Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Bioenergy
Course code	45535
Scientific sector	ING-IND/24
Degree	Master Energy Engineering
Semester	2
Year	2
Academic year	2017/2018
Credits	6
Modular	no

Total lecturing hours	50
Total lab hours	10
Total exercise hours	
Attendance	
Prerequisites	Capability to write mass and energy balances
Course page	

Specific educational objectives	The course focuses on Bio-Energy and in particular on the exploitation of biomass and biomass waste for energy recovery. The course encompasses thermochemical energy processes (combustion, gasification, pyrolysis, reforming), mechanical and chemical processes (oil extraction and trans-esterification), finally biochemical processes (fermentation and anaerobic digestion). Emphasis is given to thermochemical processes. The course provides chemical engineering tools applied to the analysis of energy conversion processes involving biomass. The course provides also the fundamentals of ASPEN PLUS® - a software package designed for process modeling and simulation that is extensively utilized in chemical and energy industrial sectors. The student at the end of the course will be capable to design a bio-energy thermo-chemical conversion process.

Lecturer	Luca Fiori
Scientific sector of the lecturer	ING-IND/24
Teaching language	English
Office hours	The lecturer is available to meet students along the whole week, to be agreed through e-mail appointment.
Teaching assistant ***(if any)***	
Office hours	
List of topics covered	**Biomass: Properties and types**

	• Properties: proximate and ultimate analysis, calorific value, density, moisture content. • Type 1: ligno-cellulosic, starchy, sugar, oilseeds. • Type 2: municipal residual waste, organic waste, sewage sludge, manure. • Type 3: biofuels from biomass conversion processes (solid: biochar; liquids: bioethanol and biodiesel; gaseous: biogas and syngas). **Processes for biomass conversion** • Introduction to thermochemical, biochemical, and mechanical processes. • Types of reactors, chemical equilibrium and reaction kinetics. • Thermochemical conversion (pyrolysis, gasification, reforming, combustion). • Biochemical conversion (anaerobic digestion, fermentation). • Oil extraction and esterification. • Pretreatment of biomass (pelleting; chipping; biodrying, etc.). • Management of solids / liquids / gaseous biomass process waste. **Generation of heat and power** • Heat generation from biomass boilers and stoves (operation, sizing criteria). • Power generation from biofuels: engines (ICE), turbines (steam, ORC, gas) and fuel cells. • Case studies: gasification plant + ICE. • Cogeneration. • Costs of generating heat and power from biomass. **Process modeling and simulation with the commercial software ASPEN PLUS®** • Methane combustion and methane steam reforming. • Distillation of a water-methanol-ethanol stream. • Gasification of biomass. **Project of biomass plants** • Design of a thermal plant fueled by wood chips P=70 kW. • Cogeneration plant (ICE) fueled by vegetable oil P=1 MWe. • Anaerobic digestion plant for organic waste P=999 kWe.
Teaching format	Lectures, exercises in class and in computing labs.

Learning outcomes	**Knowledge and understanding:** The student will be aware form a technical point of view of energy plants where biomasses and organic wastes are used. **Applying Knowledge and understanding:** The student will be capable to apply the acquired knowledge to design biomass energy plants and to evaluate their performances. **Making judgments:** The student will became capable to judge the different options available given the nature of the feedstock

	available (kind of biomass, kind of organic waste) and the technological opportunities to valorize it as bioenergy. **Communication skills:** The student will be capable to efficiently communicate concerning bio-energy options, processes and plants. **Learning skills:** The student will be taught that significant bioenergy process advancements are in progress, and that he/she should keep him/herself updated on the last technological outcomes that face the bio-energy market.
Assessment	The exam consists in an oral examination and an optional examination regarding the project of an energy process by ASPEN PLUS®.
Assessment language	English
Evaluation criteria and criteria for awarding marks	Capability to address practical and theoretical issues related to bio-energy processes and plants. Capability to solve simple and complex bio-energy problems. Capability to design bio-energy processes by ASPEN PLUS®.

Required readings	Lecture notes
Supplementary readings	Biomass for renewable energy, fuels, and chemicals. D.L. Klass, Academic Press. Sistemi a biomasse: progettazione e valutazione economica. E. Bocci, A. Caffarelli, M. Villarini, A. D'Amato, Maggioli Editore.