-doc assistants, which both are in the final phase of completing their doctoral studies, Christian Hofer, and Andreas Schober.

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 and language-based training tools ("Skills") for digital assistants.

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 chair for energy and resource innovation is conceptualized as endowment chair and is funded by the Land Steiermark (Province of Styria) and financing from private donors.

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

[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.

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 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.

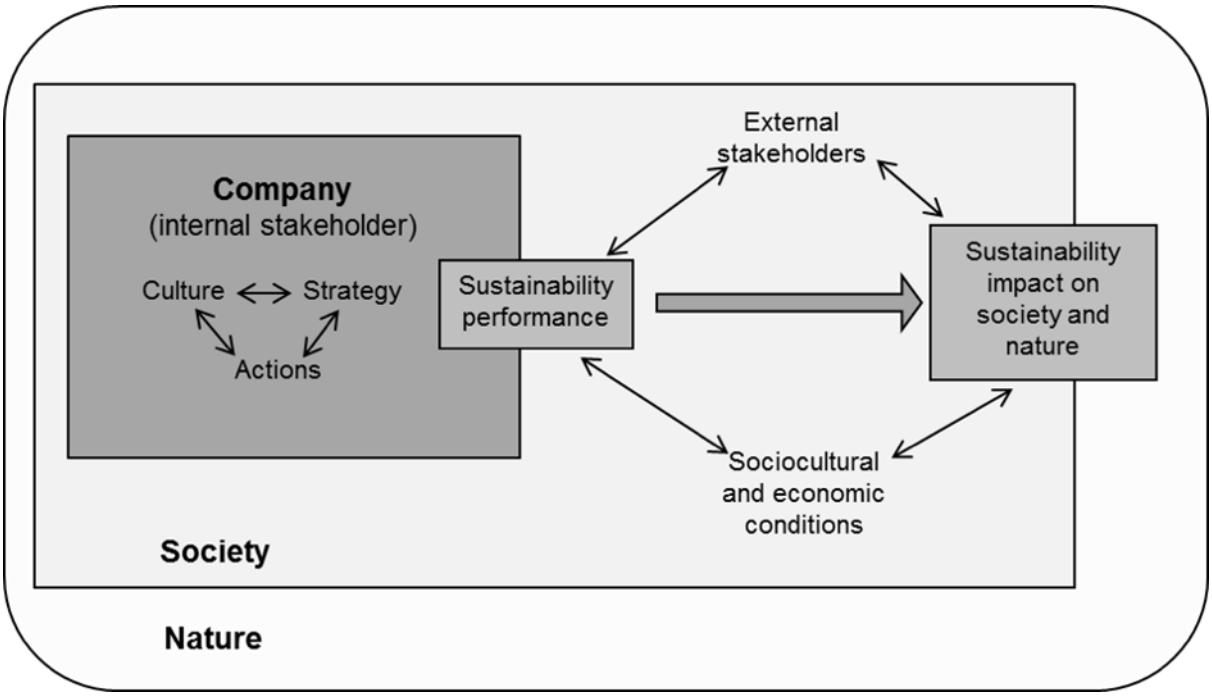
Following topics characterize the research activities undertaken in this research area:

- **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.

[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.

[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.

- **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.
- **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

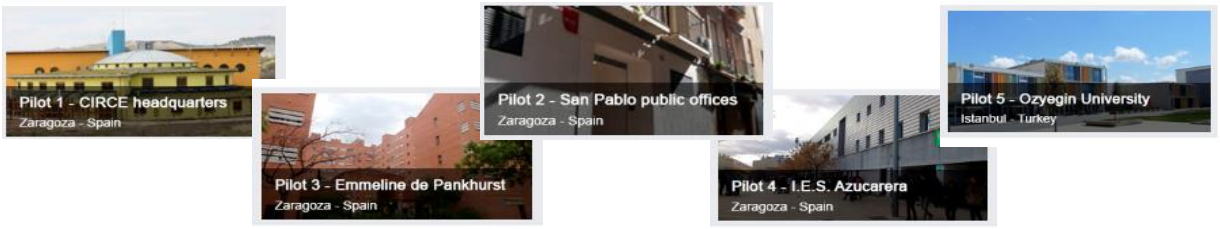
2.2 Research Projects

2.2.1 TRIBE - Training Behaviours Towards Energy Efficiency - Play it!

The general objective of TRIBE is to contribute to a citizens' behaviour change towards energy efficiency in public buildings, through their engagement in the experience of playing a social game, linked by ICT to real-time data collected from 5 pilot buildings including three different environments: residential, workplace and academic.
The achievement of TRIBE objectives allows the development of:

1. The TRIBE game: A serious game providing the possibility to engage public buildings users in a behavioural change towards energy efficiency,
2. The TRIBE pack: A package including a number of tools and guidelines for public building owners and operators, providing the opportunity to implement the project solutions in their buildings, addressing their particular challenges.

TRIBE project is based on real-time as well as empirical data collected in 5 public pilot facilities:



Scientific & technical objectives:

- Development of public building users' behaviour profiles in relation to energy-related behaviours, identification of different conduct patterns and drivers towards behaviour change based on different psycho-social behavioural theories.
- Collection of real-time comparable and reliable data about the energy performance of the pilots and their users' behaviour.
- Modeling and simulating the effects of the set of energy efficiency actions on the building and on the users' behaviour.
- Assess the evolution of the players' behaviour towards energy efficiency at the individual level of the residents of buildings and evaluate its effect on the overall energy consumption pattern of the buildings.
- Develop an EU-wide virtual community for exchanging knowledge and positive attitudes towards energy efficiency.

The goal is to foster the spread of the public building users' behaviour change as well as to support the deployment of ICTs for energy efficiency among public building owners and operators. (see also under http://tribe-h2020.eu/)

Project team:	Ao. Univ.-Prof. Dr. Alfred Posch, Ass.-Prof. Dr. Thomas Brudermann, Eva Fleiß, MA, Patrick Hart, BA, Mag. Stefanie Hatzl
Project partners:	CIRCE Foundation, Spain, ACCIONA Infraestructuras, Spain, Zaragoza Vivienda, Spain, Özyeğin University, Turkey, bio by Deloitte, France, Interactive Institute - Swedish ICT, Sweden
Duration:	March 2015 - March 2018
Funding:	European Union's Horizon 2020 research and innovation programme, grant agreement No 649770

2.2.2 AKRoSA – Processing of critical raw materials from special waste streams

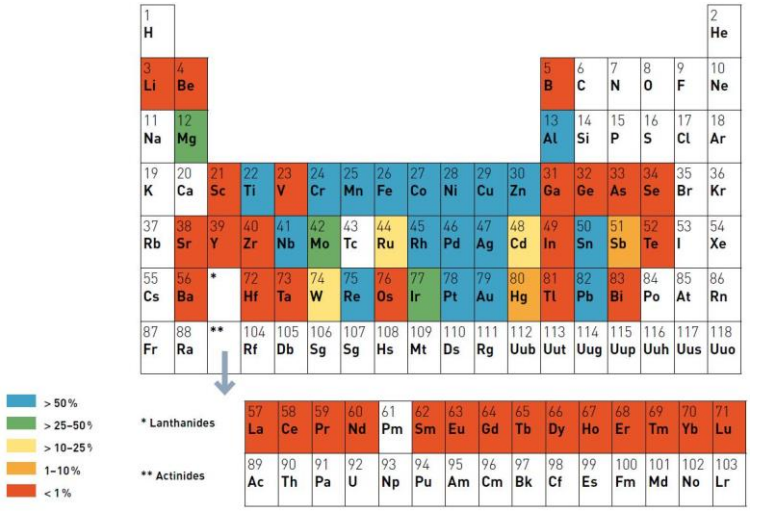
The European Commission defined a number of elements and raw materials (e.g., REE, gallium, germanium, PGE, and tantalum) as critical raw materials (CRM) because of their limited resource availability in Europe and the EU dependency on imports. To tackle this challenge increased recycling and the use of these CRM as the secondary raw materials in the sense of a circular economy is promising but not readily available. Therefore, a consortium of medium-sized and large enterprises and the Universities of Leoben and Graz was formed to develop new innovative approaches for processing and recovering certain critical raw materials.

The objective of AKRoSA is to investigate the following three waste streams with respect to processability and suitability for critical raw material recovery:

- Residue and waste streams of waste treatment plants
- Waste from special industrial processes, including, e.g. mixed waste and by-product streams of the industry
- Landfilled waste

The project includes the identification of waste and residue streams and the improvement and adaption of current processing and recycling technologies. In order to conduct appropriate recycling in the field of critical raw materials, besides the registration and collection and technological aspects, also the economic evaluation plays a crucial role.

The role of SIS is to complement the technical research with the analysis of material flows and the subsequent development of a system dynamics model based on the results. This aims at providing a comprehensive understanding of the underlying causal relationships with regards to the three analyzed waste streams which can facilitate the decision-making of relevant stakeholders.



The recycling rate of different metals (Gradel et al. 2011)

Project team: Univ.-Prof. Dr. Rupert Baumgartner, Morgane Fritz, MIM, Mag. Andreas Schober, Josef-Peter Schöggl, Bakk. Msc.

Duration: April 2015 - March 2018

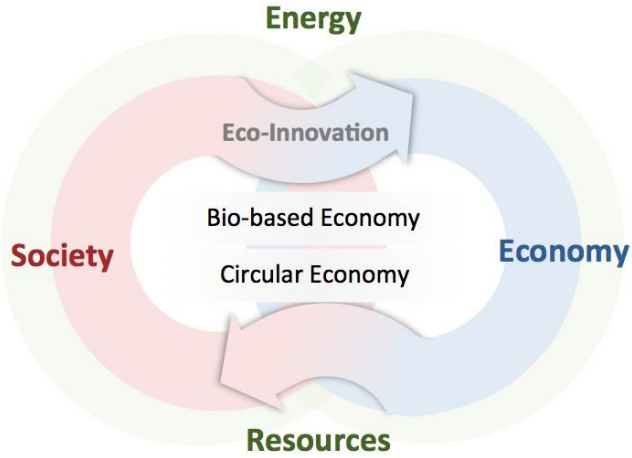
Funding: Austrian Research Promotion Agency (FFG)

2.2.3 Endowment Chair: Energy and Resource Innovation

Bioresources constitute an uncontested key pillar of European 21st-century economies. Whether in regards to wood for power plants, rapeseeds as biofuels or corn-based packaging material, renewable bio-based fuels and materials are crucial for a transition to a petroleum-free economy. However, the application of such resources is not free of technical, ecological, economic and societal conflicts. The adherent causes, dynamics, and consequences 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.

Having his academic background in the field of forestry, Professor Tobias Stern is especially interested in examining the diffusion processes of future-oriented technologies. In particular, he works on decisive questions like, how to overcome the gap between technical maturity and practical implementation, what broader implications might derive from an intensified use of bioprocessing technologies or which transition pathways are most feasible for sustainable use of bio-based materials. Hence, the center of his research activity can be summarized by focusing on facilitation and development of a bio-based economy and the further anchoring of this emerging topic in the Austrian research landscape.

In assessing the abovementioned questions, the research is underpinned by analysing the transition, (eco-)innovation and adaption 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. However, not every material is applicable in the same context under altered circumstances in different regions.



Energy and Resource Innovation

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 chair for energy and resource innovation is conceptualized as endowment chair and is funded by the Land Steiermark (Province of Styrian) for the next three years. At the moment, the faculty is in search of further collaboration partners.

Project team:	Univ.-Prof. Dr. Tobias Stern, Mag.rer.nat. Raphael Asada, BA, Claudia Mair, Bsc. Msc.
Duration:	January 2016 – December 2020
Funding:	Land Steiermark

2.2.4 Joint Program for Sustainability Leadership

Funded by the Erasmus+ Programme of the European Union

The major aim of this Erasmus+ partnership project was to develop a study program for sustainability leadership jointly. The study program aims to enhance the ability of leaders to innovate, collaborate and catalyze change, eventually creating sustainable organizations and societies.

Morgane Fritz at Ss. Cyril and Methodius University

The program was developed based on the needs of managers and leaders, research evidence and principles of sustainability leadership, sustainability standards and SDGs requirements. The study program has been implemented in Lithuania, Slovenia and Macedonia and the first cohort started their studies in October 2017; the project team from Graz contributed to the development of the program by providing expertise in the field of sustainability management and curriculum development; furthermore, institute members offered courses at the University of Ljubljana, Ss. Cyril and Methodius University in Skopje and Vytautas Magnus University in Kaunas during teaching mobility in the summer term 2018. The teaching contents included sustainable supply chain management, life cycle assessment, environmental impact assessments, and other topics related to sustainable business management.

Moreover, eight motivated students of the program attended a special course at the University of Graz in March 2018, in which they learned about sustainable business models, business ethics, and renewable resource management.

Ralf Aschemann at University of Lubljana

The wider objective of the developed program is to improve manager's and leader's performance and sustainability actions through enhancing their leadership skills and abilities to innovate, collaborate and manage change.

The target group consists of managers working in local, national and governmental bodies, as well as in the private and non-profit sector; managers who are willing to make a difference and integrate strategies for sustainability in their organizations are very welcome to the program. Another target group is interested students who plan to work as key players in project management and organizational development, where broader issues of societal development are important.

Thomas Brudermann at Vytautas Magnus University

Project team:	Ass.-Prof. Dr. Thomas Brudermann, Dr. Thomas Winkler, Morgane Fritz Ph.D., Dr. Ralf Aschemann, Ass.-Prof. Dr. Romana Rauter, Arijit Paul Ph.D., Mag. Andreas Schober, Ao. Univ.-Prof. Dr. Alfred Posch
Project partners:	Ss. Cyril and Methodius University (Macedonia), Institute for Research in Environment, Civil Engineering and Energy (Macedonia), Vytautas Magnus University (Lithuania), University of Ljubljana (Slovenia)
Duration:	September 2016 – August 2018
Funding:	Erasmus+, Key action 2 (Strategic Partnerships), grant agreement No 2016-1-MK01-KA203-021670

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

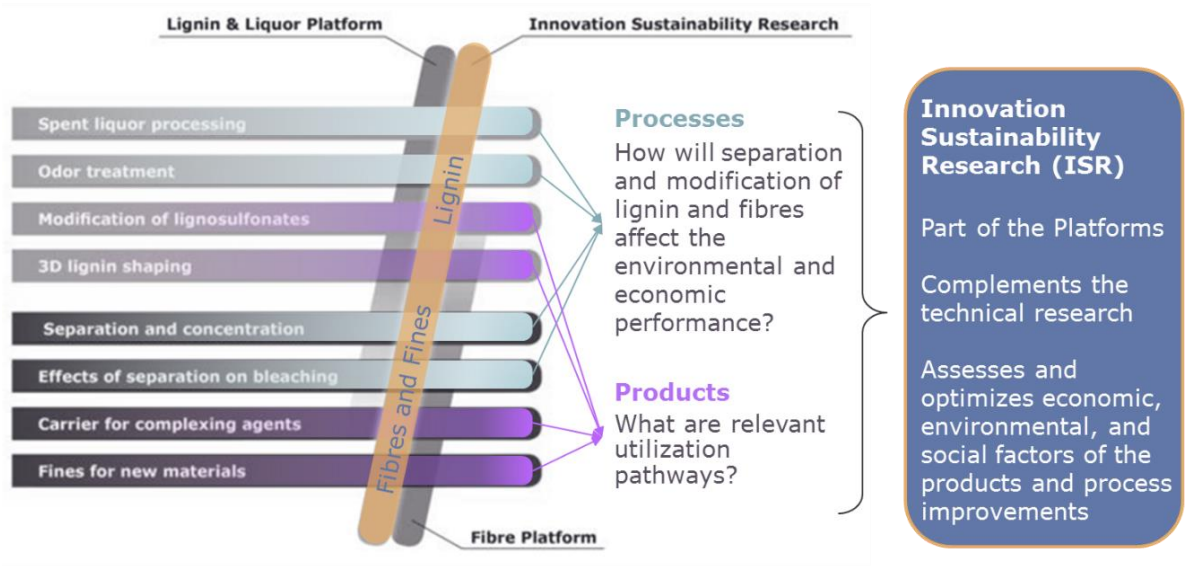
The Institute of Systems Sciences, Innovation and Sustainability Research is responsible for assessing the environmental and socio-economic impacts of wood in an automotive application. More precisely the institute will perform a Life Cycle Assessment (LCA) of the defined application cases in order to 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)

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

2.2.8 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)

2.2.9 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, performing as the 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), the 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.

2.3 Research cooperations and networks

2.3.1 Visiting researchers

Name	from	until	University	Host
Rafia Zaman, MBA	1.09.2017	31.5.2018	Kuhlna University, Bangladesh	Thomas Brudermann
Ass.-Prof Matevs Obrecht, PhD	8.1.2018	16.2.2018	University of Maribor, Slovenia	Tobias Stern
Prof. Dr. Anne Toppinen	15.3.2018	15.4.2018	University of Helsinki, Finland	Tobias Stern
Annukka Näyhä, PhD	15.5.2018	18.5.2018	University of Jyväskylä, Finland	Romana Rauter
Marat Karatayev, PhD	1.9.2018	31.5.2019	University of Nottingham, UK	Thomas Brudermann
Prof. Maria Rosário do Partidário	15.10.2018	19.10.2018	University of Lisbon, Portugal	Ralf Aschemann

2.3.2 Outgoing faculty

Name	from	until	University and Purpose
Romana Rauter	15.01.2018	19.01.2018	University of Jyväskylä, Finland
Romana Rauter	12.09.2018	27.09.2018	ESCP Europe Business School, Campus Berlin, Germany
Raphael Asada	01.06.2018	31.08.2018	International Institute for Applied Systems Analysis (IIASA), participation in Young Scientists Summer Program (YSSP)
Thomas Brudermann	27.10.2018	19.11.2018	Prince of Songkla University, research project on energy transitions in South-East Asia (funded by ASEA-Uninet, project number ASEA2018/Uni-Graz/8)

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 2018, the 24th annual International Sustainable Development Research Conference was held in Messina/Italy. Rupert Baumgartner is a board member and executive secretary 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 organisations 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 organisations.

Institute of Systems Sciences, Innovation, and Sustainability Research (SIS) is part of this ECR NoN since mid-2016, with another 25 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 Aisma Linda Kiesnere, together with 16 other networks/organizations have joined the Future Earth Working Group (FE WG), which concentrates specifically on sustainability and interdisciplinary research. Additionally, in the last FE WG meeting in London (22-24 January 2018) Aisma Linda Kiesnere took over the team lead of Structure, Governance and Communication Team of the FE WG, letting the Institute plant its sustainability research ideas straight into this global early career researcher community.

More information on the latest meeting is available here: http://futureearth.org/news/early-career-researcher-networks-meet-london

2.4 Ph.D. projects (ongoing)

2.4.1 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.

Ph.D. student: Michael Kriechbaum, MSc.
Duration: 2014 - 2019
Reference: Doctoral Programme DK Climate Change

2.4.2 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 - 2019

2.4.3 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.

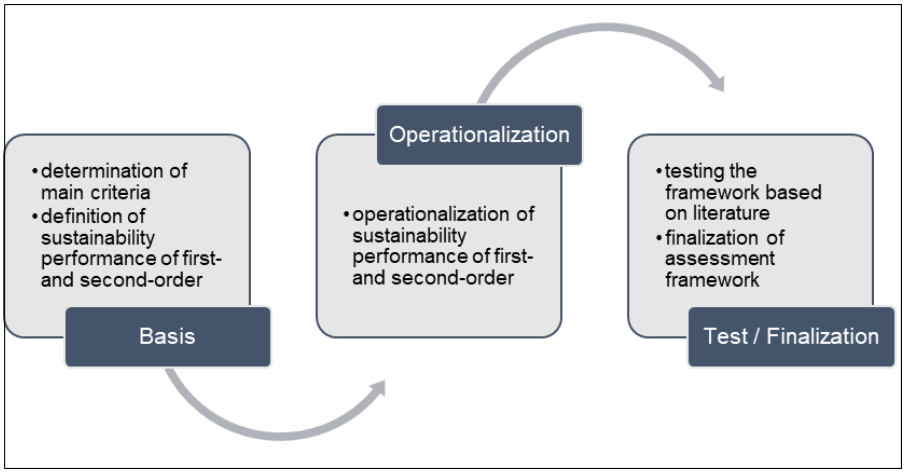
The first research objective focuses on the development of a generic opinion diffusion model that can include different forms of survey data that did not necessarily have to be adapted for the model.
In the second research objective critical transitions, sudden changes of a systems stable state, and 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 - 2019

2.4.4 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 - 2019

2.4.5 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, MSc
Duration: 2016 - 2020

2.4.6 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.

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

2.4.7 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: 2016-2019

2.4.8 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

2.5 Ph.D. Projects (finalized)

2.5.1 Corporate strategies in response to climate change - an empirical analysis of characteristics, drivers and outcomes with a focus on the global automotive industry

Businesses play a crucial role in climate change mitigation efforts since most emissions are caused by industrial activities. Although there has been plenty of research on other sustainability and environmental issues, corporate action on climate change remains poorly understood. This especially applies to the dynamics of strategies employed in specific industries and supply chains.

This dissertation aims at closing these knowledge gaps through four empirical studies that address (i) the characteristics of companies' strategic responses to climate change; (ii) their intra-organizational and external drivers; and (iii) the impact of strategies in terms of GHG reductions and financial performance. An empirical focus is on the global automotive industry because of the need for combatting CO2 emissions from road transport. For comparison purposes, the global cement and steel industries and suppliers of multinational corporations were also considered.

Based on strategic management literature, novel definitions of and conceptual frameworks for climate change strategies are developed. In contrast to previous research, the conceptualizations proposed in this dissertation adopt an integrated perspective by including both market (e.g., development of low-carbon products and processes) and non-market aspects (e.g., political lobbying) and by distinguishing between several underlying strategic objectives. Stakeholder, institutional and legitimacy theory and the resource-based view of a firm, in turn, serve to derive theoretical propositions about internal and external drivers of corporate climate change strategies. For the empirical analyses, secondary data was sourced from company documents, financial databases, trade associations, and international institutions. A mixed-method approach was employed to analyze the data, including content analysis techniques and statistical methods.

The findings show that climate action in the automotive industry is particularly dependent on effective corporate governance, the position of a company in the supply chain and its size. Moreover, suppliers (regardless of industry affiliation) are more likely to implement low-carbon initiatives when perceiving climate-related risks and opportunities. Having said that, results concerning external factors are rather ambiguous. In general, regulatory pressures to reduce GHG emissions are not associated with a greater extent of action among automotive firms. The opposite applies, however, when looking at the largest companies in the automotive, steel and cement industries and suppliers of multinational corporations. Interestingly, empirical evidence cannot be provided for a positive relationship between companies' emission reduction initiatives and environmental performance. Yet, climate change strategies are partly associated with financial gains in the long run.

PhD student: Matthias Damert, MSc.
Duration: 2014 - 2018
Reference: Doctoral Programme DK Climate Change

2.5.2 Scenarios for a Low Carbon Society: Sector Agriculture

Accumulation of greenhouse gases (GHGs) in the atmosphere has led to rising temperatures, variable precipitation, and other extreme events like droughts and floods. In order to limit negative impacts to climate, the environment, and human livelihoods in general, emissions of these compounds need to be strongly reduced. International agreements have not been effective, in part due to missing concepts of realistic "low carbon" situations. Hence there is a need to devise scenarios for a low carbon society that is technically and economically viable.

The agricultural sector is a source of food and is indispensable to society. However, it is associated with significant GHG emissions. The Intergovernmental Panel on Climate Change's (IPCC) 5th assessment report, identifies the agricultural sector as one of the major GHG emitting sectors, responsible for almost a quarter of GHG emissions (~10–12 $GtCO_2$ eq./yr) mainly from deforestation and agricultural emissions from livestock, soil and nutrient management. Reports have also shown that agricultural yields are vulnerable to climate impacts, as seen by a decreasing rate in production increase over recent years. Hence agriculture is not only a major source of GHG emissions but is also affected by the accumulation of the GHG's in the atmosphere and subsequent changes in climate. The economic mitigation potential in the supply-side is estimated to be around 7.2 to 11 $GtCO_2$ eq./yr in 2030 consistent with carbon prices (IPCC 5th Assessment Report, 2014). Although it is characterized by a high level of GHG emissions, the agricultural sector is indispensable for society. Understanding the negative impacts of climate change due to GHG accumulation and accounting for the potential that exists to mitigate emissions, it is necessary to devise low carbon scenarios to reduce GHG emissions in the agricultural sector.

This study, using international emission inventories, country-specific reports and the International Institute for Applied Systems Analysis's (IIASA) Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model will assess the policies and measures undertaken by the European Union (EU) countries to mitigate GHG emissions in the agricultural sector. Additionally, the study will also identify and evaluate other novel mitigation options and estimate their subsequent costs using the GAINS model. Overall, the results would identify and describe low carbon scenarios in the agricultural sector to mitigate climate change. This holistic framework analyzing the mitigation potential of current and proposed measures is more advanced than previous research. The results are helpful for farmers, crop advisors, and policymakers struggling to identify economically viable mitigation strategies and understand the impact of a changing climate on commodity agriculture.

PhD student: Sajeev Erangu Purath Mohankumar, MSc. Eng.
Duration: 2014 - 2018
Reference: Doctoral Programme DK Climate Change

2.5.3 I Shine, Not Burn. Empirical studies on citizen participation initiatives in the field of photovoltaics

During the last decades, citizen participation initiatives in renewables spread across Europe in various forms and shapes – including 'small' or 'large' initiatives with respect to capacity and/or number of members involved; 'strong' or 'weak' ones regarding the level of community engagement and the amount of resources available to operate the initiative, 'idealistic' or 'market-oriented' ones regarding their goal, etc. One overarching benefit of such initiatives is, however, that they provide the opportunity for different actors (e.g. energy supply companies, private companies or individuals, etc.) to aid the transition towards a more sustainable energy system, to reduce greenhouse gas (GHG) emissions and to foster the diffusion of renewable energy technologies, and thereby contribute to meeting the current goals defined by several policy agreements on national, European and international level.
For coping with the variety of energy community projects, the term 'citizen participation initiatives' (CPI) will be used in the Ph.D. thesis at hand to underline the importance of individual citizens for implementing renewable energy projects – more specifically: projects in the field of photovoltaics (PV). This broad definition also allows for considering different possibilities of participation (e.g. financial investment, active contribution to operating the initiative, etc.), as well as for recognizing the involvement of a broad variety of actors who may found and operate such initiatives, including not only individual citizens but also external firms, energy supply companies, municipalities, etc.
CPIs in renewables received attention from researchers of various disciplines. Owing the complexity and diversity of such initiatives in respective national contexts, research questions address different dimensions, most importantly: (1) the overall goal of such initiatives from initiators' perspectives, (2) relevance and impact of framework conditions (e.g. legal, acceptance, etc.) as well as the development potential of such initiatives, and (3) motives to participate in an initiative. However, results are still rather fragmented, owing (not only but heavily) to methodological weaknesses.
The Ph.D. thesis at hand aims to make a contribution to this field of research by innovating regarding the methods applied as well as content-wise by providing rather comprehensive information about PV-CPIs in Austria. Therefore, all three of the above-mentioned dimensions are addressed, as indicated by the following research questions:

- What kind of niche processes operate within CPI social innovation? How do market-based and grassroots PV-CPIs perform in these processes, how do both types of PV-CPIs evolve towards a global niche, and what is their potential success at the regime level?
- Why do people participate in PV-CPIs?
- What factors foster or hinder the development of CPIs for PV diffusion I Austria?
- Which resources are necessary to implement a PV-CPI successfully?

The Ph.D. thesis was embedded in the project RESHAPE.

PhD student: Eva Fleiß, MA
Duration: 2013 - 2018

2.5.4 Adoption – Diffusion – System Change: Empirical insights into demand-side aspects of transition towards a sustainable energy system

Our energy system is strongly connected to various global trends such as climate change, whereas the predominance of fossil fuels contributes to harmful environmental impact. As a result, a transition to a sustainable energy-system is required based on a shift of energy technology investment into renewable and sustainable solutions, as well as the innovation and cultivation of new social practices and business models.
Especially for the demand side of the energy system, a successful transition has to include the prompt and widespread adoption and diffusion of technical and social innovations. Consequently, the purpose of the thesis was to investigate aspects contributing to the adoption of social and technical innovations, niche development and further regime diffusion of social innovations in order to gain empirical insights. Three specific innovations are considered in the big picture of the energy system: (i) heating systems (i.e., technical innovation), (ii) photovoltaic citizens participation initiatives (PV-CPI) (i.e., social innovation), and (iii) energy municipalities (i.e., socially focused innovations). The adoption and diffusion of these innovations can be located on micro, meso and macro level of the socio-technical system based on the multi-level perspective, whereas analysis was done on different theoretical scales (i.e., individual, context-independent and context-dependent, collective theories).
Based on a survey research results show that the adoption of alternative heating systems is dependent on the underlying trigger, whereas economic aspects such as subsidies and perceived operational costs as well as the feasibility of heating system implementation predicted the adoption decisions. Research on PV-CPI showed three main results: first, the adoption of PV-CPIs, which was researched based on a survey approach, was not predicted by people's desires, but financial beliefs were the main driver behind joining such an initiative. Secondly, drawing on qualitative interviews market-based and grassroots PV-CPIs showed different key processes at the niche level. The former exhibit a relatively heterogeneous external actor-network, follow a policy of business development, engage in highly professionalized learning, and access a large, widespread customer base. In contrast, grassroots CPIs leverage a tightly-knit network of local actors, engage in informal learning and shared expectations. Both types seemed capable of achieving regime level, either through individual growth or by aggregation of multiple small-scale initiatives. Thirdly, the findings of a SWOT-AHP approach showed that successful initiatives are those which are able to draw upon public interest and support, and which manage to combine financial attractiveness with environmental concerns. The research on the impact of energy municipalities was done based on quantitative methods. The results indicated that despite the program's ambitious aims, the implementation has almost no impact on citizen awareness and behaviour.
To conclude, the empirical insights given in this thesis show that various aspects of different system levels determine the adoption and further regime diffusion of technical and social innovations at the demand side of the energy system. Single research findings on innovation adoption and diffusion, received through analysis on different scales and allocated in a system perspective, allows to view them within the big picture of sustainable energy transition.

PhD student: Mag. Stefanie Hatzl
Duration: 2014 - 2018

2.5.1 Strategic and ethical dimensions of business responses to climate change

Current fragmented understanding of business strategies and climate change is a major barrier for a post-fossil transition: a task that is of paramount importance to improve the chances of meeting the 2°C global warming target of the Paris Agreement. This thesis tries to address this concern in three collaborative research papers. The first paper proposes an integrated model of business strategy and climate change that combines climate strategy, climate performance and financial performance of companies. The model is operationalized using the statistical method of structural equation modelling. The results from the application of the model indicate: in the long run, internal greenhouse gas emission reduction efforts at companies are profitable and the combination of regulatory and stakeholder pressures are effective in pushing companies towards more action on climate change. A need for developing a deeper integrated view emerged from the first paper. Attempts at addressing this need are made in the second paper by trying to uncover the ontology of the interaction between business and climate change.

Grounded in the philosophy of critical realism and supported by an extensive structured literature review, in the second paper a multilevel ontology of the interaction between business and climate change is proposed. The ontology shows that the organizational level strategic responses to climate change are influenced by four other levels, comprising of individual, national, sectoral and transnational levels. The multilevel ontology of the proposed framework makes the need for interdisciplinary research in developing an integrated understanding of business strategies and climate change explicit. Using the statistical technique of multilevel modelling an empirical example of the operationalization procedure of the framework is demonstrated. The empirical example is the first global study on corporate lobbying behavior on climate change. The results of the study show lobbying behavior of companies on climate change does not vary between developed and developing countries but instead are guided by their sector affiliations and organizational level characteristics.

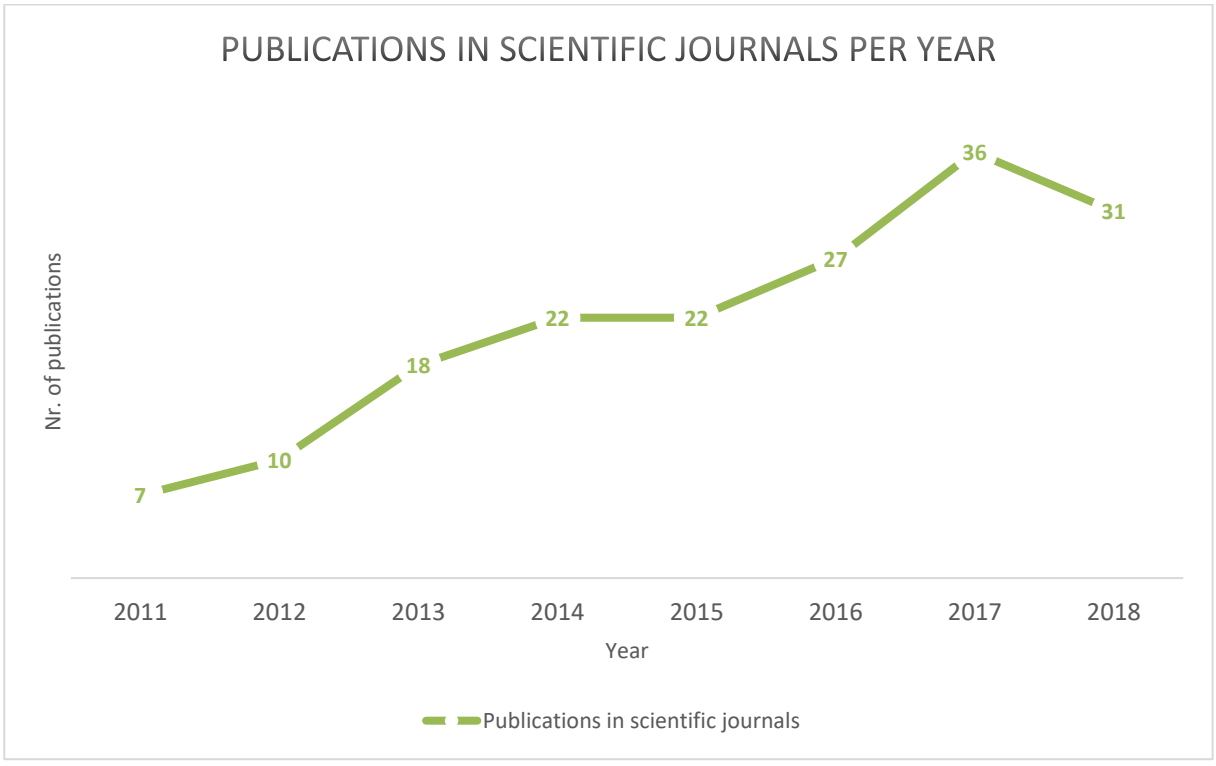
In the third paper, a conceptual application of the framework is shown by developing a novel interdisciplinary insight of business inaction on climate change. Focussing on business leaders as moral agents and by combining insights from climate ethics, psychology and ethical decision-making theories a theoretical explanation for the collective level failure of business actions on climate change is explained. In the end, a vision for an integrated understanding of business strategies and climate change is presented, and it is emphasised that such a vision can only be achieved through deep interdisciplinary research.

PhD student: Arijit Paul, MSc.
Duration: 2014 - 2018
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	2014	2015	2016	2017	2018
Publications					
Publications in scientific journals	22	22	27	36	31
Contributions to an edited book or proceedings	19	16	22	12	16
Posters presented at scientific conferences	3	6	19	4	3



Number of publications in scientific journals over the last years

3.1 Publications

3.1.1 Edited book series/journal

Pekka Leskinen, Giuseppe Cardellini, Sara González-García, Elias Hurmekoski; Roger Sathre, Jyri Seppälä, Carolyn Smyth, Tobias Stern and Pieter Johannes Verkerk (Ed.): From Science to Policy 7: Substitution effects of wood-based products in climate change mitigation. JoensuuEFI: EFI 2018.

3.1.2 Contribution to peer-reviewed journals

Asada, Raphael; Stern, Tobias: *Competitive Bioeconomy? Comparing Bio-based and Non-bio-based Primary Sectors of the World,* in: Ecological Economics 149 (2018), 120-128. DOI: 10.1016/j.ecolecon.2018.03.014

Bartoszewicz-Burczy, H., ; Baumgartner, R.J., ; Fawcett, T., ; Fritz, M.M.C., ; Killip, G., ; Valladolid, T., ; Violi, C.: *Assessing the intangibles: socioeconomic benefits of improving energy efficiency.* in: Acta Energetica 1,34 (2018), TBD. (in print)

Dentchev, N., Rauter, R., Jóhannsdóttir, L., Snihur, Y., Rosano, M., Baumgartner, R., Nyberg, T., Tangh, X., van Hoof, B., Jonker, J. : *Embracing the variety of sustainable business models: A prolific field of research and a future research agenda,* in: Journal of Cleaner Production 194,1 (2018), 695-703. DOI: https://doi.org/10.1016/j.jclepro.2018.05.156

Fritz, M. M.C.; Rauter, R. ; Baumgartner, R.J. ; Dentchev, N.: *A supply chain perspective of stakeholder identification as a tool for responsible policy and decision-making.* in: Environmental Science & Policy 81 (2018), 63-76. DOI: 10.1016/j.envsci.2017.12.011

Füllsack, Manfred: *Granularity and Irritation, and the Irritations They Aroused,* in: Constructivist Foundations 13,2 (2018), 321-323.

Füllsack, Manfred: *Plasticity, granularity and multiple contingency - essentials for conceiving an artificial constructivist agent,* in: Constructivist Foundations 13,2 (2018), 282–291.

Hofer, Christian; Jäger, Georg; Füllsack, Manfred: *Critical transitions and Early Warning Signals in repeated Cooperation Games,* in: Journal of Dynamics and Games 5,3 (2018), 014. DOI: 10.3934/jdg.2018014

Hofer, Christian; Jäger, Georg; Füllsack, Manfred: *Including traffic jam avoidance in an agent-based network model,* in: Computational Social Networks 5,1 (2018), 5. DOI: https://doi.org/10.1186/s40649-018-0053-y

Hofer, Christian; Jäger, Georg; Füllsack, Manfred: *Large scale simulation of CO2 emissions caused by urban car traffic: an agent-based network approach,* in: Journal of Cleaner Production 183 (2018), 1-10.

Huber, D.-J., Huber, J., Hesser, F., Höllbacher, E., Stern, T. : *Two experts, three opinions: volatile organic compounds' testing methods and regulative systems,* in: European Journal of Wood and Wood Products 76,1 (2018), 5-12.

Ilieva, Vikotorija; Brudermann, Thomas; Drakulevski, Ljubomir: *"Yes, we know!" (Over)confidence in general knowledge among Austrian entrepreneurs,* in: PLoS One 13,5 (2018), e0197085. DOI: doi.org/10.1371/journal.pone.0197085

Jäger, Georg: *Using Elementary Cellular Automata to Model Different Research Strategies and the Generation of New Knowledge,* in: Complex Systems 27,2 (2018), 145-158. DOI: https://doi.org/10.25088/ComplexSystems.27.2.145

Karutz, Raphael; Riedner, Lukas; Robles Vega, Luisa; Stumpf, Lukas; Damert, Matthias: *Compromise or complement? Exploring theinteractions between sustainable and resilient supplychain management,* in: International Journal of Supply Chain and Operations Resilience 3,2 (2018), 117-142. DOI: 10.1504/IJSCOR.2017.10010519

Kriechbaum, Michael; Brent, Alan C.; Posch, Alfred: *Interaction patterns of systemic problems in distributed energy technology diffusion: a case study of photovoltaics in the Western Cape province of South Africa,* in: Technology Analysis & Strategic Management 30, 12 (2018), 1422-1436. DOI: 10.1080/09537325.2018.1473851

Kriechbaum, Michael; López Prol, Javier; Posch, Alfred: *Looking back at the future: Dynamics of collective expectations about photovoltaic technology in Germany & Spain,* in: Technological Forecasting and Social Change 129 (2018), 76-87. DOI: https://doi.org/10.1016/j.techfore.2017.12.003

Rachinger, Michael; Rauter, Romana; Müller, Christiana; Vorraber, Wolfgang; Schirgi, Eva: *Digitalization and its influence on business model innovation,* in: Journal of Manufacturing Technology Management,. (2018), 10.1108/JMTM-01-2018-0020. DOI: 10.1108/JMTM-01-2018-0020

Ranacher, Lea; Höfferer, Kathrin; Lettner, Miriam; Hesser, Franziska; Stern, Tobias; Rauter, Romana; Schwarzbauer, Peter: *What would potential future opinion leaders liketo know? An explorative study on the perceptionsof four wood-based innovations,* in: Die Bodenkultur 69, 1 (2018), 47-59. DOI: 10.2478/boku-2018-0005

Reischl, Christiane; Rauter, Romana; Posch, Alfred: *Urban vulnerability and adaptation to heatwaves: a case study of Graz (Austria),* in: Climate Policy 18, 1 (2018), 63-75. DOI: 10.1080/14693062.2016.1227953

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 forthcoming (2018), 13. DOI: doi.org/10.1007/s10098-018-1615-2 (in print)

Sangkakool, Tachaya; Techato, Kuaanan; Zaman, Rafia; Brudermann, Thomas: *Prospects of green roofs in urban Thailand – A multi-criteria decision analysis,* in: Journal of Cleaner Production 196 (2018), 400-410. DOI: doi.org/10.1016/j.jclepro.2018.06.060

Schober, Andreas; Kittel, Christopher E.; Baumgartner, Rupert J.; Füllsack, Manfred: *Identifying dominant topics appearing in the Journal of Cleaner Production,* in: Journal of Cleaner Production 190 (2018), 160-168. DOI: 10.1016/j.jclepro.2018.04.124

Schober, Andreas; Simunovic, Nenad; Darabant, Andras; Stern, Tobias: *Identifying sustainable forest management research narratives: a text mining approach,* in: Journal of Sustainable Forestry 37, 6 (2018), 537-554. DOI: 10.1080/10549811.2018.1437451

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Stern, T.; Ranacher, L.; Mair, C.; Berghall, S.; Lahtinen, K.; Forsblom, M.; Toppinen, A.: *Perceptions on the Importance of Forest Sector Innovations: Biofuels, Biomaterials, or Niche Products?* in: Forests 9,5 (2018), -. DOI: 10.3390/f9050255

Stern, Tobias; Ursula Ploll; Raphael Spies; Peter Schwarzbauer; Franziska Hesser and; Lea Ranacher: *Understanding perceptions of the bioeconomy in Austria-An explorative case study,* in: Sustainability 10, 11 (2018), 4142. DOI: 10.3390/su10114142

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Wang, Jing; Maier, Stephanie D.; Horn, Rafael; Holländer, Robert; Aschemann, Ralf: *Development of an Ex-Ante Sustainability Assessment Methodology for Municipal Solid Waste Management Innovations,* in: Sustainability 2018, 10, 3208 (2018), 1-29. DOI: 10.3390/su10093208

Zaman, Rafia; Brudermann, Thomas: *Energy governance in the context of energy service security: A qualitative assessment of the electricity system in Bangladesh,* in: Applied Energy 223 (2018), 443-456. DOI: doi.org/10.1016/j.apenergy.2018.04.081

Zaman, Rafia; Brudermann, Thomas; Kumar, S. and Islam, Nazrul: *A multi-criteria analysis of coal-based power generation in Bangladesh,* in: Energy Policy 116 (2018), 182-192. DOI: doi.org/10.1016/j.enpol.2018.01.053

3.1.3 Contribution to non-peer-reviewed journal

Rauter, Romana; Globocnik, Dietfried; Perl-Vorbach, Elke; Baumgartner, Rupert Ja.: *Open innovation and its effects on economic and sustainability innovation performance,* in: Journal of Innovation & Knowledge https://doi.org/10.1016/j.jik.2018.03.004 (2018)

Schweiger, Gerald, Cláudio Gomes, Georg Engel, Irene Hafner, Georg Engel, Thierry Nouidui, Niki Popper, Josef-Peter Schoeggl,: *Co-Simulation: Leveraging the potential of urban energy system simulation,* in: Euroheat and Power (English Edition) 15(1) (2018), 13-16.

3.1.4 Contribution to an edited book or proceedings

Baumgartner, Rupert J.: *Nachhaltiges Produktmanagement durch die Kombination physischer und digitaler Produktlebenszyklen als Treiber für eine Kreislaufwirtschaft,* in: Redlich, T.; Moritz, M.; Wulfsberg J. (Ed.), Interdisziplinäre Perspektiven zur Zukunft der Wertschöpfung. Wiesbaden: Springer Gabler 2018, pp. 347-360. DOI: 10.1007/978-3-658-20265-1_26

Baumgartner, Rupert J.: *Universitäten als Katalysatoren eines nachhaltigen Wandels am Beispiel der Universität Graz,* in: Raueiser, Markus; Kolb, Monika (Ed.), CSR und Hochschulmanagement. Berlin & Heidelberg: Springer Gabler 2018, pp. 251-262.

Brudermann, Thomas: *Plastic use and plastic waste in Thailand – a social practice perspective,* in: ASEA UNINET (Ed.), Annual Report 2017. Presented by the Austrian Board of Trustees of the Austrian Member Universities. Vienna: ASEA UNINET - Chair: o.Univ.-Prof. Dr. Dr.h.c. A Min Tjoa 2018, 90-95. (in print)

Fritz, M.M.C.; Schöggl, J.-P.; Baumgartner, R.J.: *Enabling a Supply Chain-Wide Sustainability Assessment: A Focus on the Electronics and Automotive Industries,* in: Brandenburg, M.; Hahn, G.J.; Rebs, T. (Ed.), Social and Environmental Dimensions of Organizations and Supply Chains. Greening of Industry Networks Studies, vol 5. . Cham: Springer 2018, pp. 61-77.

Fritz, M.M.C.; Tessmann, Niklas: *Management of Conflict Minerals in Automotive Supply Chains: Where to Start from?* in: Brandenburg, M.; Hahn, G.J.; Rebs, T. (Ed.), Social and Environmental Dimensions of Organizations and Supply Chains.. Cham: Springer 2018 (Greening Industry Networks Stud., 5), 153-169.

Füllsack, Manfred: *Der Rationalisierungshorizont der Normalarbeit und die Digitalisierung von "non-routine tasks",* in: Johanna Muckenhuber, Josef Hödl, Martin Griesbacher (Ed.), Normalarbeit. Nur Vergangenheit oder auch Zukunft? Bielefeld: transcript 2018, 305-324.

Füllsack, Manfred: *Geschichte und Zukunft der Arbeitsrationalisierung,* in: Wolfram Kawohl, Wulf Rössler (Ed.), Arbeit und Psyche. Stuttgart: Kohlhammer 2018, 19-28.

Gelbmann, Ulrike-Maria; Zimek, Martina: *Enticing Consumers to Avoid Waste - Digital and Analogue Ways of Raising their Awareness,* in: Pomberger, R. et al. (Ed.), Recy&Depotech 2018 Recycling & AbfallverwertungAbfallwirtschaft & RessourcenmanagementDeponietechnik & AltlastenInternationale Abfallwirtschaft & Spezielle Recyclingthemen. Leoben: MUL Eigenverlag 2018, 407-414.

Gutounig, Robert; Rauter, Romana; Sack-Sharif, Susanne; Klinger, Sabine; Dennerlein, Sebastian: *Zwischen Produktivität und Überlastung. Auswirkungen digitalisierter Arbeitsprozesse im Gesundheitsdienstleistungsbereich am Beispiel Krankenhaus.* in: Forschungsforum der Fachhochschulen Österreich (Ed.), Tagungsband des 12. Forschungsforum der österreichischen Fachhochschulen (FFH) 2018. 2018, http://ffhoarep.fh-ooe.at/bitstream/123456789/1138/1/FFH2018-T3-06-03.pdf.

Haas, Johannes Christoph; Sajeev Erangu Purath Mohankumar: *Groundwater, climate change and air pollution impacts from manure amendment to agricultural soils,* in: Banning, A. Frank, S. Kaufmann-Knoke, R. Niedermayr, A. Wisotzky, F. Wohnlich, S. (Ed.), Tagungsband, Grundwasser im Umfeld von Bergbau, Energie und urbanen Räumen; 26. Fachtagung der Fachsektion Hydrogeologie e.V. in der DGGV e. V.; Bochum, 21.-24. März 2018. D-44780 Bochum: Selbstverlag Institut für Geologie, Mineralogie und Geophysik der Ruhr-Universität Bochum 2018 (Bochumer Geowissenschaftliche Arbeiten), 176-177.

Hofer, Christian, Jäger, Georg, Füllsack, Manfred: *Generating Realistic Road Usage Information and Origin-Destination Data for Traffic Simulations: Augmenting Agent-Based Models with Network Techniques.* in: Cherifi C., Cherifi H., Karsai M., Musolesi M. (Ed.), Complex Networks & Their Applications VI. Cham: Springer 2018, 1223-1233.

Lackner, Bettina Christina; Sajeev Erangu Purath Mohankumar; Matthias Damert; Daniel Petz; Lukas Meyer; Roman Klug; Barbara Reiter: *Communicating Climate Change in a Museum Setting—A Case Study,* in: Leal Filho, W.; Manolas, E.; Azul, A.M.; Azeiteiro, U.M.; McGhie, H (Ed.), Handbook of Climate Change Communication. Berlin: Springer Nature 2018 (Handbook of Climate Change Communication, 3), 1-16. DOI: 10.1007/978-3-319-70479-1_14

Mautz, Rüdiger; Fleiß, Eva; Hatzl, Stefanie; Reinsberger, Kathrin; Posch, Alfred: *Bottom-up-Initiativen im Bereich Photovoltaik in Deutschland und Österreich: Rahmenbedingungen und Handlungsressourcen,* in: Holstenkamp, Lars; Radtke, Jörg (Ed.), Handbuch Energiewende und Partizipation. Wiesbaden: Springer VS 2018, 597-610. DOI: 10.1007/978-3-658-09416-4

Saari, U.A.; Fritz, M.M.C.; Mäkinen, S.J.; Baumgartner, R.J.: *Designing Green Marketing Across Industries: A Conceptual Framework and Implications for Consumers and Transdisciplinary Research.* in: Leal Filho, W. (Ed.), Handbook of Sustainability Science and Research. World Sustainability Series. Cham: Springer 2018, pp. 581-596.

Schober, Andreas; Füllsack, Manfred: *Computergestützte Echtzeitanalyse der Entwicklung des österreichischen Arbeitsmarktes und damit einhergehender regionsspezifischer Konsequenzen für ArbeitnehmerInnen.* in: Filipič Ursula (Ed.), Sozialpolitik in Diskussion: Zur Zukunft von Arbeit und Wohlfahrtsstaat. Wien: ÖGB-Verlag 2018

Schweiger, Gerald, Georg Engel, Josef-Peter Schoeggl, Irene Hafner, Cláudio Gomes, Thierry Nouidui: *Co-Simulation an Empirical Survey: Applications, RecentDevelopments and Future Challenges,* in: MATHMOD (Ed.), Proceedings of the 9th ViennaInternational Conference on Mathematical Modelling, MATHMOD2018. Vienna: MATHMOD 2018

3.1.5 Other Publications

Posch A., T. Brudermann, M. Buchner, E. Fleiß, D. Geringer, P. Hart, S. Hatzl, T. Kallsperger, G. Lang, T. Mayrold, E. Meißner, C. Reischl, G. Schnedl, S. Seebauer, K. Stöger, A. Würz-Stalder: *Optimierung der SOLARenergienutzung in URbanen Energiesystemen (URSOLAR).* Wien: Bundesministerium für Verkehr, Innovation und Technologie Bundesministerium für Verkehr, Innovation und Technologie 2018.

Stumpf, Lukas: *Exploring and evaluating business showcases from the Circular Economy Industry Platform.* Vienna: CEC4EUROPECEC4EUROPE 2018.

Wenger, Julia; Stern, Tobias; Schöggl, Josef-Peter; Van Ree, René; De Corato, Ugo; De Bari, Isabella; Bell, Geoff; Stichnothe, Heinz: *Natural Fibers and Fiber-based Materials in Biorefineries*. Paris: Status Report 2018. IEA Bioenergy Task 42. 2018.

3.2 Presentations

Asada, Raphael: *Towards a Material-based Indicator of Bioeconomic Transition,* for: 9th International Sustainability Transitions Conference, The University of Manchester, Manchester (United Kingdom), 12.06.2018.

Baumgartner, Rupert J.: *Was bedeutet Nachhaltigkeit bei Produkten und Unternehmen?,* for: Montagsakademie, Zentrum für Weiterbildung, Universität Graz, Graz (Austria), 16.04.2018.

Brudermann, Thomas: *Decision Making in Complex Systems - Workshop at Institute for Ecological Economics, WU Vienna,* for: Institute for Ecological Economics, WU Vienna, (Austria), 12.06.2018.

Brudermann, Thomas: *Energy transition or energy trilemma?,* for: EECC Seminar, Asian Institute of Technology, School of Environment, Resources and Development, (Thailand), 31.10.2018.

Brudermann, Thomas: *Energy transitions in the global north, energy trilemmas in the global south,* for: EcolEcon Research Seminar Series, Institute for Ecological Economics, WU Vienna, WU Vienna (Austria), 11.06.2018.

Brudermann, Thomas: *One step ahead, two steps backwards: Energy Transitions and Coal in Developing Countries,* for: International Conference on Green Energy for Sustainable Development (ICUE 2018), Asian Institute of Technology, Phuket (Thailand), 26.10.2018.

Brudermann, Thomas; Aschemann, Ralf: *Komplexe Systeme und Nachhaltigkeit,* for: Schnupperuni 2018, Uni Graz, (Austria), 22.08.2018.

Brudermann, Thomas; Aschemann, Ralf: *Komplexe Systeme und Nachhaltigkeit,* for: Tag der offenen Tür 2018, Uni Graz, (Austria), 05.04.2018.

Füllsack, Manfred: *A new kind of traffic model: Road usage information and origin-destination-data based on mobility behavior,* for: IWcee18, IWcee18, Rom (Italy), 27.06.2018.

Füllsack, Manfred: *Predicting Critical Transitions in Time Series with ML-Tools,* for: VI International Workshop on Computational Economics and Econometrics, National Research Council of Italy, Rom (Italy), 26.06.2018.

Gelbmann, Ulrike-Maria: *Die Welt verändern lernen (Podiumsdiskussion),* for: Die Welt verändern lernen, Transition Graz David Steinwender, Graz (Austria), 07.06.2018.

Gelbmann, Ulrike-Maria: *Inputvortrag: SDG 12 als Basis für die Diskussion von Wirkungsbeiträgen des Landes Steiermark zu den SDG,* for: Wirkungsbeiträgen des Landes Steiermark zu den SDG, Land Steiermark, Graz (Austria), 10.04.2018.

Gelbmann, Ulrike-Maria: *Podiumsdiskussion "Music for Social Change",* for: FIESTA!! Ein Festtag der „El Sistema Venezuela“ Ensembles in Graz, Kunstuniversität Graz, Graz (Austria), 18.05.2018.

Gelbmann, Ulrike-Maria: *Zur Abfallvermeidung verführt,* for: Recy & Depotech, Montanuniversität Leoben, Leoben (Austria), 09.11.2018.

Jäger, Georg: *Data Mining, Big Data und Machine Learning,* for: USW Talks, Graz (Austria), 28.11.2018.

Kiesnere, Aisma Linda; Baumgartner, Rupert; Rauter, Romana: *CSR management in practice: Decision-making for sustainability in medium-sized companies in Austria,* for: The 24th International Sustainable Development Research Society Conference, University of Messina, Department of Economics, Messina, Italy (Italy), 14.06.2018.

Mair, Claudia; Zimek Martina: *Differences in perception among experienced and non-experienced electrical vehicle users in the agricultural sector,* for: 15. Symposium Energieinnovation, Technische Universität Graz, Graz (Austria), 14.02.2018.

Mair, Claudia; Zimek Martina: *Streamlined ex-ante LCA of wood-based components for the automotive industry: Challenges and uncertainties,* for: SETAC Europe 24th LCA Symposium - "The Role of LCA in Shaping the Future: Food, Fibre, Feed, Fertiliser, Fuel and Other Resources", SETAC Europe, BOKU Vienna, Vienna (Austria), 26.09.2018.

Mair, Claudia; Zimek, Martina: *Social LCA of wood-based components for the automotive industry: Re-importing social impacts,* for: SETAC Europe 24th LCA Symposium - "The Role of LCA in Shaping the Future: Food, Fibre, Feed, Fertiliser, Fuel and Other Resources", SETAC Europe, BOKU Vienny, Vienna (Austria), 24.09.2018.

Mair, Claudia; Zimek, Martina: *Sustainability performance of wood-based materials: A systemic assessment of lightweight materials for the mobility sector,* for: The 24th International Sustainable Development Research Society Conference - "Actions for a sustainable world: from theory to practice", University of Messina, Messina (Italy), 13.06.2018.

Ploll, U., Petritz, H., & Stern, T.: *Diffusion of Vegetarian and Vegan Diets as Social Innovations: Motive Dynamics and Impacts on Environmental- and Animal-Conscious Behaviour,* for: 9th International Sustainability Transitions Conference, STRN, Manchester (United Kingdom), 13.06.2018.

Rauter, Romana; Baumgartner, Rupert; Peer, Michael; Schöggl, Josef-Peter; Zimek, Martina: *Assessing the Impact of Sustainable Business Models. Is it only a matter of system boundaries and methods applied?,* for: 24th Annual ISDRS Conference, International Sustainable Development Research Society , Messina (Italy), 14.06.2018.

Stern, Tobias: *Biorefinery Business Modells,* for: ENVISION - H2020 Project / Delft University of Technology, Wien (Austria), 19.01.2018.

Stern, Tobias: *The role of retail in a circular bioeconomy,* for: ANNUAL STRATEGIC RETAIL TRADE CONFERENCE, University of Ljubljana/Slovenian Chamber of Commerce, Brdo Congress Center (Slovenia), 17.10.2018.

Wenger, Julia; Stern, Tobias: *Natural Fibers and Fiber-Based Materials in Biorefineries*. *A report on behalf of the International Energy Agency*, for: National IEA Bioenergy Task 42 Stakeholder Meeting, University of Natural Resources and Life Sciences, Vienna (Austria), 22.11.2018.

3.3 Posters

Haas, Johannes Christoph; Sajeev Erangu Purath Mohankumar: *Groundwater, climate change and air pollution impacts from manure amendment to agricultural soils,* for: Grundwasser im Umfeld von Bergbau, Energie und urbanen Räumen; 26. Fachtagung der FH-DGGV, Fachsektion Hydrogeologie e.V. in der DGGV e. V., Bochum (Germany), 2018.

Macke, Janaina; Rauter, Romana; Sarate, João: *Sustainable Busines Models: How Much Sustainability Has in Them?,* for: 24th Annual ISDRS Conference, International Sustainable Development Research Society (ISDRS), Messina (Italy), 2018.

Neuhold, Bianca; Hofer, Kathrin; Amort, Frank; Bauer, Lisa; Aschemann, Ralf: *EIA plus HIA for the transport sector: A promising combination approach?,* for: Urban Transitions 2018 - Integrating Urban and Transport Planning, Environment and Health for Healthier Urban Living, Elsevier, IS Global, Sitges (Spain), 2018.

3.4 Science to Public

3.4.1 Media article

Füllsack, Manfred: *Interview zu Arbeitstugenden im Wandel,* Radiosender Ö1 "Dimensionen", radio, 13.06.2018.

Füllsack, Manfred: *Interview zum Arbeitsmarkt,* Falter, print, 21.02.2018.

Thomas Brudermann; Regie: Edith Stecker: *Galileo, Episode 231 - WTF: Wie weit treibt uns der Herdentrieb?,* PRO 7, television, 25.07.2018.

3.4.2 Mentioned in media

Baumgartner, Rupert J. in: Brandstätter, Christian; Reisinger, Roswitha; Oberhollenzer, Ursula, *Klimawandel: Die unterschätzte Herausforderung,* Business Art: Wirtschaft mit Weitblick, print, 30.06.2018.

Brudermann, Thomas in: *Les livres d'avant et d'ailleurs,* BFM Business, television, internet, 23.05.2018.

Brudermann, Thomas in: Rafia Zaman, *Coal Power Generation In Developing Countries: A Bangladesh Case Study,* Science Trends, internet, 18.05.2018.

3.5 External Scientific Functions

Reviews were undertaken for following journals:

- Biomass and Bioenergy
- 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
- Scandinavian Journal of Management
- Science and Public Policy
- Sustainability
- Sustainable Development
- Systems Research and Behavioral Science

3.6 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.

3.7 Prices and Awards

3.7.1 Scholarship Steiermärkische Sparkasse

In 2006, the University Council and the Steiermärkische Sparkasse established the Young Researchers Fund at the University of Graz in order to promote excellent young researchers. Every year, these funds are used to finance scholarships for outstanding doctoral students and postdocs. In 2018 Marie Kapeller was awarded such a scholarship, which will support her research for the next two years.

Marie Kapeller's dissertation at the Institute for Systems Sciences, Innovation and Sustainability Research deals with fundamental questions on the effectiveness, sustainability, and robustness of cooperation in social action. Using a dynamic network model developed for this purpose, she examines the dynamics of the overall system, its resilience to population changes and strategy errors, as well as characteristics of the spread of non-cooperation in the network, with the aim of identifying particularly influential factors.

3.7.2 Best Reviewer Award

At the Academy of Management Annual Meeting, Romana Rauter received the 2018 Best Reviewer Award from the Organizations & the Natural Environment Division. This award acknowledges researchers who have generously given of their time to referee papers and have shown great dedication, as well as attention to detail, and professionalism when they review submissions.

3.7.3 Award of the Austrian Society of Agricultural Economics

Ursula Ploll received the Award of the Austrian Society of Agricultural Economics 2018 for young researchers for her thesis *"Motives of Austrian Vegetarians and Vegans and their Behavioural Expressions."* The aim of this thesis, supervised by Professor Tobias Stern, was to define the motives of vegetarians and vegans and the development of this dietary movement by analysing the internal and external factors that influenced them. With her work, she was able to shed light on the relationship between motives, behaviour and social innovation with regard to vegetarianism and veganism.

3.7.4 Award of Excellence

The Award of Excellence, State Prize for the best Ph.D. theses 2018 was given to Philipp Babcicky by the Austrian Federal Ministry of Education, Science, and Research. His thesis, titled “Flood preparedness of private households: Determinants of protective behaviour and insights into collective action” was supervised by Professor Alfred Posch and investigated the question why only a relatively low number of households are adequately prepared for a flood and what could be done to increase this number.

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.

4.1.1 International Joint 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, the University of Stellenbosch (South Africa) and TERI University in New Delhi (India) joined the consortium as further mobility partners.

Welcome meeting for the 2018 generation in September. 18 students from 10 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 competencies 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 third integration semester, and one specialization track (second semester) in Sustainable Business Management. Master theses are generally supervised by two teachers of two different partner universities.

Comprehensive information on the International Joint 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.

4.1.2 Erasmus Mundus Master's Programme on Circular Economy

The European Commission's Education, Audiovisual and Culture Executive Agency has selected the "Erasmus Mundus Master's Programme on Circular Economy (CIRCLE)" for funding in July 2018. Beside the International Joint Master's Programme in Sustainable Development. In 2017, "Erasmus Mundus Master's Programme in Industrial Ecology" was completed. this is already the third Joint Master Programme co-ordinated by our institute.

CIRCLE intends to

- bring together and to bundle the existing expertise in education in the field of Circular Economy (CE), European wide and beyond, which fosters internationalisation and excellence in higher education institutions,
- train students in order to contribute to environmentally sustainable economic growth by their capability,
- enhance the attractiveness and quality of the European Higher Education Area by offering a unique international master programme in CE to the best students inside and outside the European Union,
- improve the level of competences and skills of the CIRCLE students in order to increase their employability,
- contribute to the European Union's "Circular Economy Action Plan."

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 a double degree from those.

Dr. Ralf Aschemann is the academic CIRCLE co-ordinator, and Dr. Anja Hoffmann from the Office for International Relations serves as administrative coordinator. 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).

The first intake of students will start with the CIRCLE orientation week, which is scheduled in Sweden from 4 to 9 August 2019. Then the students will be allocated to one of the European CIRCLE universities to start their first semester.

For more information on CIRCLE, please visit https://www.emcircle.eu

4.1.3 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.

4.1.4 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.

So far 13 postgraduate students have been selected for this highly competitive programme. Four of these students are affiliated with the Institute of Systems Sciences, Innovation and Sustainability Research. They 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 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.

4.3 Completed theses (master and doctoral)

In 2018 40 master students completed their thesis within one of the study programs Environmental Systems Sciences, Global Studies, Sustainable Development, and Industrial ecology. The list is ordered alphabetically; supervisors are named in brackets.

Allmer, Victoria: Chances and risks of organic and conventional beekeeping - a system science-oriented analysis *(Füllsack Manfred)*

Beeg, Marc Adrian: Evaluating the applicability of early warning signals for critical transitions in the hurricane regime. Insights from an empirical analysis of intensifying tropical cyclones in the North Atlantic *(Füllsack Manfred)*

Bruckner, Gerald: The Impact of Digitalization on Business Models in the Austrian Electricity Sector *(Rauter Romana)*

Cucchiara, Francesca: The Transition towards a Sound E-Waste Management: The Implementation of the Extended Producer Responsibility in Ghana *(Baumgartner Rupert)*

Engelmann, Klaus Peter: Business models for the distribution of agriculturally produced local foods *(Gelbmann Ulrike-Maria)*

Gartner, Rebecca Johanna: Norms, standards and guidelines in the field of social responsibility by using the example of the automotive industry *(Gelbmann Ulrike-Maria)*

Grabmaier, Katharina: Waste collection at the level of waste management associations - Development of criteria for the evaluation of joint tenders *(Gelbmann Ulrike-Maria)*

Gretler, Matthias: Techno-economic Assessment of Renewable Energy Supply Concepts for Urban Development Areas. Integral Contemplation of Heat and Cold Supply for the District Donaufeld *(Posch Alfred)*

Haberl, Nicole Rosa: Influencing factors of market diffusion for lignin-based PU-foams - A bio-based alternative to conventional PU-foams *(Stern Tobias)*

Hanna, Lukas: Sustainable Business Model Innovation. Mapping the Literature Landscape *(Rauter Romana)*

Höller, Christina: Regional energy data acquisition: An analysis of Austrian energy regions' data requirements *(Posch Alfred)*

Kanhai, Gina: Waste Management and Health: The case of Accra in Ghana *(Aschemann Ralf)*

Kastner, Franziska: Innovating Sustainability Reporting: Developing a Process to create a customized Sustainability Reporting for Higher Education Institutions. A Case Study at the University of Basel *(Posch Alfred)*

Mandl, Lisa: The Role of Transaction Costs in the Diffusion of Physical and Digital Products - A Comparison *(Stern Tobias)*

Melbinger, Isabella: Opportunities and limitations of disposable and reusable systems for coffee to go with particular regard to selected life cycle assessments *(Aschemann Ralf)*

Moser, Patrick: Designing a Green Supply Chain in Manufacturing Startups: An Austrian Case Study *(Baumgartner Rupert)*

Obermayr, Katrin: Implementation of quality and environmental management systems in service companies according to ISO 9001 and 14001: Deduction of requirements and revision based on Austrian service companies working in the field of waste management *(Baumgartner Rupert)*

Oswald, Yannick: Renewable Bio-Resource Endowment as Driver for Bioeconomic Convergence. A Comparative Study on the Chemical and Pharmaceutical Industries *(Stern Tobias)*

Peer, Michael: Towards the Assessment of Sustainable Business Models - Prospects for utilizing existing sustainability assessment methods from a business model perspective *(Rauter Romana)*

Perdomo Echenique, Enrique Alejandro: Contribution of musical education on Sustainability. The study case of "El Sistema" musical education for underprivileged children in Venezuela *(Gelbmann Ulrike-Maria)*

Polic, Stefan: District Cooling in Austria - An analysis of stakeholders and decision criteria *(Posch Alfred)*

Purgstaller, Angela: Coffee to go cups: Possibilities and limitations of disposable and reusable systems for coffee to go under particular consideration of environmental impacts *(Aschemann Ralf)*

Pusch, Melissa: CSR in Small Service Providing Companies. From Requirement Definition to Implementation - An Application-Oriented Case Study *(Baumgartner Rupert)*

Quiroz Galvan, Mayra del Pilar: Sustainability partnerships in the apparel industry: a multiple-case study of business-nonprofit collaborations *(Stern Tobias)*

Rauter, Maritha: The impacts of environmental education and triggers on environmental related behaviour. A case study about Reef Guardian Schools in Australia with a particular focus on the age of onset and the influence of gender *(Aschemann Ralf)*

Reiter, Patrick: Solar district heating - Economic feasibility of large-scale solar thermal systems in municipal district heating networks - A case from Austria *(Posch Alfred)*

Reznik Rocha, Rafaela: Socioeconomic Impact of the Block Farming System within the Cashew Value Chain in Rural Sierra Leone: Fostering Smallholder Agriculture *(Aschemann Ralf)*

Röser, Leonard: Sustainable tourism among young adults. A survey of the presence of sustainable tourism among young adults in Austria and Germany *(Brudermann Thomas)*

Schrempf, Bernhard: Assessing the Potentials of Electricity Storage Systems in a Defined Microgrid: An Agent-Based-Modelling Approach *(Stern Tobias)*

Selzer, Emily: Energy Optimization through Heat Pumps: An Economic and Environmental Analysis of Heat Pumps in Austria *(Baumgartner Rupert)*

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

Simo, Maria-Georgiana: Social Life Cycle Assessment of Quinoa Production in Peru. Empirical study of the quinoa quandary on the Peruvian population *(Posch Alfred)*

Straner, Florian: Sustainable business models in food retail - an analysis in the city of Graz *(Gelbmann Ulrike-Maria)*

Tessmann, Niklas: Cooperation regarding conflict minerals in the automotive, aviation and electronics industries´ supply chains *(Baumgartner Rupert)*

Thaller, Annina Elisa: Climate (In)Action in Austria - About the Relation between Knowledge, Perception and Behavior *(Brudermann Thomas)*

Uitz, Evelyn: CO2 Footprint as a competition-influencing element in the railway infrastructure market *(Baumgartner Rupert)*

Van Wijk, Willem: Public Acceptance of Autonomous Cars in the Netherlands: Results of a Discrete Choice Experiment *(Stern Tobias)*

Wallnöfer, Laura Maria: Transition to Sustainable Development: Focusing on Lifestyles. The role of young citizens for capacity building and disseminating practices *(Brudermann Thomas)*

Yamamoto, Tales: Potential to Mitigate Rebound Effects by Directing Re-Spending onto the Environment *(Posch Alfred)*

Zaki Abdelaziz, Yasmine: Life cycle assessment (LCA) of phosphorus management for Recirculating Aquaculture System (RAS) sludge *(Aschemann Ralf)*

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

Babcicky, Philipp: Flood preparedness of private households: Determinants of protective behaviour and insights into collective action *(Posch Alfred)*

Damert, Matthias: Corporate strategies in response to climate change - An empirical analysis of characteristics, drivers and outcomes with a focus on the global automotive industry *(Baumgartner Rupert)*

Erangu Purath Mohankumar, Sajeev: Rethinking the manure management chain: An investigation of climate, air quality and animal welfare impacts *(Winiwarter Wilfried)*

Fleiß, Eva: I shine, not burn. Empirical studies on citizen participation initiatives in the field of photovoltaics. *(Posch Alfred)*

Hatzl, Stefanie: Adoption – Diffusion – System Change: Empirical insights into demand-side aspects of transition towards a sustainable energy system *(Posch Alfred)*

Paul, Arijit: Strategic and ethical dimensions of business responses to climate change *(Baumgartner Rupert)*

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

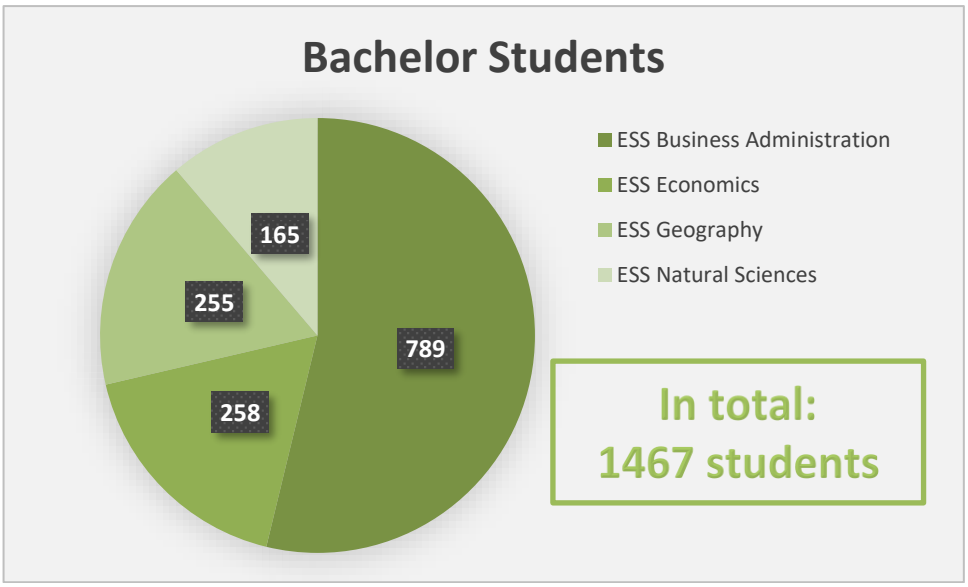
Summer Term 2018			
Type	**Course**	**Contact hours**	**Lecturers**
PS	Applied Systems Sciences 1	2	Jäger G, Kapeller M, Schober A
PS	Applied Systems Sciences 2	2	Maraun D
VU	Calculus for Systems and Environment Sciences	3	Batzel J, Keeling S
KS	Eco-Controlling	2	Baumgartner R
PS	Economic Technology 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	Tschernatsch M
VO	Human Beings and Environment: Geosphere	2	Fischer W, Sass O, Schöner W
SE	Human Factor of Digital Transformation	2	Füllsack M, Kleinert J, Staudegger E, Vogeler G
AG	Interdisciplinary Practical Training	4	Fritz M, Neuhold L, Vötsch G
AG	Interdisciplinary Practical Training	4	Dullnig K, Kozina C, Reiter K
AG	Interdisciplinary Practical Training	4	Baumast A, Friedrich A, Muner-Sammer K
AG	Interdisciplinary Practical Training	4	Kienberger T, Lehner M, Posch A, Tichler R
AG	Interdisciplinary Practical Training	4	Gelbmann U, Höflehner T, Peskoller A
AG	Interdisciplinary Practical Training	6	Aschemann R, Friedrich A, Schweitzer S
PS	Introductory Seminar - Elementary Statistical Concepts and Methods, Examples and Practice	1	Feit T

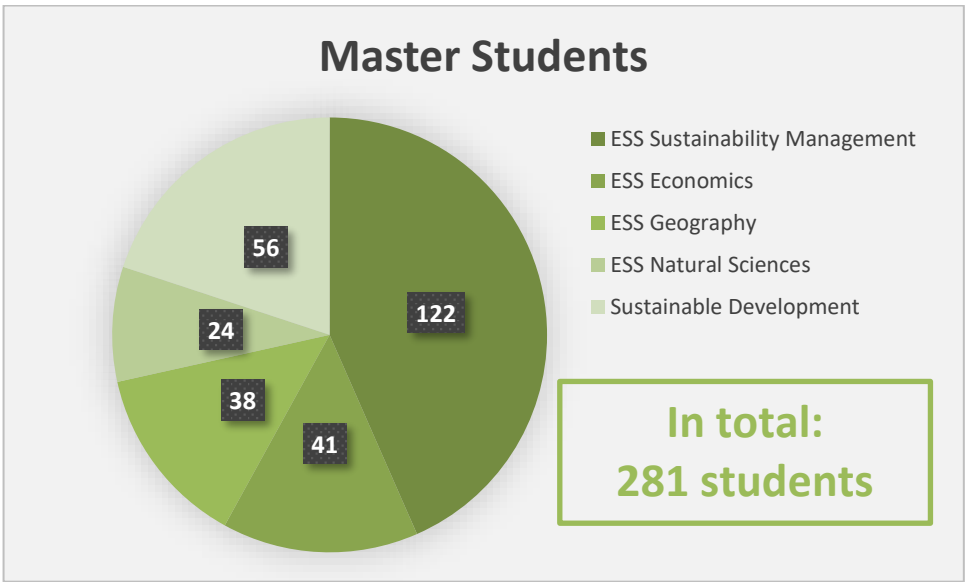
AG	IP - Environmental and social governance in supply chains to optimize sustainability performance	6	Aschemann R, Baumgartner R, Fritz M
VU	Linear Algebra for USW	2	Fripertinger H, Hötzl E, Prager W
PS	Management of Sustainable Development 2 Environmental Management	2	Baumgartner R
SE	Master Seminar	2	Baumgartner R, Füllsack M, Posch A, Stern T
AG	MIND Summer School	2	Aschemann R
VO	Modelling of Systems	2	Jäger G
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	Zilian L
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	2	Mair C, Stern T
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 the Integration and Evaluation of Systems	2	Füllsack M
SE	Seminar for the Modelling of Systems	2	Füllsack M, Schmickl T
SE	Seminar on Multilevel Analysis Methods	2	Lang J
KS	Strategic Sustainability Management	2	Gelbmann U
SE	Sustainability and Environmental Management	2	Posch A
KS	Sustainability Entrepreneurship	2	Kiesnere A, Stern T
KS	Sustainable Innovation	2	Rauter R
VO	Systems Sciences 2	2	Propst G
VU	Systems Sciences 3	2	Granigg W
KS	Value Chain Management	2	Aschemann R

Winter Term 2018/2019			
Type	**Course**	**Contact hours**	**Lecturers**
PS	Applied Systems Sciences 1	2	Hofer C, Jäger G, Kapeller M
PS	Applied Systems Sciences 2	2	Rieder H
VU	Calculus for Systems and Environment Sciences	3	Batzel J, Fripertinger H, Hötzl E, Keeling S
VO	Data in System Sciences	2	Füllsack M
KS	Eco-Controlling	2	Baumgartner R, Mair 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
VO	Human Beings and Environment: Anthroposphere	2	Posch A, Steininger K
KS	Integrated Management Systems	2	Dully S, Ulz A
AG	Inter- and Transdisciplinary Case Study on Sustainable Development	6	Brudermann T, Crockett S, Fleiß E, Kriechbaum M, Posch A
AG	Interdisciplinary Practical Training	4	Bernhard F, Hasler A, Janitschek G
AG	Interdisciplinary Practical Training	4	Baumgartner R, Reindl S, Schlesinger A, Zimek M
AG	Interdisciplinary Practical Training	4	Boch R, Haslinger E, Stern T, Winkler G
AG	Interdisciplinary Practical Training	6	Redik M, Schöggl J, Vötsch G
AG	Interdisciplinary Practical Training	4	Gelbmann U, Kranzinger L, Ledersteger A, Mayer J, Nabernegg S
VO	Interdisciplinary Scientific Approaches at the URBI Faculty	2	Aschemann R, Payer G, Stefanec E, Wlasak P
VO	Interdisciplinary Working Methods	2	Aschemann R
SE	Introduction to Industrial Ecology	2	Aschemann R
PS	Introductory Seminar - Elementary Statistical Concepts and Methods, Examples and Practice	1	Ambros R, Feit T, Fleiß E
SE	Introductory workshop DK Climate Change	2	Baumgartner R, Bednar-Friedl B, Birk S, Foelsche U, Kirchengast G, Maraun D, Meyer L, Posch A, Sass O, Schulev-Steindl E, Steiner A, Steininger K
AG	IP - Circular Economy - System change towards a sustainable future	6	Hadler M, Prettenthaler F, Schwarzinger S, Schweitzer S

SE	Colloquium DK Climate Change	2	Baumgartner R, Bednar-Friedl B, Birk S, Foelsche U, Kirchengast G, Maraun D, Meyer L, Posch A, Sass O, Schulev-Steindl E, Steiner A, Steininger K
SE	Life Cycle Assessment: Theoretical and Practical Insights	2	Sorensen B
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
UE	Practical Exercises: USW Computational Basics	1	Kapeller M, Schröck A, Thaller A, Zilian L
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	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	2	Füllsack M, Schmickl T
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	Feit T
KS	Strategic Sustainability Management	2	Gelbmann U
VO	Sustainability and Environmental Management	2	Baumgartner R
KS	Sustainability Entrepreneurship	2	Kiesnere A, 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

4.5 Student Statistics





Number of registered students in 2018 (source: student statistics from UniGrazOnline)

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

Merangasse 18/I,
8010 Graz, AUSTRIA