HS PF

MODULE MANUAL SPO2024

STUDY PROGRAM

BUSINESS ADMINISTRATION/

SUSTAINABILITY AND RESOURCE EFFICIENCY

B.Sc.

January 2024

This is a convenience translation, which is provided to English-speaking readers for informational purposes only.

Only the German version of this document is legally binding in accordance with § 23 paragraph 1 Federal State Administrative Procedure Act (Landesverwaltungsverfahrensgesetz).

TABLE OF CONTENTS

Page

List of abbreviations

CR	Credits according to the ECTS system
PLH	Examination based on term paper
PLK	Examination based on written exam
PLL	Examination based on laboratory work
PLM	Examination based on oral exam
PLP	Examination based on project work
PLR	Examination based on presentation
PLS	Examination based on research project
PLT	Examination based on written thesis
PVL	Prerequisite examination
PVL-BVP	Prerequisite examination for bachelor interim overall exam
PVL-BP	Prerequisite examination for final bachelor graduation
PVL-MP	Prerequisite examination for final master graduation
PVL-PLT	Prerequisite examination for registration for bachelor thesis
SWS	Contact hours per week
UPL	Non-graded examination (pass/fail only)
WPF	Mandatory elective subject

Alignment matrix for teaching the competence objectives according to KMK - "Sustainability and Resource Efficiency"

Modules	Knowledge and Understanding			Knowledge Application and Generation Skills		Communication and Collaboration Skills	Academic Integrity and Professionalism
	Knowledge Broadening	Knowledge Deepening	Knowledge Comprehension	Application and Transfer	Scientific Innovation		
BNRE1120	X		X	X		X	X
BNRE2120	X	X	X	X		X	X
BNRE2220	X		X	X		X	X
BNRE2320	X	X	X	X		X	X
BNRE2420	X	X	X	X		X	X
BNRE2520	X	X		X		X	X
LAW3200	X	X	X	X		X	X
BNRE3110		X	X	X			X
BNRE3210	X*	X*	X*	X*	X*	X	X*
BNRE4110		X	X	X	X	X	X

*) depending on the chosen combination of the two compulsory electives

Second stage of studies - program-specific modules

BNRE1120: RESOURCE EFFICIENCY AND ENVIRONMENTAL PROTECTION

Resource Efficiency and Environmental Protection	
Module ID	BNRE1120
Semester	1 / 2
Credits	6
SWS	5
Frequency	BNRE1121 in the winter semester BNRE1122 in the summer semester
Associated courses	BNRE1121 – Industrial Resource Efficiency (1 ECTS), 1st semester BNRE1122 - Climate and Environmental Protection (5 ECTS)
Prerequisites	None
Exam type / duration	BNRE1121: PLK - 60 minutes BNRE1122: PLR/PLH
Requirements for granting of credits	Passing the examination
Significance for the final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 5 The module grade is determined (even if the number of credits for the courses differs) on an equal basis (mean value or equal number of achievable points).
Planned group size	max. 50 students
Language	German
Module duration	1 semester
Module coordinator	Prof Dr Claus Lang-Koetz
Lecturers	Prof Dr Mario Schmidt (Industrial Resource Efficiency) Prof Dr Claus Lang-Koetz (Climate and Environmental Protection)
Subject area	Sustainability and Resource Efficiency
Pedagogical approach	Lecture with exercises
Applicability in other programs/modules	None
Objectives	The students... • know the main starting points for the sparing use of energy and raw materials in production. • have learnt about a cross-section of different production companies and industries. • are familiar with the concept of resource efficiency and the most important publications on the subject. • understand the basics of climate change • have an overview of the social and ecological conse-quences of climate change • understand other important environmental problem areas, their scientific and social implications

	• know important climate and environmental protection measures The module contributes to the achievement of the following competences: Broadening knowledge, understanding knowledge, utilisation and transfer, communication and cooperation, scientific self-image/professionalism
Contents	<u>Industrial Resource Efficiency:</u> • Introduction to the topic of resource efficiency from the perspective of operational production • Examples and starting points for resource-conserving production in the economy • Ways of saving energy and raw materials in production processes <u>Climate and Environmental Protection:</u> • Foundations of climate change • Social and ecological consequences of climate change • Causes and consequences of other environmental problems • Foundations of climate and environmental protection
Connection to other modules	The module is the basis for all other program-specific modules in the degree program.
Workload	It is expected that the students, in addition to the 4 x 15 = 60 SWS attendance time and 90 h for preparation and follow-up work, study independently , work on exercises and prepare for the exam.
Literature	<u>Industrial Resource Efficiency:</u> Schmidt et al. (2017/2019): 100 companies for resource efficiency. Springer publishing house <u>Climate and Environmental Protection:</u> • BMU, BMBF, and DE-IPCC UBA. "Fifth Assessment Report of the IPCC Partial Report 1 (Scientific Basis)." (2015). • Heinrichs & Michelsen (eds.): Sustainability Sciences. Part III: Natural science perspectives. Springer-Verlag, 2014. • Steffen, Will, et al. "Planetary boundaries: Guiding human development on a changing planet." Science 347.6223 (2015). • Latest edition unless otherwise stated
Miscellaneous	--
Keywords	Industrial Resource Efficiency, Environmental and Climate Protection
Last change	January 2024

BNRE2120: SUSTAINABILITY AND RESOURCES

Sustainability and Resources	
Module ID	BNRE2120
Semester	3
Credits	6
SWS	4
Frequency	in the winter semester
Associated courses	BNRE2111 - Industrial Ecology and Sustainability (3 ECTS) BNRE2112 - Raw Materials and Resources (3 ECTS)
Prerequisites	none
Exam type / duration	PLK/PLH - 90 minutes
Requirement for granting of credits	Passing the examination
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 6 The module grade is determined (even if the number of credits for the courses differs) on an equal basis (mean value or equal number of achievable points).
Planned group size	max. 50 students
Language	German
Module duration	1 semester
Module coordinators	Prof Dr Mario Schmidt
Lecturers	Prof Dr Hendrik Lambrecht (Industrial Ecology and Sustainability) Prof Dr Mario Schmidt (Raw Materials and Resources)
Subject area	Sustainability and Resource Efficiency
Pedagogical approach	Lecture
Applicability in other programs/modules	none
Objectives	The students... • can categorize and critically reflect on the concept of resource efficiency in the context of sustainability and industrial ecology. • know the historical, social and economic significance of environmental and sustainability issues • know the most important concepts and terms of the sustainability debate (strong vs. weak sustainability, efficiency, sufficiency and consistency strategy, etc.) • understand anthropogenic activities and economic activity as an energetic and material metabolism • know the meta-strategies of industrial ecology (circular economy, dematerialisation, detoxification) and the central analysis paradigm of industrial metabolism. • know the basic principles of material flow analysis as the

	most important tool of industrial ecology/material flow management. • have the prerequisite to understand advanced life cycle-oriented analysis methods (especially LCA) in their mode of action • know the main raw material groups and raw materials that are of great importance in production and are currently being discussed in the context of the criticality of resources (e.g. copper, aluminium, rare earths, gold, tantalum, phosphorus) • know the origin, market situation, scarcities and significance of the raw materials addressed for future technologies, • know how selected future technologies work and how they are used in products, • learn concepts for assessing the scarcity of raw materials, such as criticality The module contributes to the achievement of the following competences: Broadening knowledge, deepening knowledge, understanding knowledge, utilisation and transfer, communication and cooperation, scientific self-image/professionalism
Contents	<u>Industrial Ecology and Sustainability</u> • Introduction to industrial ecology (material flow analyses, material flow analyses, input/output) • Eco- and resource efficiency • Fundamentals of sustainability • Introduction to Life Cycle Thinking methods <u>Raw Materials and Resources</u> • The lecture provides an overview of raw material groups and selected individual raw materials that are of great importance for production and are currently being discussed in the context of the criticality of resources (e.g. copper, aluminium, rare earths, gold, tantalum, phosphorus). • To this end, concepts for assessing scarcity are presented. • Corresponding applications in technologies or products are presented for the respective raw materials.
Connection to other modules	none
Workload	It is expected that the students, in addition to the 4 x 15 = 60 SWS attendance time, use 120 h for preparation and follow-up work, independent study of literature, working on exercises and preparing for the exam.
Literature	<u>Industrial Ecology and Sustainability</u> • Heinrichs, H.; Michelsen, G. (eds.) (2014) Nachhaltigkeitswissenschaften. Springer Spektrum, Berlin, Heidelberg • Graedel, Allenby (2010) Industrial Ecology and Sustainable Engineering. Pearson, Upper Saddle River • Ayres, Ayres (ed.) (2002) A Handbook of Industrial Ecology. Edward Elgar, Northampton • Klöpffer, W., Grahl, B. (2009) Life Cycle Assessment (LCA). Wiley-VCH. <u>Raw Materials and Resources</u> • Achzet B., Reller A., Zepf V., University of Augsburg, Rennie C., BP, Ashfield M. and Simmons J., ON Communica-

	tion (2011): Materials critical to the energy industry. An introduction • Angerer, G. et al. (2009): Raw materials for future technologies, influence of sector-specific raw material requirements in raw material-intensive future technologies on the future demand for raw materials. BMWI/ ISI/ IZT • EU (2014): Report on critical Raw Materials for the EU. Report of the Ad hoc Working Group on defining critical raw materials
Miscellaneous	--
Keywords	Resource Efficiency, Industrial Ecology, Sustainability, Raw Materials, Resources
Last change	January 2024

BNRE2220: TECHNICAL FUNDAMENTALS

Technical Fundamentals	
Module ID	BNRE2220
Semester	3
Credits	6
SWS	4
Frequency	in the winter semester
Associated courses	BNRE2221 - Natural Sciences Fundamentals (3 ECTS) BNRE2212 - Production Engineering (3 ECTS)
Prerequisites	none
Exam type / duration	PLK - 90 minutes
Requirements for granting credits	Passing the examination
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 6 The module grade is determined (even if the number of credits for the courses differs) on an equal basis (mean value or equal number of achievable points).
Planned group size	max. 50 students
Language	German
Module duration	1 semester
Module coordinator	Prof Dr Claus Lang-Koetz
Lecturers	Prof Dr Hendrik Lambrecht (Natural Sciences Fundamentals) Prof Dr Claus Lang-Koetz (Production Engineering)
Subject area	Sustainability and resource efficiency
Applicability in other programs / modules	none
Pedagogical approach	Lecture
Objectives	The students... • know the central scientific concepts and laws, in particular from the fields of mechanics, thermodynamics, electricity and inorganic chemistry. • are familiar with the concept of energy and the conservation of energy and understand the most important principles of conversion between different forms of energy. • know how matter is structured and are familiar with the basic principles of (chemical) material conversion. • can apply this knowledge to practical issues relating to the environment and technology. • know the basic concepts and terms of production engineering and production organisation • know the most important properties of the materials iron and steel • can balance low-complexity production processes and create Sankey diagrams

	• know the most important manufacturing processes in the fields of primary moulding, forming and cutting processes The module contributes to the achievement of the following competences: Broadening knowledge, understanding knowledge, utilisation and transfer, communication and cooperation, scientific self-conception/professionalism
Contents	<u>Natural Sciences Fundamentals</u> • Introduction, basic tools • Mechanics • Thermodynamics • Electromagnetism • Structure of matter <u>Production Engineering</u> • Introduction and overview of production technology • Basic principles of production organisation • Properties of the materials iron and steel • Introduction to the balancing of production processes • Primary moulding from the liquid state (casting): Casting production with lost mould and permanent mould. Casting defects and how to avoid them • Forming: Solid forming, sheet metal forming • Cutting separation processes: Cutting with geometrically defined and undefined cutting edge, cutting by ablation
Connection to other modules	none
Literature	<u>Natural Sciences Fundamentals</u> • Harten, U.: Physics. An introduction for scientists and engineers. Springer, Heidelberg et al. (E-book!) • Povh, B.: Anschauliche Physik für Naturwissenschaftler. Springer, Heidelberg. • Tipler, P. A.; G. Mosca: Physics for Scientists and Engineers. Spektrum, Heidelberg. <u>Production Engineering</u> • Ilschner, B.; Singer, R. F.: Werkstoffwissenschaften und Fertigungstechnik, Springer. • Witt, G.: Taschenbuch der Fertigungstechnik, Fachbuchverlag Leipzig. • König, W., Klocke, F.: Fertigungsverfahren 1-5: Urformtechnik, Gießen, Sintern, Rapid Prototyping: Bd 5; Springer. • Doege, E.; Behrens, B.-A.: Handbuch Umformtechnik, Springer. • Grote, K.-H.; Feldhusen, J.: Dubbel, Taschenbuch für den Maschinenbau; Springer.
Workload	It is expected that the students, in addition to the 4 x 15 = 60 SWS attendance time, 120 hours for preparation and follow-up work, take time for independent literature study, work on exercises and prepare for the exam.
Miscellaneous	--
Keywords	Natural Sciences Fundamentals, Production Engineering
Last change	January 2024

BNRE2320: GREEN AND LEAN PRODUCTION

Green and Lean Production	
Module ID	BNRE2320
Semester	4
Credits	5
SWS	4
Frequency	in the summer semester
Associated courses	BNRE2321 - Environmental Technologies (2 ECTS) BNRE2322 - Lean Production (3 ECTS)
Prerequisites	none
Exam type / duration	PLK/PLH/PLR- 90 minutes
Requirements for granting of credits	Passing the examinations
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 5 The module grade is determined (even if the number of credits for the courses differs) on an equal basis (mean value or equal number of achievable points).
Planned group size	max. 50 students
Language	English
Module duration	1 semester
Module coordinator	Prof Dr Frank Bertagnolli
Lecturers	Prof Dr Claus Lang-Koetz (Environmental Technologies) Prof Dr Frank Bertagnolli (Lean Production)
Subject area	Sustainability and resource efficiency
Applicability in other programs / modules	none
Pedagogical approach	Lecture with exercises
Objectives	The students... • know selected basic operations (unit operations) of environmental technology; • understand individual process combinations of basic operations in environmental technology; • are familiar with the structures of environmental engineering systems and have mastered their basic design; • are familiar with the theoretical and practical aspects of selected environmental technologies and can establish the practical relevance of these processes; • are able to set up simple models for environmental engineering issues and processes and carry out corresponding simple balancing simulation calculations. • are familiar with the history, approaches and interrelationships of the Toyota Production System and other integrated production systems,

	• know essential analysis methods (value stream mapping) and principles from the field of lean production and can apply them to simple cases in practice, • know the effect of lean on a company's productivity and the goals that can be derived from it for managers, • were confronted with corresponding management approaches. The module contributes to the achievement of the following competences: Broadening knowledge, deepening knowledge, understanding knowledge, utilisation and transfer, communication and cooperation, scientific self-image/professionalism
Contents	<u>Environmental Technologies:</u> • Introduction and overview of environmental technology • Exhaust air treatment • Generation of gaseous emissions • Design and function of selected processes for the treatment of exhaust gases • Simple modelling for balancing mass and energy flows for concepts to solve environmental engineering problems • Presentation of resource-efficient concepts for reducing and avoiding emissions • Waste water treatment • Generation of waste water • Design and function of individual selected wastewater treatment processes • Treatment of special pollutants • Overview of industrial wastewater treatment <u>Lean Production:</u> • Introduction • Waste • Flow, beat, pull • Value stream mapping • Perfection • Standardisation • Continuous improvement • Supply logistics • Assembly production area • Production area Manufacturing • Lean and production systems
Connection to other modules	None
Literature	<u>Environmental Technologies:</u> Textbooks: • K. Schwister et. al., Taschenbuch der Umwelttechnik, Fachbuchverlag Leipzig im Carl Hanser Verlag, 2003 • Hans Dieter Janke, Environmental Biotechnology, UTB GmbH, Stuttgart, 2008 • Wilhelm Hosang, Wolfgang Bischof, Abwassertechnik, B. G. Teubner, Stuttgart, Leipzig, 1998 • Heinz Brauer, Handbuch des Umweltschutzes und der Umwelttechnik, Volume 3: Additive Environmental Protection: Treatment of Exhaust Air and Exhaust Gases, Springer, 1996 • Franz Joos, Technical Combustion, Springer, 2006 • Charles E. Baukal, Jr, The John Zink Combustion handbook, CRC Press, 2000

	• Ulrich Förstner, Environmental Protection Technology, Springer, 2004 • Michael Schultes, Exhaust gas purification, Springer, 1996 • Michael F. Jischa, Studies in Environmental Sciences, Springer, 2004 • Stanley E. Manham, Environmental Science and Technology, Second Edition, Taylor & Francis Group, 2007 • H. D. Baehr, S. Kabelac, Thermodynamics, Fundamentals and Technical Applications, 15th edition, Springer, 2012 • M. Kraume, Transport Processes in Process Engineering, Fundamentals and Apparatus Implementation, 2nd edition, Springer, 2012 Deepening/substance data: • VDI-Wärmeatlas, publisher: Verein Deutscher Ingenieure, VDI-Gesellschaft Verfahrenstechnik und Chemieingenieurwesen (GVC), 10th edition, Springer, 2006 • http://webbook.nist.gov/chemistry/ Lean Production: • Bertagnolli, F.: Lean Management (2022). Springer Gabler • Ohno, T.: The Toyota Production System. Campus • Womack, J.P., Jones, D.T.: Lean Thinking: shedding dead weight, increasing company profits. Campus • Rother, M., Shook, J.: Learning to See. Lean Management Institute • Takeda, H.: The Synchronised Production System. Vahlen
Workload	It is expected that the students, in addition to the 4 x 15 = 60 SWS attendance time and 90 h for preparation and follow-up work, take time for independent literature study, work on exercises and prepare for the exam.
Miscellaneous	--
Keywords	Environmental Technologies, Lean Production
Last change	January 2024

BNRE2420: ENERGY MANAGEMENT AND ENERGY TECHNOLOGIES

Energy Management and Energy Technologies	
Module ID	BNRE2420
Semester	4
Credits	5
SWS	4
Frequency	in the summer semester
Associated courses	BNRE2421 - Energy Technologies (3 ECTS) BNRE2422 - Industrial Energy Management (2 ECTS)
Prerequisites	none
Exam type / duration	PLK/PLH/PLR - 120 minutes
Requirement for granting of credits	Passing the examinations
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 5 The module grade is determined (even if the number of credits for the courses differs) on an equal basis (mean value or equal number of achievable points).
Planned group size	max. 50 students
Language	German
Module duration	1 semester
Module coordinator	Prof Dr Ingela Tietze
Lecturers	Prof Dr Ingela Tietze (Energy Technologies) Prof Dr Ingela Tietze (Industrial Energy Management)
Subject area	Sustainability and Resource Efficiency
Applicability in other programs / modules	none
Pedagogical approach	Lecture with exercises
Objectives	The students... • know the thermodynamic principles of energy conversion and the corresponding terminology, • know the relevant technical systems for energy conversion and supply (both conventional (fossil) and renewable), • can independently carry out basic calculations for the design and evaluation of energy conversion systems, • are able to compare energy conversion technologies from different perspectives (technical, economic and ecological), • understand the connection between energy technology and energy management aspects with regard to the different energy conversion technologies and • are familiar with concepts at the interface between energy technology and the energy industry, such as contracting and energy management recognise the concept of energy management systems according to DIN EN ISO 50.001 and can explain their strengths and weaknesses

	• can categorise operational energy demand by determining relevant key figures • are able to identify typical potential energy savings and develop solutions for them • are familiar with common approaches to in-house energy supply and can evaluate these economically and technically • know the central energy markets and their pricing mechanisms • understand the requirements for energy procurement and can develop and evaluate suitable procurement models on the basis of demand characteristics The module contributes to the achievement of the following competences: Broadening knowledge, deepening knowledge, understanding knowledge, utilisation and transfer, communication and cooperation, scientific self-image/professionalism
Contents	<u>Energy Technologies:</u> • Thermodynamic principles • Steam generator and heat exchanger • Cooling supply • Compressed air supply • Centralised power generation technologies (steam power plants, gas and steam turbine power plants, • utilisation of renewable energies, combined heat and power generation) <u>Industrial Energy Management:</u> • Introduction (basic terms, load curves, energy management and its components) • Energy management according to DIN EN ISO 50001 • Operational demand and energy savings • Technical and economic evaluation of energy supply systems (conventional, CHP, renewable energies) • German electricity and natural gas market • Electricity and gas procurement (full supply contracts, portfolio management)
Connection to other modules	none
Literature	<u>Energy Technologies:</u> • Richard Zahoransky: Energy technology: Systems for conventional and renewable energy conversion, Springer 2019 <u>Industrial Energy Management</u> • Panos, K.: Praxisbuch Energiewirtschaft, Energieumwandlung, -transport und -beschaffung im liberalisierten Markt, Springer, 2013 • DIN EN ISO 50.001 Energy management systems - Requirements with guidance for use (ISO 50001:2011) • Geilhausen, M.; Bränzel, J.; Engelmann, E.; Schulze, O.: Energiemanagement: Für Fachkräfte, Beauftragte und Manager, Springer, 2015
Workload	It is expected that the students, in addition to the 4 x 15 = 60 SWS attendance time and 90 h for preparation and follow-up work, take time for independent literature study, work on exercises and prepare for the exam.
Miscellaneous	--

Keywords	Energy Technology, Energy Management, Energy Saving
Last change	January 2024

BNRE2520: SUSTAINABILITY MANAGEMENT AND LIFE CYCLE ASSESSMENT

Sustainability Management and Life Cycle Assessment	
Module ID	BNRE2520
Semester	4
Credits	9
SWS	6
Frequency	in the summer semester
Associated courses	BNRE2521 - LCA and Material Flow Analyses (3 ECTS) AQM2140 - Software and Databases for Sustainability and Resource Efficiency (3 ECTS) BNRE2512 - CSR and Sustainability Management (3 ECTS)
Prerequisites	none
Exam type / duration	PLL/PLP/PLR CSR and Sustainability Management: PLK (90 minutes)
Requirement for granting of credits	Passing the respective examinations
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 9 The module grade is determined (even if the number of credits for the courses differs) on an equal basis (mean value or equal number of achievable points).
Planned group size	max. 50 students
Language	German CSR and Sustainability Management: English
Module duration	1 semester
Module coordinator	Prof Dr Hendrik Lambrecht
Lecturers	Prof Dr Hendrik Lambrecht (LCA and Material Flow Analyses as well as Software and Databases for Sustainability and Resource Efficiency) Prof Dr Tobias Viere (Software and Databases for Sustainability and Resource Efficiency) and CSR and Sustainability Management)
Subject area	Sustainability and resource efficiency
Applicability in other programs / modules	none
Pedagogical approach	Lectures, exercises, laboratory
Objectives	The students... • have deepened their knowledge of a selected analysis method (LCA, material flow cost accounting, energy and material flow analysis) by applying it to given or self-selected problems • learn to document and communicate their own research results according to scientific standards (reproducible, comprehensible).

	• know important software tools for problem solving in the field of resource efficiency management and their fields of application • can use the tools independently for simple tasks and questions • understand the business context of environmental and sustainability issues, in particular corporate social responsibility and sustainability management and their theoretical foundation • know important concepts and tools in this subject area, in particular environmental management systems, material flow cost accounting and sustainability communication The module contributes to the achievement of the following competences: Broadening knowledge, deepening knowledge, utilisation and transfer, communication and cooperation, scientific self-conception/professionalism

Contents	<u>LCA and Material Flow Analyses</u>
	New seminar topics assigned each semester from the following areas
	• LCA
	• Energy and material flow analyses (both at macroeconomic and operational level)
	• Material flow cost accounting
	
	<u>Software and Databases for Sustainability and Resource Efficiency</u>
	The focus here is on the use of IT.
	• In order to deepen the knowledge from the two other courses in the module and to link it to the subject area of lean, practice-orientated tasks are solved with the support of common software.
	• In particular, Excel, Visio, e!Sankey and Umberto are used.
	
	<u>CSR and Sustainability Management</u>
	• Reasons for companies to address environmental and sustainability issues
	• References to stakeholder theory and business ethics
	• Historical development of CSR and sustainability management
	• Important instruments and concepts
	  ○ Environmental management systems
	  ○ Environmental accounting incl. material flow cost accounting
	  ○ Sustainability reporting and communication
	  ○ Sustainable Entrepreneurship
	  ○ Other methods

Connection to other modules	none
Literature	<u>LCA and Material Flow Analyses</u> • Depending on the topic: will be announced in the course <u>Software and Databases for Sustainability and Resource Efficiency</u> Relevant tutorials for software applications are provided in the course

	CSR and Sustainability Management • Sanders, N. R., & Wood, J. D. (2019). Foundations of sustainable business: Theory, function, and strategy. John Wiley & Sons • ISO 14001: Environmental Management Systems • ISO 14051: Material Flow Cost Accounting • IFAC (2004): International Guidelines on Environmental Management Accounting (EMA) • Schneider, A., & Schmidpeter, R. (2012). Corporate social responsibility. Springer Berlin Heidelberg
Workload	It is expected that the students, in addition to the 6 x 15 = 90 SWS attendance time and 180 h for preparation and follow-up work, take time for independent literature study, work on exercises and prepare for the exam.
Miscellaneous	Work on the PC is possible in groups of max. 2 people. In any case, the module should also include individual work on the PC to ensure that all participants acquire modelling and IT skills. CSR and Sustainability Management is offered exclusively in English. The credits earned count towards the existing 30-credit requirement for the degree programme.
Keywords	Sustainability and Resource Efficiency, CSR, LCA, Material Flow Analysis
Last change	January 2024

LAW3200: LEGAL ASPECTS OF ENVIRONMENTAL PROTECTION

Legal Aspects of Environmental Protection	
Module ID	LAW3200
Semester	6
Credits	5
SWS	4
Frequency	every semester
Associated courses	LAW3201 - Legal Aspects of Environmental Protection
Prerequisites	Completed first stage of studies
Exam type / duration	PLK/PLH/PLM (60 minutes)
Requirement for granting of credits	Passing the examinations
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 5
Planned group size	max. 50 students
Language	German
Module duration	1 semester
Module coordinator	Prof Dr Tobias Brönneke
Lecturers	Prof Dr Tobias Brönneke Dr Rüdiger Herpich
Subject area	Law
Applicability in other programs / modules	none
Pedagogical approach	Lecture with exercises
Objectives	The students... • recognize legal issues at the interface with the business and technical management of sustainability and resource efficiency • have an initial overview of the most important German and European environmental regulations • can distinguish between what the law requires of a citizen/company (substantive legal requirements) and the instruments it provides for the implementation of these requirements and with which the authorities ensure compliance with the law. • know practical aspects of environmental protection and resource conservation • are able to engage in a solution-orientated exchange with environmental law specialists or lawyers on the legal problems in the context of managing sustainability and resource efficiency and to contribute adequately to the appropriate resolution of the issues. <u>Critical thinking and analytical skills</u> Students are able to apply analytical skills constructively and critically to problems.

	<u>Communication skills</u> Students are able to express complex issues in clear written form. The module contributes to the achievement of the following competences: Broadening knowledge, deepening knowledge, understanding knowledge, utilisation and transfer, communication and cooperation, scientific self-image/professionalism
Contents	• Environmental law: Introduction, objectives, principles and systematics, legal sources of environmental law • Instruments of the environmental administration: plant authorisation, ancillary provisions and orders, operating bans, discretionary powers • Legal protection in environmental law • Immission control law • Circular economy and waste law • Operational framework for the implementation of resource efficiency • Material flow management in the context of resource efficiency: REACH, GHS/CLP, dangerous goods legislation, ProdHaftG, KrWG • Production and handling of hazardous substances / products • Implementation of regulations on resource efficiency and sustainability • Global industry standards, norms and management systems for quality / environmental protection / energy: ISO9001, 14001, 50001 (EMAS) and their relationship to national, European and international law • Resource efficiency in practice: industrial promotion, examples of implementation
Connection to other modules	The module builds on: LAW1010 (Law I), LAW1200 (Law II), BNRE1112 (Industrial Resource Efficiency) and BNRE2111 (Industrial Ecology and Sustainability)
Literature	• Nomos: Public law (legal texts) • Supplementary printed legal texts as necessary working material • Erbguth/Schlacke: Environmental Law, latest edition • Oberrath: Public law or • Detterbeck: Public Law. - latest edition - Scripts of the two sub-courses can be found on the E- Learning platform
Workload	It is expected that the students, in addition to the 4 x 15 = 60 SWS attendance time and 90 h for preparation and follow-up work, do independent literature study, work on exercises and prepare for the exam.
Miscellaneous	The module can also be completed as part of an equivalent course during a semester abroad.
Keywords	Environmental law
Last change	November 2021

BNRE3110: MARKETS AND THE ECONOMICS OF NATURAL RESOURCES

Markets and the Economics of Natural Resources	
Module ID	BNRE3110
Semester	6
Credits	5
SWS	4
Frequency	every semester
Associated courses	BNRE3111 - Markets and the Economics of Natural Resources
Prerequisites	Completed first stage of studies
Exam type / duration	PLK/PLH - 90 minutes
Requirement for granting of credits	Passing the examination
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 5
Planned group size	max. 50 students
Language	English
Module duration	1 semester
Module coordinator	Prof Dr Jürgen Antony
Lecturers	Prof Dr Jürgen Antony
Subject area	Economics
Applicability in other programs / modules	none
Pedagogical approach	Lecture with exercises
Objectives	The students... • know the most important commodity markets (including secondary raw materials and energy) and how they work, • are able to track and assess commodity prices on the global markets, • know the basic principles of resource economics • are familiar with resource policy options (operational, macroeconomic) and can reflect on them critically. The module contributes to the achievement of the following competences: Deepening knowledge, understanding knowledge, utilisation and transfer, scientific self-conception/professionalism
Contents	<u>Commodity markets</u> • Functionality of LMX, EEX, CME, MCX etc. • Price trends and influencing factors within the raw materials and energy industry • Relocation effects (e.g. BTL) • Forecasts • Public goods, Tragedy of the Commons, external effects, resource allocation, Coase Theorem, Pigouvian taxes, Hotelling Rule, Hartwick Rule, Jevons and rebound effects, UGR

	<u>Raw materials policy</u> • Operational risk management • Political options and players
Connection to other modules	none
Literature	• Baker, R. P. (2010): The Trade Lifecycle: Behind the Scenes of the Trading Process (Wiley Finance) • Clark, E. et al. (2001): International Commodity Trading: Physical and Derivative Markets (Wiley Trade Series) • Conrad, J. (2011): Resource Economics. Cambridge University Press • OECD (2012): Sustainable Materials Management: Making Better Use of Resources, Paris • Perman, R. et al. (2011): Natural Resource and Environmental Economics, Pearson
Workload	4 x 15 SWS = 60 SWS attendance time plus 90 h for preparation and follow-up work, independent literature study, working on case studies and exercises and exam preparation
Miscellaneous	The module can also be completed as part of an equivalent course during a semester abroad. The module is offered exclusively in English as part of the International Study Program. The credits earned count towards the existing 30-credit requirement for the degree program.
Keywords	Resource Economics, Resource Markets, Scarcity, Risk Management, Resource Policy, Sustainable Development, Non-renewable Resources
Last changes	January 2024

BNRE3210: ELECTIVES: SUSTAINABILITY AND RESOURCE EFFICIENCY

Electives: Sustainability and Resource Efficiency	
Module ID	BNRE3210
Semester	6
Credits	6
SWS	4
Frequency	every semester
Associated courses	BNRE3211 - Technology and Innovation Management (3 ECTS) BNRE3212 - Seminar Lean Management (3 ECTS) BNRE3213 - Industrial Change Management (3 ECTS) BNRE3214 - Renewable Energies (3 ECTS) BNRE3215 - Sustainable Innovation Camp (3 ECTS) IDS3010 - Interdisciplinary Studies (3 ECTS) Alternative courses or WPFs from other degree programs possible.
Prerequisites	Completed first stage of studies
Exam type / duration	Technology and Innovation Management: PLK/PLH/PLR 60 minutes Seminar Lean Management: PLR/PLP/PLH Change management in industry: PLK/PLH 60 minutes Renewable energies: PLH/PLR Sustainable Innovation Camp: PLP+PLR 60 minutes Interdisciplinary studies depending on the specific crediting
Requirement for granting of credits	Passing the respective examinations. WPF courses amounting to a total of 6 credits must be successfully completed.
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 6
Planned group size	max. 30 students
Language	Depending on the chosen program: German or English
Module duration	1 semester
Module coordinator	Prof Dr Frank Bertagnolli
Lecturers	Prof Dr Claus Lang-Koetz (Technology and Innovation Management and Sustainable Innovation Camp) Prof Dr Frank Bertagnolli (Seminar Lean Management and Industrial Change Management) Prof Dr Ingela Tietze (Renewable Energies) Various lecturers (Interdisciplinary Studies)
Subject area	Sustainability and Resource Efficiency

Applicability in other programs/modules	Individual WPF courses can also be taken as part of other degree programs
Pedagogical approach	Lecture with exercises / seminar / project
Objectives	The WPF module is intended to offer students the opportunity to set an individual, degree program-related focus. The objectives vary depending on the WPF program: <u>Technology and Innovation Management</u> Students learn the basics of technology and innovation management and their significance for companies. They learn how to apply selected methods using simple practical problems. <u>Seminar Lean Management</u> Students are able to independently research, develop and present a complex, practically relevant topic. They can process literature and systematize and incorporate practical experience. They are familiar with the basics and also with some details from the field of lean management and recognize the transfer in practice. <u>Industrial Change Management</u> Students know why changes take place, why they are necessary and why they are normal. They are familiar with the process of change and its accompanying symptoms and background and can categorize the topic of change management in the context of their studies and future field of work. Students know the most important starting points and obstacles within change management. They know management tools and methods for the successful planning and internal implementation of change. They also reflect on themselves in the context of change and further develop their personality. <u>Renewable Energies</u> Students learn about the economic and technical principles of utilising renewable energies. They are able to evaluate locations with regard to the use of different technologies. They will be able to develop site-specific rough concepts and evaluate them technically, economically and ecologically. <u>Sustainable Innovation Camp</u> Students learn the concepts of design thinking, business model development and methods for developing sustainability-orientated innovations. Using these, they develop their own business idea and a suitable business model in a "camp format". Alternatively, they further develop a business idea from a business partner. <u>Interdisciplinary studies</u> Students are able to carry out an interdisciplinary project on a challenging topic independently and as part of a team, which requires social interaction as well as methodological skills. In addition to instrumental competence, the focus is also on systemic competence. The module contributes to the achievement of the following competences: Broadening knowledge, deepening knowledge, understanding knowledge, utilisation and transfer, scientific innovation, communication and cooperation, scientific self-image/professionalism

Contents	The content of the courses is based on the common topics of the respective subjects and, in addition to the basics, should always convey instruments and demonstrate their use using practical examples.
Connection to other modules	Compulsory elective subjects in a cluster with other business administration subjects
Literature	Technology and Innovation Management • Vahs, D.; Brem, A. (2013): Innovationsmanagement - Von der Idee zur erfolgreichen Vermarktung, 4th edition, Schäffer-Poeschel Verlag. • Spath, D. et al: Technologiemanagement. Grundlagen, Konzepte, Methoden, Fraunhofer Verlag. Seminar Lean Management • Bertagnolli (2020) Lean Management. Springer Gabler. Industrial Change Management • Bertagnolli et al (2018) Change Canvas. Springer Gabler. • Kruse (2004) next practice. Successful management of instability. Gabal. • Regber and Zimmermann (2001): Change management in production: Improving processes efficiently as a team. Modern industry. • John P. Kotter (2011): Leading Change (German edition). Vahlen. • Doppler et al. (2011): Corporate change against resistance: Change management with people. Campus. • Lauer (2010): Change Management: Fundamentals and success factors. Springer. Renewable Energies • Kaltschmitt, Martin, Streicher, Wolfgang, Wiese, Andreas (2020): Renewable energies. Springer • Quaschning, Volker (2020): Renewable energies and climate protection. Carl Hanser Sustainable Innovation Camp Plattner, Hasso; Meinel, Christoph, Weinberg, Ulrich (2009): Design-Thinking, mi-Wirtschaftsbuch, Munich Alexander Osterwalder, Yves Pigneur, Greg Bernarda, Alan Smith (2015): Value Proposition Design, Campus Verlag, Frankfurt/New York Osterwalder, Alexander and Pigneur, Yves (2010) Business Model Generation, Campus Verlag, Frankfurt/New York. Interdisciplinary studies Depending on the specific subject area
Workload	2 x 15 SWS = 30 SWS attendance time, plus 60 hours each for preparation and follow-up work, independent study of literature, working on case studies and exercises and exam preparation
Miscellaneous	The module or an individual course of the module can also be completed as part of a semester abroad. Modules or courses related to the study programme specialisation are eligible for recognition. English-language courses within the module are offered as part of the International Study Program (ISP). The credits earned

	count towards the existing 30-credit requirement for the degree program.
Keywords	Sustainability and resource efficiency, practical applications, interdisciplinarity
Last change	January 2024

BNRE4110: SEMINAR SUSTAINABILITY AND RESOURCE EFFICIENCY

Seminar Sustainability and Resource Efficiency	
Module ID	BNRE4110
Semester	7
Credits	7
SWS	2
Frequency	every semester
Associated courses	BNRE4011 - Seminar Sustainability and Resource Efficiency
Prerequisites	Completed first stage of studies
Exam type / duration	PLH/PLR/PLP
Requirement for granting of credits	Passing the examinations
Significance for final grade	The module is weighted with its credits in the Bachelor's final grade. Weighting according to credits = 8
Planned group size	max. 30 students
Language	German
Module duration	1 semester
Module coordinator	Prof Dr Claus Lang-Koetz
Lecturers	Prof Dr Claus Lang-Koetz Prof Dr Jörg Woidasky
Subject area	Sustainability and Resource Efficiency
Applicability in other programs / modules	none
Pedagogical approach	Seminar
Objectives	The students... • are able to independently develop and present a complex technical and economic topic on sustainability and resource efficiency, • can process scientific literature and/or systematise and incorporate (possibly indirect) practical experience, • are familiar with the basics and also with some details from the areas of production organisation, sustainability and resource efficiency, • can independently carry out analyses in the context of sustainability and resource efficiency and derive conclusions, • have all the prerequisites for writing a thesis. The module contributes to the achievement of the following competences: Deepening knowledge, understanding knowledge, utilisation and transfer, scientific innovation, communication and cooperation, scientific self-image/professionalism

Contents	In the NRE seminar, students work independently on a technical and business management topic relating to sustainability and resource efficiency under the guidance of the lecturer. Students carry out specialist research and independently analyse and work on a given topic from science and/or practice ("research and practice topic").
Connection to other modules	The module builds on BNRE3210 (WPF Efficiency in Practice)
Literature	Depending on the respective topics and content
Workload	2 x 15 SWS = 30 SWS attendance hours plus 210 h preparation and follow-up work including literature study and the preparation and presentation of a case study or presentation
Miscellaneous	The module is offered as a block in the 7th semester within the first 6 or 7 weeks of lectures
Keywords	Seminar, Sustainability and Resource Efficiency
Last change	January 2024