HS PF

MODULE HANDBOOK

COURSE OF STUDY FOCUS

BW /
SUSTAINABILITY AND RESOURCE EFFICIENCY

B. Sc.

Status: November 2021

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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)

Competence model - matrix of competence goals according to KMK Qualification framework for German university degrees
Study program modules BNRE

Modules	Knowledge and understanding			Use, application and generation of knowledge		Connumication and Cooperation	Scientific Self-Image and Professionalism
	Knowledge enlargement	Knowledge-consolidation	Knowledge understanding	Use and transfer	Scientific inno-vation		
BNRE1110	X		X				
BNRE2110	X	X	X				
BNRE2210	X		X				
BNRE2310	X	X	X	X		X	
BNRE2410	X	X	X	X		X	
BNRE2510	X	X		X		X	
LAW3200	X	X	X	X		X	X
BNRE3110		X	X	X			X
BNRE3210	/*	/*	/*	/*	/*	X	/*
BNRE4110		X	X	X	X	X	X

*) depending on the chosen combination of the two elective subjects.

Second stage of study - modules specific to the course of study

BNRE1110 – Sustainability and Resources 1

Sustainability and Resources 1	
Module ID	BNRE1110
Semester	2
Credits	5
Level	Beginner
SWS	4
Frequency	Every summer semester
Associated courses	Climate and Environmental Protection (3 ECTS) Industrial Resource Efficiency (2 ECTS)
Prerequisites	none
Assessment Methods and duration	PLR/PLK – 60 minutes
Requirements for granting of credits	Passing the examination performance
Significance for the Final Grade	The module is weighted with its credits in the Bachelor final grade. Weighting according to credits = 5 The module grade is determined by equal distribution (even if the ECTS of the respective courses differ; mean value or equal number of achievable points).
Planned group size	max. 50 students
Language	German
Module Duration	1 Semester
Module Coordinator	Prof. Dr. Mario Schmidt
Lecturer(s)	Prof. Dr. Claus Lang-Koetz (Climate and Environmental Protection) Prof. Dr. Mario Schmidt (Industrial Resource Efficiency)
Subject area / course of study	Sustainability and Resource Efficiency
Pedagogical Approach	Lecture with exercises
Applicability in other programs	none
Objectives	The students... • understand the basics of climate change. • have an overview of the social and ecological consequences of climate change. • understand other important environmental problem areas, their scientific and their societal implications. • know important climate and environmental protection measures. • know the essential starting points for the careful use of energy and raw materials in production.

	• are familiar with a cross-section of different production companies and industries. • know the concept of resource efficiency and the most important publications on it.
Content	<u>Climate and environmental protection:</u> • Fundamentals of climate change • Social and ecological impacts of climate change • Causes and impacts of other environmental problems • Fundamentals of climate and environmental protection <u>Operational resource efficiency:</u> • Introduction to the topic of resource efficiency from the viewpoint of industrial production • Examples and starting points for resource-saving production in the economy • Possibilities for saving energy and raw materials in production processes
Relation to other modules	The module is the basis for all other course-specific modules in the study program.
Workload	In addition to the 4 x 15 = 60 SWS attendance time, students are expected to spend an additional 90 h for preparation and post-processing, independent literature study, processing of exercise cases and exam preparation
Literature	<u>Climate and Environmental Protection:</u> • BMU, BMBF, and DE-IPCC UBA. "Fünfter Sachstandsbericht des IPCC Teilbericht 1 (Wissenschaftliche Grundlagen)." (2015). • Heinrichs & Michelsen (Hrsg.): Nachhaltigkeitswissenschaften. Teil III: Naturwissenschaftliche Perspektiven. Springer-Verlag, 2014. • Steffen, Will, et al. "Planetary boundaries: Guiding human development on a changing planet." Science 347.6223 (2015). Latest edition in each case unless otherwise stated. <u>Operational resource efficiency:</u> • Schmidt et al. (2017/2019): 100 Betriebe für Ressourceneffizienz. Springer-Verlag Latest edition in each case unless otherwise stated.
Additional Remarks	-
Keywords	Industrial Resource Efficiency, Climate and Environmental Protection
Last edited	November 2021

BNRE2110 – Sustainability and Resources 2

Sustainability and Resources 2	
Module ID	**BNRE2110**
Semester	3
Level	Advanced
Credits	6
SWS	4
Frequency	Every winter semester
Associated courses	Industrial Ecology and Sustainability (3 ECTS) Raw materials and resources (3 ECTS)
Prerequisites	none
Assessment Methods and duration	PLH/PLK – 90 minutes
Requirements for granting of credits	Passing the examination performance
Significance for the Final Grade	The module is weighted with its credits in the Bachelor final grade. Weighting according to credits = 6 The module grade is determined by equal distribution (even if the ECTS of the respective courses differ; mean value or equal number of achievable points).
Planned group size	max. 50 students
Language	German
Module Duration	1 semester
Module Coordinator	Prof. Dr. Mario Schmidt
Lecturer(s)	Prof. Dr. Hendrik Lambrecht (Industrial Ecology and Sustainability) Prof. Dr. Mario Schmidt (Raw Materials and Resources)
Subject area / course of study	Sustainability and Resource Efficiency
Pedagogical Approach	Lecture
Applicability in other programs	none
Objectives	The students… • can classify and critically reflect on the concept of resource efficiency in the context of sustainability and industrial ecology. • know the historical, societal, and business significance of the environment 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 metastrategies of Industrial Ecology (circular economy, dematerialization, detoxification) and the central analytical 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 major commodity groups and raw materials that are important in production and are currently being discussed in the context of resource criticality (e.g., copper, aluminum, rare earths, gold, tantalum, phosphorus). • know the origin, the market situation, shortages and the importance for the addressed raw materials for future technologies. • know how selected future technologies work and how they are applied in products. • learn concepts for evaluating the scarcity of raw materials such as criticality.
Inhalt	<u>Industrial Ecology and Sustainability</u> • Introduction to Industrial Ecology (material flow analyses, input/output) • Eco- and resource efficiency • Basics of sustainability • Introduction to Life Cycle Thinking methods <u>Raw materials and resources</u> • The lecture gives an overview of raw material groups and selected individual raw materials that are of great importance for production and are currently discussed in the context of resource criticality (e.g. copper, aluminum, rare earths, gold, tantalum, phosphorus). • To this end, concepts for evaluating scarcity are presented. • Corresponding applications in technologies or products are presented for the respective raw materials.
Relation to other modules	none
Workload	In addition to the 4 x 15 = 60 SWS attendance time, students are expected to spend an additional 90 h for preparation and post-processing, independent literature study, processing of exercise cases and exam preparation.
Literature	<u>Industrial Ecology and Sustainability</u> • Heinrichs, H.; Michelsen, G. (Hrsg.) (2014) Nachhaltigkeitswissenschaften. Springer Spektrum, Berlin, Heidelberg • Graedel, Allenby (2010) Industrial Ecology and Sustainable Engineering. Pearson, Upper Saddle River • Ayres, Ayres (Hrsg.) (2002) A Handbook of Industrial Ecology. Edward Elgar, Northampton • Klöpffer, W., Grahl, B. (2009) Ökobilanz (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 Communication (2011): Materials critical to the energy industry. An introduction • Angerer, G. et al. (2009): Rohstoffe für Zukunftstechnologien, Einfluss des branchenspezifischen Rohstoffbedarfs in rohstoffintensiven Zukunftstechnologien auf die zukünftige

	Rohstoffnachfrage. 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
Additional Remarks	-
Keywords	Resource Efficiency, Industrial Ecology, Sustainability, Raw Materials, Resources
Last edited	November 2021

BNRE2210 – Technologies 1

Technologies 1	
Module ID	**BNRE2210**
Semester	3
Level	Advanced
Credits	6
SWS	4
Frequency	Every winter semester
Associated courses	Fundamentals of Natural Sciences (3 Credits) Production Engineering (3 Credits)
Prerequisites	none
Assessment Methods and duration	PLK – 90 minutes
Requirements for granting of credits	Passing the examination performance
Significance for the Final Grade	The module is weighted with its credits in the Bachelor final grade. Weighting according to credits = 6 The module grade is determined by equal distribution (even if the ECTS of the respective courses differ; 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
Lecturer(s)	Prof. Dr. Hendrik Lambrecht (Fundamentals of Natural Sciences) Prof. Dr. Claus Lang-Koetz (Production Engineering)
Subject area / course of study	Sustainability and Resource Efficiency
Applicability in other programs	none
Pedagogical Approach	Lecture
Objectives	The students... • are familiar with the central scientific concepts and principles, especially in the fields of mechanics, thermodynamics, electricity and inorganic chemistry. • are familiar with the concept of energy or energy conservation and understand the most important principles of conversion between different forms of energy. • know how matter is built up and know the basic principles of (chemical) matter conversion. • can apply this knowledge to practical problems in the environment and technology. • know the basic concepts and terms of manufacturing technology and manufacturing organization.

	• know the most important properties of the materials iron and steel. • can balance production processes in low complexity and create Sankey diagrams. • are familiar with the most important manufacturing processes in the areas of forming, shaping and metal-cutting processes.
Content	<u>Fundamentals of Natural Sciences</u> • Introduction, basic tools • Mechanics • Thermodynamics • Electromagnetism • Matter Structure <u>Production Engineering</u> • Introduction and overview of production engineering • Basic principles of production organization • Properties of iron and steel materials • Introduction to the accounting of production processes • Primary forming from the liquid state (casting): Casting production with lost mold and permanent mold. Casting defects and their prevention • Forming: Solid forming, sheet metal forming. • Cutting processes: Cutting with geometrically determined and undetermined cutting edge, cutting by ablation.
Relation to other modules	none
Literatur	<u>Fundamentals of Natural Sciences</u> • Harten, U.: Physik. Eine Einführung für Naturwissenschaftler und Ingenieure. Springer, Heidelberg u.a. (E-book!) • Povh, B.: Anschauliche Physik für Naturwissenschaftler. Springer, Heidelberg. • Tipler, P. A.; G. Mosca: Physik für Wissenschaftler und Ingenieure. 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	In addition to the 4 x 15 = 60 SWS attendance time, students are expected to spend an additional 120 h for preparation and post-processing, independent literature study, processing of exercise cases and exam preparation
Additional Remarks	-
Keywords	Natural Sciences, Production Engineer
Last edited	November 2021

BNRE2310 – Technologies 2

Technologies 2	
Module IS	BNRE2310
Semester	4
Level	Advanced
Credits	5
SWS	4
Frequency	Every summer semester
Associated courses	Environmental Technologies (2 Credits) Energy Technologies (3 Credits)
Prerequisites	none
Assessment Methods and duration	PLK/PLH/PLR– 120 minutes
Requirements for granting of credits	Passing the examination performance
Significance for the Final Grade	The module is weighted with its credits in the Bachelor final grade. Weighting according to credits = 5 The module grade is determined by equal distribution (even if the ECTS of the respective courses differ; 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
Lecturer(s)	Prof. Dr. Claus Lang-Koetz (Environmental Technologies) Prof. Dr. Ingela Tietze (Energy Technologies)
Subject area / course of study	Sustainability and Resource Efficiency
Applicability in other programs	none
Pedagogical Approach	Lecture with exercises
Objectives	The students... • know selected basic operations (Unit Operations) of environmental engineering. • understand individual process combinations of basic operations in environmental engineering. • are familiar with the structures of environmental engineering systems and master their basic design. • are familiar with theoretical and practical aspects of selected environmental techniques and are able to make practical reference to these techniques. • are able to build simple models for environmental issues and processes and to carry out corresponding balancing simulation calculations. • know the thermodynamic basics of energy conversion and the corresponding terminology. • know the relevant technical systems for energy conversion and supply, (both conventional (fossil) and renewable).

	• can independently perform basic calculations for the design and evaluation of energy conversion systems. • are able to compare energy conversion technologies from different points of view (technical, economic and ecological). • understand the connection between energy engineering 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.
Content	<u>Environmental Technology</u> • Introduction and overview environmental technology • Exhaust air treatment • Formation of gaseous emissions • Design and operation of selected processes for the treatment of exhaust gases • Simple modeling for balancing mass and energy flows for concepts to solve environmental engineering problems. • Presentation of resource-efficient concepts for the reduction and avoidance of emissions • Wastewater treatment • Waste water generation • Structure and mode of operation of individual selected processes for the treatment of wastewater • Treatment of special pollutants • Industrial wastewater treatment overview <u>Energy Technologies</u> • Thermodynamic basics • Steam generator and heat exchanger • Cold supply • Compressed air supply • Central technologies for electricity generation (steam power plants, gas and steam turbine power plants, • Use of renewable energies, combined heat and power generation)
Relation to other modules	none
Literatur	<u>Environmental Technology</u> Textbooks: • K. Schwister et. al., Taschenbuch der Umwelttechnik, Fachbuchverlag Leipzig im Carl Hanser Verlag, 2003 • Hans Dieter Janke, Umweltbiotechnik, UTB GmbH, Stuttgart, 2008 • Wilhelm Hosang, Wolfgang Bischof, Abwassertechnik, B. G. Teubner, Stuttgart, Leipzig, 1998 • Heinz Brauer, Handbuch des Umweltschutzes und der Umwelttechnik, Band 3: Additiver Umweltschutz: Behandlung von Abluft und Abgasen, Springer, 1996 • Franz Joos, Technische Verbrennung, Springer, 2006 • Charles E. Baukal, Jr., The John Zink Combustion handbook, CRC Press, 2000 • Ulrich Förstner, Umweltschutztechnik, Springer, 2004 • Michael Schultes, Abgasreinigung, Springer, 1996 • Michael F. Jischa, Studium der Umweltwissenschaften, Springer, 2004 • Stanley E. Manham, Environmental Science and Technology, Second Edition, Taylor & Francis Group, 2007

	• H. D. Baehr, S. Kabelac, Thermodynamik, Grundlagen und technische Anwendungen, 15. Auflage, Springer, 2012 • M. Kraume, Transportvorgänge in der Verfahrenstechnik, Grundlagen und apparative Umsetzungen, 2. Auflage, Springer, 2012 In-depth/substance data: • VDI-Wärmeatlas, Herausgeber: Verein Deutscher Ingenieure, VDI-Gesellschaft Verfahrenstechnik und Chemieingenieurwesen (GVC), 10. Auflage, Springer, 2006 • http://webbook.nist.gov/chemistry/ <u>Energy Technologies</u> • Richard Zahoransky: Energietechnik: Systeme zur konventionellen und erneuerbaren Energieumwandlung, Springer 2019
Workload	In addition to the 4 x 15 = 60 SWS attendance time, students are expected to spend an additional 90 h for preparation and follow-up, independent literature study, processing of exercise cases and exam preparation.
Additional Remarks	-
Keywords	Environmental Technologies, Energy Technologies, power generation, heat supply, refrigeration plants
Last edited	November 2021

BNRE2410 – Lean and Energy Management

Lean and Energy Management	
Module ID	BNRE2410
Semester	4
Level	Advanced
Credits	5
SWS	4
Frequency	Every summer semester
Associated courses	Lean Production (3 Credits) Industrial Energy Management (2 Credits)
Prerequisites	none
Assessment Methods and duration	PLK/PLH/PLR – 90 minutes
Requirements for granting of credits	Passing the examination performance
Significance for the Final Grade	The module is weighted with its credits in the Bachelor final grade. Weighting according to credits = 5 The module grade is determined by equal distribution (even if the ECTS of the respective courses differ; mean value or equal number of achievable points).
Planned group size	max.50 students
Language	German
Module Duration	1 semester
Module Coordinator	Prof. Dr. Frank Bertagnolli
Lecturer(s)	Prof. Dr. Frank Bertagnolli (Lean Production) Prof. Dr. Ingela Tietze (Industrial Energy Management)
Subject area / course of study	Sustainability and Resource Efficiency
Applicability in other programs	none
Pedagogical Approach	Lecture with exercises
Objectives	The students... • know the history, approaches and interrelationships of the Toyota Production System as well as other holistic 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 Production on the productivity of a company as well as the goals that derive from it for managers. • were confronted with corresponding management approaches. • know the concept of energy management systems according to DIN EN ISO 50.001 and can explain strengths and weaknesses.

	• can classify the operational energy demand by determining relevant key figures. • are able to identify typical energy saving potentials and develop solutions for them. • are familiar with common approaches to operational energy self-sufficiency and can evaluate them economically and technically. • know the central energy markets and their pricing mechanisms. • Understand energy procurement requirements and be able to develop and evaluate appropriate procurement models based on demand characteristics.
Content	<u>Lean Production</u> • Introduction • Waste • Flow, cycle time, pull • Value stream mapping • Perfection • Standardization • Continuous improvement • Supply Logistics • Production area assembly • Production area manufacturing • Lean and production systems <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 power supply plants (conventional, CHP, renewable energies) • German electricity and natural gas market • Electricity and gas procurement (full supply contracts, portfolio management)
Relation to other modules	none
Literature	<u>Lean Production</u> • Bertagnolli, F.: Lean Management (2020). Springer Gabler • Ohno, T.: Das Toyota-Produktionssystem. Campus • Womack, J.P., Jones, D.T.: Lean Thinking: Ballast abwerfen, Unternehmensgewinn steigern. Campus • Rother, M., Shook, J.: Sehen Lernen: Mit Wertstromdesign die Wertschöpfung erhöhen und Verschwendung beseitigen. Lean Management Institut • Takeda, H.: Das Synchrone Produktionssystem. Vahlen <u>Industrial Energy Management</u> • Panos, K.: Praxisbuch Energiewirtschaft, Energieumwandlung, -transport und -beschaffung im liberalisierten Markt, Springer, 2013 • DIN EN ISO 50.001 Energiemanagementsysteme – Anforderungen mit Anleitung zur Anwendung (ISO 50001:2011) • Geilhausen, M.; Bränzel, J.; Engelmann, E.; Schulze, O.: Energiemanagement: Für Fachkräfte, Beauftragte und Manager, Springer, 2015

Workload	In addition to the 4 x 15 = 60 SWS attendance time, students are expected to spend an additional 90 h for preparation and follow-up, independent literature study, processing of exercise cases and exam preparation.
Additional Remarks	-
Keywords	Energy Management, Energy Saving, Lean Production, Lean Management
Last edited	November 2021

BNRE2510 – Sustainability and Resources 3

Sustainability and Resources 3	
Module ID	BNRE2510
Semester	4
Level	Advanced
Credits	9
SWS	6
Frequency	Every summer semester
Associated courses	LCA and Material Flow Assessments (3 credits) CMM in Resource Efficiency Management (3 credits) CSR and Sustainability Management (3 credits)
Prerequisites	none
Assessment Methods and duration	PLL/PLH/PLR BNRE2512 PLK (90 minutes)
Requirements for granting of credits	Passing of the respective examination performances
Significance for the Final Grade	The module is weighted with its credits in the Bachelor final grade. Weighting according to credits = 9 The module grade is determined by equal distribution (even if the ECTS of the respective courses differ; 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
Lecturer(s)	Prof. Dr. Hendrik Lambrecht (LCA and Material Flow Assessments as well as CMM in Resource Efficiency Management) Prof. Dr. Tobias Viere (CMM in Resource Efficiency Management as well as CSR and Sustainability Management)
Subject area / course of study	Sustainability and Resource Efficiency
Applicability in other programs	none
Pedagogical Approach	Lectures, exercises, laboratory
Objecitves	The students… • have deepened their knowledge of a selected analysis method (LCA, material flow costing, energy and material flow analysis) by applying it to given or self-selected problems. • learn to document or 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 field, especially environmental management systems, material flow cost accounting and sustainability communication.

Content	<u>LCA and Material Flow Assessments</u>
	New seminar topics assigned each semester in the areas of.
	• LCA
	• Energy and material flow analyses (both at macroeconomic and operational level)
	• Material Flow Cost Accounting
	
	<u>CMM in Sustainability and Resource Efficiency</u>
	• The focus here is on IT deployment.
	• To deepen the knowledge from the other two courses of the module and to link it to the topic area of Lean, practice-oriented 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 tools and concepts
	  ○ Environmental management systems
	  ○ Environmental accounting incl. material flow cost accounting
	  ○ Sustainability reporting and communication
	  ○ Sustainable Entrepreneurship
	  ○ More methods

Relation to other modules	none
Literature	<u>LCA and Material Flow Assessments</u> • Depending on the topic: will be announced in the course <u>CMM in Resource Efficiency Management</u> The course will provide relevant tutorials for software applications <u>CSR and Sustainability Management</u> • 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	In addition to the 6 x 15 = 90 SWS attendance time, students are expected to spend an additional 180 h for preparation and

	follow-up, independent literature study, processing of exercise cases and exam preparation.
Additional Remarks	The work on the PC is possible in groups of max. 2 persons. In any case, individual work on the PC should also take place in the module in order to ensure that all participants acquire modeling and IT competence. CSR and Sustainability Management is offered exclusively in English as part of the International Study Program. The credits earned will count toward the 24-credit requirement of the program.
Keywords	Sustainability and Resource Efficiency, CSR, LCA, Material Flow Assessments
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LAW3200 – Legal Aspects of Environmental Protection

Legal Aspects of Environmental Protection	
Module ID	LAW3201
Semester	6
Level	Advanced
Credits	5
SWS	4
Frequency	Every semester
Associated courses	Legal Aspects of Environmental Protection
Prerequisites	Completed first stage of studies
Assessment Methods and duration	PLM/PLH/PLK (60 minutes)
Requirements for granting of credits	Passing the examination performance
Significance for the Final Grade	The module is weighted with its credits in the Bachelor 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
Lecturer(s)	Prof. Dr. Tobias Brönneke Dr. Rüdiger Herpich
Subject area / course of study	Law
Applicability in other programs	none
Pedagogical Approach	Lecture with exercises
Objectives	The students... • recognize legal issues at the interface with business and technical resource efficiency management. • have a first overview of the most important German and European environmental regulations. • can distinguish between what the law requires of a citizen/company (substantive requirements) and the instruments it provides for implementing these requirements and with which the authorities ensure compliance with the law. • are familiar with practical aspects of environmental protection and resource conservation. • are able to discuss legal problems in the context of resource efficiency management with environmental law specialists or lawyers in a solution-oriented manner and to participate adequately in the appropriate resolution of the issues. <u>Critical thinking and analytical skills</u> Students will be able to apply analytical skills constructively and critically to problems. <u>Communication skills</u>

	Students will be able to express complex issues in clear written form.
Content	• Environmental law: introduction, goals, principles and systematics, legal sources of environmental law • Instruments of environmental administration: plant permits, ancillary provisions and orders, operating prohibitions, 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, hazardous goods law, ProdHaftG, KrWG • Production and handling of hazardous substances / products • Implementation of resource efficiency and sustainability regulations • Global industry standards, norms and management systems on quality / environmental protection / energy: ISO9001, 14001, 50001 (EMAS) and their relation to state, European and international law • Resource efficiency in practice: industrial promotion, examples of implementation
Relation to other modules	The module builds on LAW1010 (Law I), LAW1200 (Law II) BNRE1112 (Industrial Resource Efficiency) 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 partial courses can be found on the E -Learning platform.
Workload	In addition to the 4 x 15 = 60 SWS attendance time, students are expected to spend an additional 90 h for preparation and follow-up, independent literature study, processing of exercise cases and exam preparation.
Additional Remarks	The module can also be completed as part of an equivalent performance during a semester of study abroad.
Keywords	Environmental Law
Last edited	November 2021

BNRE3110 – Markets and the Economics of Natural Resources

Markets and the Economics of Natural Resources	
Modul ID	BNRE3110
semester	6
Level	job qualifying academic level
Credits	5
SWS	4
Frequency	Every semester
Associated courses	Markets and the Economics of Natural Resources
Prerequisites	Completed first stage of studies
Assessment Methods and duration	PLK – 90 minutes
Requirements for granting of credits	Passing the examination performance
Significance for the Final Grade	The module is weighted with its credits in the Bachelor 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
Lecturer(s)	Prof. Dr. Jürgen Antony
Subject area / course of study	Economics
Applicability in other programs	none
Pedagogical Approach	Lecture with exercises
Objectives	The students... • know the most important commodity markets (including secondary raw materials and energy) and how they function. • are able to track and estimate commodity prices on the world markets. • Know the basic principles of resource economics • are familiar with resource policy options (operational, macroeconomic).
Content	<u>Commodity markets</u> • Operation of LMX, EEX, CME, MCX, etc. • Price developments and influencing factors within the raw materials and energy industry • Shifting effects (e.g. BTL) • Forecasts, Public goods, Tragedy of the Commons, externalities, resource allocation, Coase theorem, Pigou taxes, Hotelling Rule, Hartwick Rule, Jevons and rebound effects, UGR <u>Raw materials policy</u> • Operational risk management • Political options for action and actors

Relation 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 post-processing, independent study of literature, processing of case studies and exercises and exam preparation.
Additional Remarks	The module can also be completed as part of an equivalent performance during a semester of study abroad. The module is offered exclusively in English as part of the International Study Program. Credits earned will count toward the 24-credit requirement in the program.
Keywords	Resource Economics, Resource Markets, Scarcity, Risk Management, Resource Policy, Sustainable Development, Non-renewable Resources
Last edited	November 2021

BNRE3210 – Elective: Sustainability and Resource Efficiency

Electives: Sustainability and Resource Efficiency	
Modul ID	BNRE3210
Semester	6
Level	job qualifying academic level
Credits	6
SWS	4
Frequency	Every semester
Associated courses	• Technology and Innovation Management (3 ECTS) • Seminar Lean Management (3 ECTS) • Industrial Change Management (3 ECTS) • Renewable Energies (3 ECTS) • Sustainable Innovation Camp (3 ECTS) • Interdisciplinary Studies (3 ECTS) Alternative offerings or enrollment in WPFs from other degree programs possible.
Prerequisites	Completed first stage of studies
Assessment Methods and duration	PLP / PLR / PLH / PLK (60 minutes)
Requirements for granting of credits	Passing of the respective examination performances. WPF offerings totaling 6 credits must be successfully completed.
Significance for the Final Grade	The module is weighted with its credits in the Bachelor final grade. Weighting according to credits = 6
Planned group size	max. 30 students
Language	Depending on the chosen WPFs: German or English
Module Duration	1 semester
Module Coordinator	Prof. Dr. Frank Bertagnolli
Lecturer(s)	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 / course of study	Sustainability and Resource Efficiency
Applicability in other programs	Individual WPF offerings can also be taken by other degree programs.
Pedagogical Approach	Lecture with exercises / seminar / project
Objectives	The WPF module is designed to provide students with the opportunity for an individualized, course-specific focus. The objectives differ depending on the WPF offered:

	<u>Technology and Innovation Management</u> Students learn the basics of technology and innovation management and their importance for companies. They learn how to apply selected methods using simple problems from practice. <u>Seminar Lean Management</u> Students are able to independently research, develop and present a complex, practice-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> The students know why changes take place, are necessary and are something normal. They know the course of a change and its side effects as well as backgrounds and can classify the topic of change management in the context of their studies and future field of work. The students know the most important starting points and obstacles within change management. They know leadership tools and methods for successful planning and internal implementation of change. In addition, they reflect on themselves in the context of change and further develop their personality. <u>Renewable Energies</u> The students learn the economic and technical basics of the use of renewable energies. They are able to evaluate sites with regard to the use of different technologies. Location-dependent rough concepts can be developed and evaluated technically, economically and ecologically. <u>Sustainable Innovation Camp</u> Students will learn the concepts of design thinking, business model development and methods for developing sustainability-oriented innovations. Using these methods, they develop their own business idea and a suitable business model in a "camp format". Alternatively, they will further develop a business idea of a corporate partner. <u>Interdisciplinary Studies</u> The students are able to carry out an interdisciplinary project on a challenging topic independently and in a team, which requires social interaction as well as methodological demands. The focus is not only on instrumental competence but also on systemic competence.
Content	The content of the courses is based on the current topics of the respective subjects and, in addition to the basics, should always impart instruments and demonstrate their use with practical examples.
Relation to other modules	Elective subjects in cluster with other subjects of business administration.
Literature	<u>Technology and Innovation Management</u> • Vahs, D.; Brem, A. (2013): Innovationsmanagement – Von der Idee zur erfolgreichen Vermarktung, 4. Auflage, Schäffer-Poeschel Verlag. • Spath, D. et al: Technologiemanagement. Grundlagen, Konzepte, Methoden, Fraunhofer Verlag.

	<u>Seminar Lean Management</u> • Bertagnolli (2020) Lean Management. Springer Gabler. <u>Industrial Change Management</u> • Bertagnolli et al. (2018) Change Canvas. Springer Gabler. • Kruse (2004) next practice. Erfolgreiches Management von Instabilität. Gabal. • Regber und Zimmermann (2001): Change Management in der Produktion: Prozesse effizient verbessern im Team. Moderne Industrie. • John P. Kotter (2011): Leading Change (Deutsche Ausgabe). Vahlen. • Doppler et al. (2011): Unternehmenswandel gegen Widerstände: Change Management mit den Menschen. Campus. • Lauer (2010): Change Management: Grundlagen und Erfolgsfaktoren. Springer. <u>Renewable Energies</u> • Kaltschmitt, Martin, Streicher, Wolfgang, Wiese, Andreas (2020): Erneuerbare Energien. Springer • Quaschning, Volker (2020): Erneuerbare Energien und Klimaschutz. Carl Hanser <u>Sustainable Innovation Camp</u> Plattner, Hasso; Meinel, Christoph, Weinberg, Ulrich (2009): Design-Thinking, mi-Wirtschaftsbuch, München Alexander Osterwalder, Yves Pigneur, Greg Bernarda, Alan Smith (2015): Value Proposition Design, Campus Verlag, Frankfurt/New York Osterwalder, Alexander und Pigneur, Yves (2010) Business Model Generation, Campus Verlag, Frankfurt/New York. <u>Interdisciplinary Studies</u> Depending on the specific subject area.
Workload	2 x 15 SWS = 30 SWS attendance time, plus 60 hours each for preparation and follow-up, independent literature study, processing of case studies and exercises, and exam preparation.
Additional Remarks	The module or an individual course of the module can also be completed as part of a semester abroad. Modules or events related to the main focus of the study program are eligible for recognition. English language courses within the module are offered as part of the International Study Program (ISP). The credits earned will count towards the 24-credit requirement in the program.
Keywords	Sustainability and Resource Efficiency, practical applications, interdisciplinarity
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BNRE4110 – Seminar Sustainability and Resource Efficiency

Seminar Sustainability and Resource Efficiency	
Module ID	BNRE4110
Semester	7
Level	job qualifying academic level
Credits	8
SWS	2
Frequency	Every semester
Associated courses	Seminar Sustainability and Resource Efficiency
Prerequisites	Completed first stage of studies
Assessment Methods and duration	PLH/PLR/PLP
Requirements for granting of credits	Passing the examination performance
Significance for the Final Grade	The module is weighted with its credits in the Bachelor 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
Lecturer(s)	Prof. Dr. Claus Lang-Koetz Prof. Dr. Jörg Woidasky
Subject area	Sustainability and Resource Efficiency
Applicability in other programs	none
Pedagogical Approach	Seminar
Objectives	The students... • are able to independently develop and present a complex technical-business topic on sustainability and resource efficiency. • can review scientific literature and/or systematize and incorporate (possibly indirect) practical experience. • are familiar with the basics and also with some details from the field of production organization, sustainability and resource efficiency. • can independently conduct analysis in the context of sustainability and resource efficiency and derive conclusions, • have all the requirements for the preparation of a thesis work. The module thus primarily serves to deepen knowledge and to acquire instrumental, systemic and communicative competence.
Content	In the NRE-seminar, a technical-business topic on sustainability and resource efficiency is worked on independently by the

	students under the guidance of the lecturer. The students conduct a technical research and analyze and work independently on a given topic from science and / or practice ("research and practice topic").
Relation to other modules	The module builds on BNRE3210 (WPF Efficiency in Practice).
Literature	Depending on the respective topics and contents.
Workload	2 x 15 SWS = 30 SWS attendance hours plus 210 h preparation and wrap-up time including literature study as well as for the processing and presentation of a case study or a presentation.
Additional Remarks	The module is offered as a blocked course in the 7th semester within the first 6 or 7 weeks of the lecture period.
Keywords	Seminar, Sustainability and Resource Efficiency
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