PROF/TRAC
PROFessional multi-disciplinary TRAINing and Continuing development in skills for NZEB principles

Introduction to the IDES-EDU project and lectures

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PROF/TRAC: building on previous IEE projects

• Skills mapping methodology > BuildUp Skills projects

• Training materials > IEE projects
  – Mainly from IDES-EDU (Master and Post Graduate education and training in multi-disciplinary teams),
  – Also all other relevant projects are mapped; training material in the PROF/TRAC database
**IEE IDES-EDU: Master and Post Graduate education and training in multi-disciplinary teams**

- IEE project, running from 2010 - 2013
- 15 universities working together to educate, train and deliver specialists in Integral Sustainable Energy Design of the Built Environment
- Curricula and Training Programs (master courses and post graduate courses) in *integrated multidisciplinary building design*, including new methods of teaching equipping students and professionals to work within a multidisciplinary and interdependent problem-solving framework
- Bringing together different disciplines: architects, engineers (mechanical, civil, HVAC, energy etc.), professional managers

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**Example IDES-EDU: Structure of the Education**

*How to translate a design strategy into training and education?*

from a strategy...

**CFF = Cleanest Fossil Fuels**  
**FFT = Fossil Fuel Technology**

**Design strategy**

- **Apply Renewable Energy Sources**
- **Reduce Energy Demand**
- **Apply Efficient CFF**

**Technology**

- **Low Exergy Systems**
- **Responsive Building Elements**
- **Conventional Envelope Constructions**

...to educational packages
**IDES-EDU**

**Relation between lectures and educational packages**

- **Fundamental Educational Packages**
  - Sustainable Building (sustainable materials and LCA, assessment tools and certification)
  - Architectural Quality
  - Indoor Environment
  - Outdoor environment
  - Integrated Design Approach
  - Whole Building and Renewable Energy Concepts
  - Marketing, cost-benefit analysis
  - Understanding of the EPBD

- **Theoretical Educational Packages**
  - Heating and Cooling
  - Lighting
  - Ventilation
  - Energy Production

- **Practical Educational Package**
  - Cross Disciplinary Teamwork
  - Training building objects as cases for implementation of Integrated Energy Efficient Building Design theory and methodology

**IDES-EDU Outcomes**

- 13 Educational Packages
  - ~ 100 Lectures (powerpoints, explanations)
  - 22 Seminars
- Course Instruction Guide
- Teaching Portal, now transferred to PROF/TRAC
- Common end-terms for the course
- Text book in Sustainable Built Environment
Will be all available on the PROF/TRAC platform

- Brochure Zero Energy Buildings (result of student’s design courses)
- Training buildings, designed by students, realized in Heerlen, the Netherlands, Ljubljana, Slovenia and Budapest, Hungary
Example of course description (WBREC)

General Description:
Whole building and renewable energy concepts can be defined as design solutions where the building and its building construction elements together with building services and renewable energy systems are integrated into one system in order to reach an optimal environmental performance in terms of energy performance, resource consumption, ecological loadings and indoor environmental quality. This educational package will provide students with the necessary knowledge and skills to take part in a professional and interdisciplinary collaboration on design of whole building and renewable energy concepts

Main objectives: At the end of this course, the student will:
• Must be able to take part in a professional and interdisciplinary collaboration on design of whole building and renewable energy concepts
• Must be able to handle complex and research-oriented cases related to development of low-energy, energy-neutral and energy-producing buildings

Intellectual skills: At the end of this course, the student will be able to:
• Must have knowledge about the integrated building energy design strategy as well as whole building and energy solutions
• Must be able to understand the interplay between microclimate, buildings and their services
• Must be able to understand the interplay between sustainable energy system, building energy demand and renewable energy production
• Must have knowledge on utilization of passive energy technologies in relation to choice of building construction and envelope system solution
• Must have knowledge on building integrated renewable energy systems and their integration with building services

Professional/practical skills: At the end of this course, the student is able to:
• Must be able to apply and combine design methods for passive energy technologies and for energy efficient building design
• Must be able to apply, combine and evaluate advanced methods for analysis of the interplay between renewable energy systems, architectural concepts, building design, building use, outdoor climate and HVAC systems
• Must be able to apply both simple and advanced calculation methods for analysis and simulation of building energy performance under dynamic load conditions

Suggestion for pedagogical approach: Lectures, etc. supplemented with instructions, workshops, presentation seminars, etc.
Whole Building and Renewable Energy Concepts

• Lecture 1: Whole Building and Energy Solutions
  — Introduction to the educational package including definition of future challenges to the building sector in relation to design and operation of very low energy buildings.
• Lecture 2: Design Strategies for Reduction of Energy Demand
  — Design considerations and applications of a design strategy.
• Lecture 3: Design Strategies for Utilization of Climatic Principles
  — Description of climatic design principles and strategies for utilization of passive energy technologies.
• Lecture 4: Energy Use Control and Occupant Impact
  — Occupant behavior and practices and their influence on building energy performance and indoor environment.
• Lecture 5: Building Integrated Renewable Energy
  — Examples and development stage of renewable energy solutions for buildings.
• Lecture 6: Whole Building Design and Simulation Tools
  — Building simulation and its role in the design process.
• Lecture 7: Built Examples
  — Description of a number of built examples worldwide to illustrate the building concepts and design strategies.

• Seminar 1: The aim of this seminar is to identify the factors related to climate, building layout and façade design that may have any influence to final energy performance
• Seminar 2: The aim of this seminar is to create a total energy concept of the building from the previous seminar to reach a net zero energy performance.

Integrated Design Approach

• Lecture 1: Introduction to Integrated Design Approaches
  — Introduction to the overall concept of integrated design process (IDP) by lecture and video from
• Lecture 2-3: Integrated Design Approaches in detail
  — A selection of three methods of integrated design approaches is presented in detail
• Lecture 4: Model for an Integrated Analysis of a Very Low Energy Buildings Life Cycle
  — Very low energy buildings knowledge management models, theories and strategies are introduced.
• Lecture 5: Introduction to design thinking vs. empirical analytical thinking (1)
  — How designers (architects) work in practices and how that is different from empirical analytical thinking (positivistic thinking, engineering).
• Lecture 6: Introduction to design thinking vs. empirical analytical thinking (2)
  — Introduction to design thinking.

• Workshops 1, 2, 3: Integrated Design Approaches in practise.
  — The three workshops can take place parallel with the lectures and the module of cross-disciplinary teamwork. The workshops are performed in groups (containing different disciplines) where the students discuss different cases of existing buildings.
Sustainable Building

• Lecture 1: Sustainable Building
  — Introduction to the overall concept of sustainable building and design

• Lecture 2: Resource efficiency
  — Review of the main methods for achieving resource efficiency in buildings, through design and material selection.

• Lecture 3: Climate change mitigation and adaptation
  — The impact of buildings on climate change and the corresponding need for buildings to adapt to climate change.

• Lecture 4: Sustainable Building Rating Tools
  — Overview of the most common sustainable building rating tools.

• Lecture 5: The neighbourhood scale
  — In order to create a more widespread design impact, the neighbourhood and city scales need to be considered to increase energy efficiency in buildings and building clusters, infrastructure and urban form.

• Lecture 6: Life cycle management
  — Management of energy efficiency in buildings throughout their entire life cycle, from early design stages to operation, renovation, transformation and demolition.

• Lecture 7: Sustainable Building Commissioning and Quality Control
  — Introduction to building commissioning and quality control

Architectural Quality

• Lecture 1: Architectural Quality and energy efficiency
  — General introduction to architecture, architectural quality and its link to energy efficiency.

• Lecture 2: Appreciating the context
  — Architecture is always placed in a pre-existing context consisting of traditions, culture, climate, geography, landscape etc., which makes every building unique. This lecture identifies the main contextual issues to take into account.

• Lecture 3: Architecture and people
  — Architecture is always created for the benefit of people, and, in turn, people’s expectations and behaviour will have a large impact on a building’s performance. This lecture identifies the main potential conflicts and

• Lecture 4: Landscape and site resources
  — Review how to make the best use of existing conditions in microclimate and site when designing buildings and built environment, and how to reduce impact of new buildings on the existing landscape and site resources.

• Lecture 5: Resource-efficient building morphologies and typologies
  — The design form and functional programme of buildings and built environment have a large impact on their performance and resource efficiency.

• Lecture 6: How buildings learn
  — Identification of techniques for creating buildings that are able to adapt to such changing conditions, increasing their lifetime and reducing the need for demolition.
Indoor Environment

• Lecture 1: Introduction
  – Introduction to indoor environmental issues.
• Lecture 2: Thermal Environment
  – Definition of thermal comfort for a human body and how to model it.
• Lecture 3: Indoor Air Quality
  – Definition and how to assess it. In detail it deals with perceived indoor quality, its modeling and assessment and factors that influence it.
• Lecture 4: Lighting environment
  – Description of light, its perception by human eye and issues connected to this process – vision, adaptation and accommodation.
• Lecture 5: Acoustical environment
  – General definition of sound and definition of noise. Possible noise sources in a building. It shows scale of sound pressure levels for different noises commonly met. The second part of the lecture is more focused on room acoustical quality.
• Lecture 6: Monitoring and evaluation of indoor environment
  – Monitoring and evaluation of IEQ.
• Lecture 7: User’s behaviour and user’s interaction
  – The role of user’s behaviour in final performance of a building.
• Seminar 1: This exercise is focused on IEQ evaluation of a working space

Outdoor Environment

• Lecture 1: Introduction
  – Basic concepts about the outdoor environment.
• Lecture 2: Meteorological Quantities and Climate Parameters
  – Introduction of the most relevant meteorological quantities and climate parameters.
• Lecture 3: Solar Energy and Solar Radiation
  – The Sun: basic concept and features. Solar radiation: concepts, theory and spectral distribution. Definition of base concepts and quantities related to solar
• Lecture 4: Available Solar Radiation
  – Solar data availability. Solar radiation: methods of quantification, measurement and statistical analysis. Atmospheric attenuation; the air mass concept. Clear sky models and assessment of clear-sky radiation. Distribution of clear and cloudy days and hours
• Lecture 5: Outdoor lighting
• Lecture 6– Wind and Wind Energy
  – Basic concepts. Theory and evaluation, measurements, statistical analysis of wind. Factors influencing the wind speed and direction
• Lecture 7: Urban Heat Island Effect and Mitigation Techniques
  – The Urban Heat Island (UHI) effect: physical characteristics.
• Lecture 8: Comfort Indices and Interventions for the Outdoor Environment
Understanding of the EPBD

• Lecture 1: Climate targets, EU energy policy
  – Global warming, CO₂ emission, general introduction

• Lecture 2: EPBD – 91/2002/EC
  – An integrated methodology to rate the energy performance of buildings
  – Minimum energy performance standards for new and existing buildings that undergo major renovation
  – Energy certificates for buildings
  – Regular inspections of boilers and air-conditioning systems

• Lecture 3: Calculation of the energy performance of buildings
  – ISO EN 13790 Energy performance of buildings – Calculation of energy use for space heating and cooling National calculation method

• Lecture 4: Energy certification of buildings
  – EN 15237 Energy performance of buildings – Methods for expressing energy performance and for energy certification of buildings

• Lecture 5: Inspection of heating and AC systems
  – EN 15378 Heating systems in buildings – Inspection of boilers and heating systems

• Lecture 6: EPBD recast – 2010/31/EU
  – Cost-optimal minimum energy performance requirements

Marketing, cost-benefit analysis

• Lecture 1: Basic principles and definitions
  – NPV calculations, estimation of price scenarios (inflation, energy costs and investments costs) including sensitivity analyses, nature of costs, different forms of cash flows, benefits. Basics of the financial and economical parameters

• Lecture 2: Models for exploitation and risk management
  – Working with exploitation models, how to prepare input for calculations, sensitivity analyses
  – How to define the demarcations and boundaries, the reference situation

• Seminar I: Energy exploitation in practice I
  – Case: demonstrating the conflict between high investments in the infra structure and the low energy demand, the role of tools like heat load duration curves to optimise buildings and RES, allocation of costs

• Seminar II: Energy exploitation in practice II
  – Case: Energy and cost effective solutions

• Lecture 3: Organisation structures
  – Key actors in the process, different forms for energy exploitation
  – Energy exploitation companies, energy production companies

• Lecture 4: Constraints
  – Legal issues, competition law, environmental permits, exploitation permits, ownership, liability, market risks, chain risks, tax mechanisms

• Seminar III: Energy exploitation in practice III
  – Case, how to organise the process
  – Metering, billing and customer care, billing and the 'business as usual principle' Purchase of energy and fuels (fossil for back up, RE as half-fabricate, etc), Selling of 'upgraded' energy
Theoretical Educational Packages (4)

Heating and Cooling

• Lecture 1:
  - Introduction to the building and energy issues.

• Lecture 2, 3: Passive heating and cooling
  - Possible approach to building concept design using passive techniques to optimize heating and cooling loads.

• Lecture 4, 5: Active Space Heating and Cooling
  - Description of different space heating and cooling systems. It covers heat emitters, radiant heating/cooling, thermal activated building structures and air heating/cooling systems.

• Lecture 6, 7: Heat distribution network
  - It describes, classifies and quantifies all the items that may influence the sizing of the network. Similar strategy is used for cooling network design. The second part of the lecture deals with piping network in terms of materials, insulation and linear dilatation. Finally safety devices are mentioned for both the systems.

• Lecture 8, 9: Heating and cooling systems control and operation
  - At first fundamentals of control are explained. Examples on different control solutions are given for a heating system. All of the parts of a control circuit are listed and described. The next part of the lecture focuses on special cases of control – predictive control

• Lecture 10: Design and Analysis Tools
  - Different tools for heating/cooling systems design and assessment. It describes in details hydraulic calculation process for heating systems. A list of computer calculation tools is provided.

• Lecture 11: Parametric models and the latest developments
  - Discussion of the design of experiments, motivation for it and the procedure at first. Next part of the lecture explains parametric models in terms of heating and cooling of the buildings and focuses on integrated design. Parametric model development is then described in details.

• Seminar 1, 2: Building analysis, H/C needs and loads optimisation
• Seminar 3, 4: Space heating and cooling concept and emitters design
• Seminar 5, 6: Hydraulic system design
**Ventilation**

- **Lecture 1: Typical ventilation design concepts and strategies**
  - Introduction of basic concepts about ventilation background, presenting which are the reasons to ventilate an enclosed space.

- **Lecture 2: Natural ventilation**
  - Natural ventilation principles and strategies.

- **Lecture 3: Mechanical (forced) ventilation**
  - Understand mechanical ventilation principles and strategies, the advantages and disadvantages of mechanical ventilation, know the technical solutions for mechanical ventilation, know noise sources in ventilation systems, achieve acknowledgments about fans, blower, air filters.

- **Lecture 4: Displacement ventilation**
  - Understand displacement ventilation principles and strategies, understand the advantages and disadvantages of displacement ventilation vs. mixing ventilation, know the ventilation effectiveness, design considerations, the displacement ventilation method applied in case studies.

- **Lecture 5: Hybrid ventilation systems**
  - Understand reasons for ventilation and consequences of poor air quality, IAQ strategy, understand the advantages and disadvantages of hybrid ventilation, know detailed classes of hybrid ventilation systems, systems’ optimization, etc.

- **Lecture 6: Simulating and predicting ventilation effect in buildings**
  - Understand ventilation modeling strategies, know possible results achieved with the presented simulation methods from case studies.

- **Lecture 7: Sizing natural ventilation systems**
  - Introduction and Typology of natural ventilation systems, Prediction methods, Network models, Methodologies for sizing openings, etc.

- **Lecture 8: Sizing mechanical ventilation systems**
  - Introduction, Components involved, Air Flow Generalities, Calculation of Flow Rate, Air Change Rates, Ventilation Design Methodology, etc.

- **Lecture 9: Sizing displacement and hybrid ventilation systems**
  - Design Concept, Design Concept - Chilled Ceiling Panels, Component Selection, Installation, Cooling Flow etc. of hybrid ventilation

- **Lecture 10: Commissioning, control and measures in ventilation**
  - Testing of Ventilation System, Recommended Procedure for Initial Ventilation Test, Recommend Procedure etc.

- **Lecture 11: Latest developments in ventilation**

**Energy Production**

- **Lecture 1: Energy carriers**
  - Overview of energy demand and supply on the world and national scale

- **Lecture 2: Heat generators – fossil fuels and biomass**
  - Combustion of fossil fuels and biomass, stoichiometry of burning, modelling of emissions, technology of oil and gas boilers, technology of biomass boilers, incinerators, environment protection technologies, condensation techniques, sizing the boilers etc.

- **Lecture 3: Heat pumps**
  - Thermodynamic cycle and thermodynamic limitations of heat pumps, mono- and bivalent operation of heat pumps etc.

- **Lecture 4: Solar collectors**
  - Potential of solar energy, solar radiation on tilted surface, heat transfer in solar collectors, improving of solar collector efficiency, technologies

- **Lecture 5: Earth heat exchangers for air pre-heating and pre-cooling**
  - Modelling of time dependent ground temperatures, heat transfer in air and water ground heat exchanger, all year efficiency, sizing of ground heat exchangers, possible microbiotic problems.

- **Lecture 6: Cooling compressor**
  - Compressor cooling cycle, nominal and all year efficiency, outdoor heat exchangers, sizing of the boilers and cooling units

- **Lecture 7: Evaporative cooling**
  - Thermodynamic processes of evaporative cooling, influence of climate on evaporative cooling, presentation of process in x-t diagrams,

- **Lecture 8: Solar cooling**
  - Thermodynamic processes and thermodynamic limitations of sorption cooling, presentation of process in t-s diagrams, efficiency of sorption cooling regarding to temperature levels of supply heat, etc.

- **Lecture 9: PV electricity generation**
  - Physical principles of solar cell operation, I-V curve of solar cell, theoretical limitation of solar cell efficiency, influence of solar radiation and cell temperature on efficiency,

- **Lecture 10: Small scale cogeneration (gas-piston engine, gas-turbine, biomass – Stirling engine),**
  - Thermodynamic of cogeneration systems, efficiency of cogeneration systems regarding to time dependant heat demand; best available technologies for cogeneration regarding to energy source and size of the units, modelling of heat supply and electricity production, etc.

- **Lecture 11: Latest developments in cogeneration and energy systems**
  - Development and limitations of district heating system, technologies of pipeline distribution systems, sizing of heat substation, high and low temperature cogeneration, DHW preparation using district heating systems etc.
Lighting

• Lecture 1: Introduction to lighting and daylighting – Regulations, certifications and directives
  – Historical perspective on daylighting and lighting in buildings, daylight and sustainability, daylighting credits in certification systems (LEED and BREEAM), luminous efficacy issue in relation to light and daylight, additional benefits of daylighting, electric light use for lights in buildings, strategies for reducing electric light consumption, etc.

• Lecture 2: Perception, visual and non-visual effects of light
  – Visual perception, vision, physiognomy of human eye, retina, macula, fovea centralis, blind spot, optic nerve, field-of-view, adaptation, accommodation, contrast, color vision, cones, rods, third receptor, visual perception, perceived brightness, spectral sensitivity function, photopic/scotopic/mesopic vision, visual comfort, glare, disability glare, discomfort glare, discomfort glare indices, etc.

• Lecture 3: Photometry and colour
  – Electromagnetic radiation, light, visible spectrum, refraction, wavelength, light propagation, reflection, laws of reflection, diffuse reflection, specular reflection, radiometry, photometry, SI photometry units, luminous flux, lumen, illuminance, exitance, lux, solid angle, steradian, luminance, candela, nits, brightness, inverse square law, cosine law, Lambert’s law

• Lecture 4 - 5: Electric light sources, luminaire and architectural lighting strategies
  – Electric light sources, lamps, incandescence, incandescent lamps, halogen lamps, electroluminescence, fluorescent lamps, ballast, compact fluorescent lamps, luminous efficacy, high-intensity discharge (HID) lamps, metal halide lamp, sodium-vapor lamp, mercury-vapor lamp, light-emitting diode (LEDs), arc lamp, gas-discharge lamps

• Lecture 6 - 7: Daylighting design strategies
  – Daylight utilization and related energy savings, benefits and risks associated with daylight utilization, luminous efficacy

• Lecture 8 - 9: Daylight design and evaluation tools
  – Validation strategies and methods, manual calculations, equation of Trezenga & Loe (LumCalcul), Lumen method, DF method, graphical method for the evaluation of daylight conditions, graphic tools

• Lecture 10 - 11: Commissioning and control and latest trends in lighting research
  – Lighting control systems, occupancy control, presence control, absence control, infra-red, movement, ultrasound, daylight or photovoltaic dimming, switch-off, constant, step dimming, integration of daylighting and electric lighting, commissioning issues, etc.

Practical Educational Package (1)
Cross-disciplinary teamwork

• **Lecture 1: Introduction to cross-disciplinary Teamwork – Main cross-disciplinary issues**
  - Introduction to the main cross-disciplinary issues, mono-disciplinary, multi-disciplinary, inter-disciplinary, trans-disciplinary, cross-disciplinary, teamwork, common language, actors of the building process, investor, architect, developer, designers, users, decision-making process, hybrid organisations.

• **Lecture 2: Case Study Presentation**
  - The basic Architects and Developers expectations.

• **Lecture 3: Case Study Presentation**
  - Basic structural engineers and HVAC engineers expectations, structural engineers and HVAC engineers values and goals, structural engineers and HVAC engineer’s needs, structural engineers and HVAC engineers expectations, structural engineers and HVAC engineers point of view, structural and HVAC technical aspects, structural engineers and HVAC engineers language.

• **Lecture 4: Cross – disciplinary networks – Teamwork**
  - Basics of teamwork, communication, information-exchange, cross-disciplinary networks, team building, goal statement, social contract, roles, interaction, inter-personal and inter teams relations, coordination meetings.

• **Workshops & Follow-up discussion – Principles**
  - Principal participants are: Investor, Developer, Architect, Structural Engineer, HVAC Mechanical Engineer and User. Additional participants could be: Energy Consultant, Electrical Engineer, Fire Protection Manager, Construction Manager, Construction Supervisor, Facility Manager
  - One of the disciplines will be then appointed as a leader to solve the case for all disciplines.
  - Students will be given a suggestion of plan and description of the aims which should be fulfilled by the final product.
  - Since each of the students will present a different professional discipline, the approach to the final solution will be different.
  - As a team – students will have to reach one final solution.
  - Teacher should be available during the workshop to act as a mediator and negotiator between each profession represented.

• **Lecture 5: Summary of the Workshops & Follow-up discussion**
  - Summarising the issues presented on the Workshops. The various cross-disciplinary networks are presented in detail. That lecture will share experiences from existing cases and final reports showing different perspectives of understanding teamwork. Lecture will include following aspects: urban planning, architectural, technical, economics, sustainability & ecology, construction.

How to use this material?

• IDES-EDU provides basic material (only in English)
• It can be used as complete set or as partial lectures (selecting sheets)
• To be customized by translation and modified for national circumstances (for example, standards & regulations, methods, products etc.)

• Use skills mapping method to determine eventual skill gaps and needed educational material, select sheets
Example

- Curriculum on building services for 1 Ma students Architecture University of Hasselt
- Specific objective: understanding of the role and possibilities of architectural design in relation to building services
- Understanding of passive and active design solutions
- Educational packages used (selected sheets):
  - Whole building renewable energy concepts and sustainable building (relation between architecture and building services, passive and active solutions, responsive building elements)
  - Integrated design approach
  - Indoor environment (thermal comfort and IEQ)
  - Heating and Cooling (basic principles of emission systems)
  - Ventilation
  - Energy production (basic understanding of PV, Solar Thermal, Heat pumps)

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