Master en Développement Durable

Semester 2

	Lecture (UE)	Exercise (UE)	ECTS
Module 1			6
Energy efficiency of buildings, part 1 and 2 & lab 1	60	15	6
Module 2			3
Efficience Energétique des Bâtiments, Partie 3, lab.2	30	12	3
Module 3			4
Transport Systems Analysis	45		4
Module 4			3
Policy, assessment & evaluation of energy projects on European Level	28		3
Module 5			2
Initiation to Project Work	60		2
Module 6			5
Thermodynamics	60		5
Module 7			4
Sustainable Water and Resources Management	45		4
Module 8			3
Circular economy in construction sector	28		3

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Semester 3

	Lecture (UE)	Exercise (UE)	ECTS
Module Circular Economy			0
Circular Economy (Optional)	30		3

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Semester 2

Energy efficiency of buildings, part 1 and 2 & lab 1

Module:	Module 1 (Semester 2)
ECTS:	6
Objective:	Concepts for energy efficient and comfortable buildings
Course learning outcomes:	Students understand basics of comfort and energy in buildings The students understands the relevant parameters for energy efficient buildings: - The basics in building physics and the aspects related to the building envelope - The user and his need in terms of comfort - The technical installations, especially heating / ventilation / air-conditioning / lighting He understands and can work with the energy relevant parameters of building materials and building components. He knows the common technical installations and he is able to evaluate them on their energy performance. relevant parameter of building He understands the basics of establishing energy balances and evaluations of buildings. As civil engineer he disposes on the necessary knowledge and vocabulary to communicate with the specialists (energy consultants, building services engineers,…) in this field.
Description:	Basics in building physics and energy efficiency of buildings (Maas, 2h /2.5-3 ECTS): 1. The role of the building 2. The actual situation of administrative buildings 3. Contaminants in buildings 4. Comfort and needs of occupants 5. How to assure thermal comfort 6. Windows (gains, losses, orientation) 7. Air tightness 8. Thermal inertia/mass 9. Ventilation & cooling

10. Heat pumps and solar collectors

11. Heat recovery

12. Heating needs

13. Final energy and primary energy

14. Coefficients of performance

15. Energy performance certificates

16. The norm EN832

17. The Energy Performance of Buildings Directives (EPBD): 2002/91/EC & 2010/31/EU

Lab 1 content (PhD-students/1 ECTS):

1. Thermal comfort

2. Heat Flowmeter

3. Thermography

4. Lighting

5. Blower-Door Test

6. Software Lesosai for stationary energy balances

7.Thermal Bridges - Catalogue

Lab. 2 &2 (F. Scholzen):

Concepts for energy efficient and comfortable buildings: Technical installations

- Introduction: active and passive measures
- Heating: Heat load, heating systems, heat production and distribution
- Ventilation needs
- Moist air, psychrometric diagram (Mollier)
- Air-conditioning: Chillers, Room Air Cooling, Air handling Units
- Free Cooling
- Short introduction to renewable energies in buildings

Lab. Sessions:

Introduction and general guidelines for the measurements, Thermography, Blower-door test, Measurement of humidity, Measurement of heat flux, Acoustic Measurement

Teaching modality: Lecture - 60 UE + Lab. 15 UE

English, lecture and syllabus in English; but partly referring to literature in "French" language part 1 & part 2 are lectures, lab-sessions are theory & demonstration of measuring devices.

45 min session

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Language: Anglais

Mandatory: Oui

Evaluation: End-of-course assessment: Written exam - 90 min - 20 points

Oral exam - Depending on the number of students and/or external constraints, a partial or completely oral exam format **may be chosen** by the teachers !

Remark: Part I:

1. Roulet, Santé et quailté de l'environnement intérieur dans les bâtiments, 2004, Lausanne
2. Multiple handouts during the lessons
3. W. Feist, das Niedrigenergiehaus, C.F. Müller, 1998
4. RWE Bau Handbuch,VWEW Energieverlag, 2004

Part II: Script

Part Lab. Sessions : Hand-out's

access to LESOSAI for one lab session

Professor: MAAS Stefan

Efficience Energétique des Bâtiments, Partie 3, lab.2

Module: Module 2 (Semester 2)

ECTS: 3

Objective: Assessment of different building categories, e.g. single family homes, apartments, schools, old & new buildings
Au terme du cours, l'étudiant doit être à même de :
- connaître et comprendre les caractéristiques constructives et les installations techniques du bâtiment qui ont un impact sur la performance énergétique du bâtiment
- comprendre le système énergétique « immeuble » et les différents concepts d'immeuble performants
- connaître et comprendre les méthodes d'établir des bilans énergétiques d'immeubles d'après la méthodologie DIN 18599 et de pouvoir appliquer les logiciels correspondants
- connaître et comprendre les méthodes de déterminer des charges thermiques et frigorifiques ainsi que le comportement thermique d'un bâtiment sur base d'une simulation horaire et de pouvoir appliquer les logiciels correspondants

Course learning outcomes: Au terme du cours, l'étudiant doit être à même de :
- connaître et comprendre les caractéristiques constructives et les installations techniques du bâtiment qui ont un impact sur la performance énergétique du bâtiment
- connaître et comprendre les méthodes d'établir des certificats de performance énergétique (CPE) d'immeubles fonctionnels d'après la méthodologie DIN 18599 et de pouvoir appliquer les logiciels correspondants
- pouvoir optimiser un immeuble sur base de ces CPE tout en restant critique quant à leur fiabilité de représenter le comportement d'un bâtiment réel

Description:	Part III : la physique du bâtiment et son monitoring (Prof. Maas, 2h, 2.5 ECTS) Assurer la qualité de l'air: les effets de l'aération, ventilation naturelle et mécanique, chiffres clefs de consommation électriques pour la ventilation et la climatisation Protection contre l'humidité et les moisissures : protection contre la pluie, l'humidité du sol, transport convectif du vapeur, condensation et diffusion Assurer la qualité de l'éclairage : Eclairage naturel et artificiel, chiffres clefs de consommation électriques pour l'éclairage
Teaching modality:	Cours magistral + TP sur ordinateur part 3: 30 UE
Language:	Français
Mandatory:	Oui
Evaluation:	Rapport de projet à soumettre par l'étudiant + examen oral
Remark:	Notes de cours (disponibles sur Moodle)
Professor:	MAAS Stefan, SCHOLZEN Frank

Transport Systems Analysis

Module:	Module 3 (Semester 2)
ECTS:	4
Objective:	This course provides the fundamentals of traffic and transport systems theory: it aims at understanding and managing the relationship between demand for mobility and the various transportation systems and explains how these lead to economic and societal problems such as congestion, pollution, etc. The goal is to provide a broad view of transportation systems analysis covering both private and public transport systems, and to complement this overview with a discussion of aspects like congestion analysis and management, intelligent transportation systems, traffic data collection methods, and new sustainable options (travel sharing, multi-modality, e-cars, etc.).
Course learning outcomes:	1. Provide the student the student with a basic knowledge of transportation systems and to get in touch with the most relevant issues addressed by transportation systems theory. 2. Introduce the student to theoretical and practical tools to analyse traffic and transport systems, to solve traffic management and infrastructure planning and design problems.
Description:	1. Introduction to transport systems analysis and transport planning and management; 2. Supply systems and traffic flow theory: Urban and motorway systems, definition of capacity, Macroscopic models (fundamental diagram approach); 3. Demand and Travel behaviour: Basics of random utility theory, decision making processes, choice set generation; 4-stage modelling, OD estimation from traffic data

4. Traffic assignment and equilibrium: Traffic assignment processes; equilibrium principles;

5. Planning and scheduling of Public Transport: Timetabling, railway capacity, safety systems, real-time rescheduling and management; PT planning and design, sustainable mobility, multimodal networks

6. Infrastructure planning and design: Basics of transport economics, pricing problems, road maintenance strategies, design and planning of new infrastructures

Theme:

1. The complexity of modelling transportation networks is elaborated in detail, from the analysis of the demand to the arising of congestion problems and how to mitigate them.

2. Different management solutions are described in the second part of the course to learn how to reduce transportation costs, and seek sustainable mobility targets.

Teaching modality: Lecture

Language: Anglais

Mandatory: Oui

Evaluation: Written Examination

Remark: Course handouts, course notes.

Cascetta E. Transport Systems Analysis. Springer (complementary reading)

Ortuzar J. and Willumsen P. Transport Modelling. Wiley (complementary reading)

Professor: VITI Francesco

Policy, assessment & evaluation of energy projects on European Level

Module: Module 4 (Semester 2)

ECTS: 3

Description: - EIB approach towards energy projects

- EIB approach towards climate change

- Technical and economic due diligence of energy efficiency projects

- Technical and economic due diligence of renewable energy projects

Language: Anglais

Mandatory: Oui

Evaluation: Written exam

Professor: STANIC Zoran

Initiation to Project Work

Module: Module 5 (Semester 2)

ECTS: 2

Objective: Ein vorgegebenes Thema wird von den Studenten selbständig aufgearbeitet und es wird in einem Vortrag mit anschliessender Diskussion vorgestellt.

Lernziel: Einblicke in Aspekte des Energieverbrauchs bei Gebäuden

Selbständiges Erarbeiten von Wissensgebieten

Vermittlung dieses Wissens im freiem Vortrag mit anschliessender Diskussion.

Dokumentation

Description: Beipielhafte Projektthemen:

-Erneuerbare Energien
-Simulation des Energieverbrauches von Gebäuden
-Rechnerische Untersuchung von Wärmebrücken
-Moderne Heiztechniken
-Moderne Kühltechniken
-Fortschrittliche Konstruktionswerkstoffe
-Gebäudeautomatisierung
- Combined heat and power production using fuel cells
- Combined heat and power production using internal combustion engines
- Combined heat and power production using thermodynamic cycles
- Biofuels production

Teaching modality: Séminaire

Language: Anglais, Français

Mandatory: Oui

Evaluation: Schriftliche Dokumentation A
bschliessendes Referat

Professor: MAAS Stefan

Thermodynamics

Module: Module 6 (Semester 2)

ECTS: 5

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Objective: Introduction to the principles of thermodynamics which gives an overview on the 1 stand 2 ndlaw of thermodynamic, the cyclic processes for heat, steam, and combustion engines, and the basis of heat transfer.

Description: -Definitions

-Change of state (ideal gas) of closed/open cycles, Carnot's cycle, efficiency

-Irreversible change of state

-Ideal gas in machines and processes

-Steam

-Heat transfer (conduction, convective heat transmission, radiation, thermal transfer)

-Combustion / Conversion of energy

Teaching modality: Vorlesung/TD (3 LE)

Übung/Exercices (1 LE)

Language: Anglais, Français

Mandatory: Oui

Evaluation: written or oral exam

Remark: Einführung in die Thermodynamik, G. Cerbe, H.-J. Hoffmann, 13. Edition, Hanser Verlag, 2002

Professor: LEYER Stephan

Sustainable Water and Resources Management

Module: Module 7 (Semester 2)

ECTS: 4

Objective: Currently, a transition is taking place in Europe towards an increasing awareness of the impact of our behavior on the environment. Instead of unrestricted use of fossil fuels, the focus is slowly shifting towards minimizing energy consumption or using renewable sources of energy with the purpose to reduce carbon emissions. The current configuration of the urban water cycle is, from and energy use perspective, not as sustainable as it could be. For example, more than 85% of the energy input in the total urban water cycle (drinking water production, distribution, use in households, wastewater collection and treatment) is used to heat our water. Much of this energy is simply wasted and ultimately discharged to the environment. The creation of a system with a sustainable use of energy within the urban water cycle is necessary.

This course provides the fundamentals of sustainable technologies in wastewater and sludge treatment: it aims at understanding and managing the main processes that are necessary, the consumption of energy to conduct these processes in wastewater treatment plants as well as

the possibilities of energy production from wastewater and sludge. The main goal is to provide a broad view of conventional wastewater treatment technologies and new sustainable options.

In addition to the theoretical part of this course, case studies will be presented by internal and external experts, simulation tools used in practice are provided to get a deeper knowledge in interactions between different treatment processes. The course is complete by two field trips to national and international enterprises dealing with sustainable wastewater and sludge treatment technologies.

Course learning outcomes:

1. Provide the student with a basic knowledge of transportation systems and to get in touch with the most relevant issues addressed by transportation systems theory.
2. Introduce the student to theoretical and practical tools to analyse traffic and transport systems, to solve traffic management and infrastructure planning and design problems.

Description:

I. State of the art in wastewater and sludge treatment

II. Future challenges

- Climate change
- Demographic development
- Shortage/limitation of Resources (energy, phosphorus)

III. Emerging pollutants: Micropollutants in wastewater

IV. Resources in Wastewater

- Energy (consumption + production)
- Nutrients (recovery)
- Water (reuse

V. Ressource-oriented concepts in wastewater treatment

Teaching modality: Lecture

Language: Anglais

Mandatory: Oui

Evaluation: Written Examination + Computer-aided essay

Remark:

- Metcalf & Eddy: 'Wastewater Engineering, Treatment and Reuse'
- Water Environment Federation 'Energy Conservation in Water and Wastewater'
- Cao 'Mass flow and Energy Efficiency of Municipal Wastewater Treatment Plants'
- Environmental Protection Agency: 'An Energy Management Guidebook for Wastewater and Water Utilities'
- Asano 'Wastewater Reclamation and Reuse'
- Khanal 'Anaerobic Biotechnology for Bioenergy Production: Principles and Applications'

Professor: HANSEN Joachim

Circular economy in construction sector

Module: Module 8 (Semester 2)

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ECTS:	3
Objective:	In this course, students will learn about the concept of circular economy in the construction sector, at the building and neighborhood level. They will be confronted with the reality on the ground and the new financial models that result. Students will discover new innovations, different certifications (C2C), as well as the evolution of the circular economy. They will carry out group projects on the application of the circular economy in a construction project.
Course learning outcomes:	Connaître les principes de l'économie circulaire en général et pour le secteur de la construction. Connaître les dernières innovations en la matière de circularité Savoir implémenter une philosophie d'économie circulaire dans un projet
Description:	Circular economy, Sustainable construction, Eco-district, Flexibility, Reuse/Repair/Recycling, Performance-as-a-Service.
Language:	Anglais, Français, Allemand
Mandatory:	Oui
Evaluation:	Written exam - 70% Group Work Project - 30%
Professor:	MAJERUS Samuel Joseph Christian

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Semester 3

Circular Economy

Module:	Module Circular Economy (Semester 3)
ECTS:	3
Objective:	Know the principles of the circular economy in general and in the construction sector. Know the latest innovations in circularity. Knowing how to implement the principles of circular economy in a project.
Course learning outcomes:	In this course, students will learn about the concept of circular economy in the construction sector, at the building and neighborhood level. They will be confronted with the reality on the ground and the new financial models that result. Students will discover new innovations, different certifications (C2C), as well as the evolution of the circular economy. They will carry out group projects on the application of the circular economy in a construction project.
Description:	Circular economy, Sustainable construction, Eco-district, Flexibility, Reuse/Repair/Recycling, Performance-as-a-Service.
Teaching modality:	Lessons, group projects.
Language:	Anglais
Mandatory:	Non
Evaluation:	Written exam (70%) and Group work (30%).
Professor:	MAJERUS Samuel Joseph Christian