IDES-EDU

Master and Post Graduate education and training in multidisciplinary teams implementing EPBD and beyond

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EXECUTIVE SUMMARY

Introduction
In order to achieve the implementation of the 20-20-20 targets set by the EU, and the EU policies towards nearly zero-energy building and renovation, it is necessary to design optimal energy efficient buildings by applying an integrated multidisciplinary design approach. This means that at least architects and specialists like mechanical, civil, and HVAC engineers, energy experts and installers should work together in multidisciplinary teams from the start in the design and building process. However it is still not common to work together in such teams. Due to this, a traditional fragmented design process is followed and the engineers and experts needed in this process are involved in a too late stage of the process. This leads in most cases to inefficient solutions, not optimized buildings and higher costs due to extra measures for integration of energy efficiency measures and renewable energy systems. The solution is that all key actors in the total chain, who have to implement these practices, need to have the necessary knowledge, skills and understanding of what is required, i.e.: Professionals need to adapt and promote sustainable and energy efficient construction practices through their work,
Construction industry needs to commit to following sustainable construction processes,
Policy makers need to encourage, enable and enforce sustainable construction.
If all these key actors and stakeholders are to fulfil their roles, the educational sector has to provide these implementers with the capacity to deal with the demands of sustainable construction both on the level of their students an on the level of the professionals. The European building process has some typical barriers and gaps in relation EU policies and initiatives on sustainable energy. Traditionally a fragmented design process is followed, leading to not optimized buildings. The solution for this barrier is dedicated training education for practitioners like architects, and specialist like civil, mechanical and HVAC engineers in the integral sustainable design approach and who work in integrated multidisciplinary teams, addressing the integration of sustainable energy in buildings and built environment in general. The IEE IDES-EDU (2010 – 2013) action intends to educate and deliver such specialists.
Also higher education has specific barriers. Although sustainable energy as subject is a limited number of cases embedded in the education of several faculties on universities (like civil engineering and mechanical engineering, building engineering and - to a less extend - architecture) it is still not common for students to study, work and graduate in integral design teams, composed of students from several different faculties, during their study. Most architecture schools have made a major effort the past years to integrate this subject into their curriculum.
Finally there are also major barriers for professionals working in the European building sector. Many professionals in the buildings sector have limited training in energy efficient building design and have no experience in working in integrated multidisciplinary teams. Although guidelines and tools on energy efficient building are available in many EU countries a broad implementation still needs to be realised and especially the training in working in integrated multidisciplinary tams is not foreseen in this. The IDES-EDU action will address this barrier and solve this gap.

Solution
A proposed solution to solve these barriers and gaps is to start with education and training as a first essential action. This education and training should focus as well as on educational programs on universities (Master students) as well as on the professionals, already working in the field of (energy efficient, nearly-zero energy) building.
In IDES-EDU 15 renowned European universities fulfil this need of the building sector by developing Master and Post Graduate Courses for Integral Sustainable Energy Design of the Built Environment in which students of several faculties of their institutes and professionals with different skills and backgrounds (architects, engineers, others) will collaborate. These courses will be developed within a European framework and further elaborated and implemented within national consortia in which educational institutes will collaborate with relevant key actors and stakeholders, such as representatives and/or branch organisations the of building sector (constructors, real estate developers, architects, building research institutes, utilities, suppliers, consultants. Both the master courses as the post graduate courses will be completed and accredited with certificates and harmonized end terms.
Students and professionals will be addressed in training schemes and will also collaborate in exchange workshops. This will lead to the creation of better mechanisms to allow the transference of knowledge from educational institutes to the market, bridging the gap between theory and practice. To bridge this gap will require intervention at different levels of education, continued education programs for both professionals and technicians and a concerted public education program. The establishment of partnerships and practical co-operation between research, education, industry and government play an important role in this respect. It is necessary to establish networks and programs to exchange staff and knowledge between these sectors to expedite the transfer of learning ensure the continued relevance of research and education to industry and government and help industry and government to be more responsive to new demands placed on them as a result of sustainable development in the building sector. In order to meet the needs for built environment practitioners skilled in the additional requirements of sustainable construction the following activities will be organised:

The development of curricula and training programs to reflect the centrality of sustainable requirements in the creation of the built environment. Coupled with this is the need to develop new methods of teaching on two levels:

One level for students working within multidisciplinary and interdependent problem-solving framework in a Master of Science Curriculum

One level for professionals with multidisciplinary integrated design methods, working in multidisciplinary teams and training in new technologies in a Post Graduate Curriculum

A collaboration and exchange between professionals and students will take place by interactive workshops during the master and post graduate courses

An intelligent dynamical and adaptive multimedia portal will be developed to make the educational packages widely available to master students and building professionals

The specific building practice and the required integrated design solutions will differ to a large extent for each country in terms of building methodologies and traditions, organisation of the building process and climatic circumstances. Therefore this action contains 15 universities representing all European climate zones, ‘old’ and ‘new’ member states, as well different representative building methodologies.

Methods

The project is organised by 15 universities, REHVA and Cauberg-Huygen Consulting engineers (coordinator) collaborating closely on a European scale and on a national scale with national stakeholders from the building sector. During the first year of the project master courses have been developed for Integrated Sustainable Energy Design of the Built Environment in which students of several faculties of their institutes will collaborate. The framework of these courses has been developed on European scale. For the further implementation these courses can be customized and further elaborated on a national scale within the national consortia. An important action in this project is that the courses for Integrated Sustainable Energy Design will be concretized in practice by the design, elaboration and realisation of so called training and education building objects. A special feature in the project is that the courses include a practical case in which students will design and develop one or more NZE buildings to apply the content of the theoretical courses and to learn to work in multi-disciplinary teams. Within this project two institutes have also actually realised and built these buildings already: Hogeschool Zuyd Heerlen, the Netherlands and University of Ljubljana, Slovenia.

During the first months of the project the universities have identified and assessed the market needs in their country and concluded to a common required expertise profile which along with their experience determined the structure of education. A distinction is made between a cluster of eight fundamental educational packages, a cluster with four theoretical packages and a cluster with a practical case and a supporting lecture on cross disciplinary teamwork. To support the implementation of the courses an intelligent dynamical and adaptive Multimedia Teaching Portal (MTP) has been developed. This portal uses moodle (http://moodle.org ) as an Open Source Course Management System (CMS), also known as a Learning Management System (LMS) or a Virtual Learning Environment (VLE). This environment has been selected because it is nowadays very popular among educators around the world as a tool for creating online dynamic web sites for their students. A number of selected most relevant education packages have been included. The nature of this framework is that it can be expanded with other educational packages. It will also offer the possibility to ‘link’ the educational packages to technical references and standards.

Within the project exchange and collaboration between the students and professionals will be organised by workshops to come to a mutual exchange of experience, approach and understanding. Also external students exchange within the ERASMUS framework will be organised.
In following figure the structure of the educational packages is shown:

Eight Fundamental Educational Packages
Integrated Design Process
Architectural Quality
Sustainable Buildings
Whole Building and Renewable Energy Concepts
Indoor Environment
Outdoor Environment
Market and exploitation
EPBD

Four Theoretical Educational Packages
Heating / Cooling
Lighting
Ventilation
Energy Production

Practical Educational Package
Cross disciplinary teamwork in combination with the design of training building objects as cases for implementation of Integrated Energy Efficient Building Design theory and methodology.
Results
The main result of the IDES-EDU project is the completion of 13 educational packages. A unique feature is that the course contains all the required educational material that students and professionals need for the design of nearly zero energy buildings. With the total material a selected number of educational packages address the core of the project, reflecting the integrated design approach: Integrated Design Process, Sustainable Buildings, Whole Building and Renewable Energy Concepts.

The next important result is the Intelligent dynamical and adaptive teaching portal. This portal gives access to all the educational material. For each educational package following additional information is available:
- calculators
- design and construction guides
- open source software
- video

The platform works in a Moodle environment and can be found by the link: http://moodle.vgtu.lt/IDES-EDU

A search function is available to select lectures and slides as a function of keywords and weightings. The Portal also has a decision system on technologies and an intelligent library.

The realization of the training and demonstration buildings in Heerlen, the Netherlands, Ljubljana Slovenia and Budapest, Hungary is another remarkable achievement.

The Dutch buildings is realized in the framework of the project ‘The Neighbourhood of Tomorrow (in Dutch: De Wijk van Morgen)’ It is an innovative program, initiated and organized by Zuyd University, in which educational institutions, researchers, businesses and public authorities join together to create an exciting environment for the transition to a sustainable built environment at the European Science and Business Park Avantis in Heerlen/Aachen. In total four smart energy-efficient buildings will be developed, produced, exhibited and exploited, each with an own theme and special features.

IDES-EDU Training house ‘Bent to the Sun’ Heerlen

The training building in Slovenia has started as a collaboration between the Faculty of Architecture (planning, building), Faculty of Mechanical Engineering (installation planning, building) and Faculty of Health Care. All faculties are involved in an integral demonstration & education. The planning and design took place in the first half of 2011, the actual building by students took place in autumn 2011. The building has a total other character then the building(s) in Heerlen: the building is much smaller and design and built as a light-weight portable construction. One of the intentions is to show the buildings and all the available NZEB technologies on several places.
IDES-EDU Training house ‘Self-sufficient Living Cell’ Ljubljana

The main goal of the Odoo Building in Budapest is to popularize the usage of solar energy in architectural solutions, to call into being the social and market support of green technologies, to raise awareness among students for renewable energy and energy-efficiency. It was a part of the Solar Decathlon competition. The house will be researched and the project will be integrated in the education of the different cooperating faculties of BUTE, and is open for the interested visitors in Budapest, who has been constantly asking the students about the built in technologies, and materials.

IDES-EDU Training house Odoo Building, Budapest, Hungary

Conclusions

Question is whether the IDES-EDU approach in education can in fact change existing scheme of building designing process. The IDES-EDU team common opinion is this is one of the most important steps towards fulfilling the energy and indoor environmental demands of the future. The more people that are acknowledged with the integrated design approach and topics related to that and the more its aspects and benefits are implemented by the design team the better the chances are that EU’s ambitious 20-20-20 climate goals will be met. Nevertheless, the role of the market is considerable. Cross-disciplinary working in teams and in an integrated design approaches are still quite unknown phenomena in Europe, not only in building practice but also in education. Despite the fact that there are definitely substantial differences in teaching methods and approaches, the IDES-EDU project shows that it is possible to develop and implement an integrated Master and Post Graduate course for nearly zero energy building on a European level. The IDES-EDU team. As well as the students involved, are convinced that this project will contribute and facilitate the way to Nearly Zero Energy Building construction and retrofitting, as a common, daily building practice.

Acknowledgements

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**PROJECT DATA**

Project Acronym: IDES-EDU

Full title: Master and Post Graduate education and training in multidisciplinary teams implementing EPBD and beyond

Objective: The development of Master Courses and Post Graduate Courses for Integrated Sustainable Energy Design of the Built Environment and principles in NZEB construction and renovation at 15 European educational institutes

Contract number: IEE/09/631/SI2.558225

Financing: Intelligent Energy Europe

Budget: € 1.251.888 (EU contribution: 75%)

Duration: 1 July 2010 – 30 June 2013

Project website: [www.ides-edu.eu](http://www.ides-edu.eu)

Project Teaching Portal: [http://iti.vgtu.lt/ieeppt/](http://iti.vgtu.lt/ieeppt/)

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National and Kapodistrian University of Athens (NKUA), Greece

Pecs Technical University, (PTE), Hungary

Czech Technical University, (CTU-FCE), Czech Republic

University of Ljubljana (UL), Slovenia

University of Zagreb (UNI-ZG), Croatia

Warsaw University of Technology (WUT), Poland

Vilnius Gediminas Technical University (VGTU), Lithuania

University of LaRochelle (UNIV-LR), France

University of Minho (UMINHO), Portugal

Lund University (LTH), Sweden

Federation of European Heating and Air-conditioning Associations (REHVA), EU
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1. INTRODUCTION

In order to achieve the implementation of the 20-20-20 targets set by the EU, and the EU policies towards nearly zero-energy building and renovation, it is necessary to design optimal energy efficient buildings by applying an integrated multidisciplinary design approach. This means that at least architects and specialists like mechanical, civil, and HVAC engineers, energy experts and installers should work together in multidisciplinary teams from the start in the design and building process. However it is still not common to work together in such teams. Due to this, a traditional fragmented design process is followed and the engineers and experts needed in this process are involved in a too late stage of the process. This leads in most cases to inefficient solutions, not optimized buildings and higher costs due to extra measures for integration of energy efficiency measures and renewable energy systems. The solution is that all key actors in the total chain, who have to implement these practices, need to have the necessary knowledge, skills and understanding of what is required, i.e.:

- clients need to demand a more sustainable and comfortable built environment;
- professionals need to adapt and promote sustainable and energy efficient construction practices through their work;
- construction industry needs to commit to following sustainable construction processes;
- policy makers need to encourage, enable and enforce sustainable construction.

If all these key actors and stakeholders are to fulfil their roles, the educational sector has to provide these implementers with the capacity to deal with the demands of sustainable construction both on the level of their students an on the level of the professionals. The European building process has some typical barriers and gaps in relation EU policies and initiatives on sustainable energy. Traditionally a fragmented design process is followed, leading to not optimized buildings. The solution for this barrier is dedicated training education for practitioners like architects, and specialist like civil, mechanical and HVAC engineers in the integral sustainable design approach and who work in integrated multidisciplinary teams, addressing the integration of sustainable energy in buildings and built environment in general. The IEE IDES-EDU action intends to educate and deliver such specialists.

Also higher education has specific barriers. Although sustainable energy as subject is a limited number of cases embedded in the education of several faculties on universities (like civil engineering and mechanical engineering, building engineering and - to a less extend - architecture) it is still not common for students to study, work and graduate in integral design teams, composed of students from several different faculties, during their study. Most architecture schools have made a major effort the past years to integrate this subject into their curriculum.

Finally there are also major barriers for professionals working in the European building sector. Many professionals in the buildings sector have limited training in energy efficient building design and have no experience in working in integrated multidisciplinary teams. Although guidelines and tools on energy efficient building are available in many EU countries a broad implementation still needs to be realised and especially the training in working in integrated multidisciplinary tams is not foreseen in this. The IDES-EDU action will address this barrier and solve this gap.

A solution to solve these barriers and gaps is to start with education and training as a first essential action. This education and training should focus as well as on educational programs on universities (Master students) as well as on the professionals, already working in the field of (energy efficient, nearly-zero energy) building.

In IDES-EDU 15 renowned European universities fulfil this need of the building sector by developing Master and Post Graduate Courses for Integral Sustainable Energy Design of the Built Environment in which students of several faculties of their institutes and professionals with different skills and backgrounds (architects, engineers, others) will collaborate.

These courses will be developed within a European framework and further elaborated and implemented within national consortia in which educational institutes will collaborate with relevant key actors and stakeholders, such as representatives and/or branch organisations the of building sector
(constructors, real estate developers, architects, building research institutes, utilities, suppliers, consultants. Both the master courses as the post graduate courses will be completed and accredited with certificates and harmonized end terms. Students and professionals will be addressed in training schemes and will also collaborate in exchange workshops.

This will lead to the creation of better mechanisms to allow the transference of knowledge from educational institutes to the market, bridging the gap between theory and practice. To bridge this gap will require intervention at different levels of education, continued education programs for both professionals and technicians and a concerted public education program. The establishment of partnerships and practical co-operation between research, education, industry and government play an important role in this respect. It is necessary to establish networks and programs to exchange staff and knowledge between these sectors to expedite the transfer of learning ensure the continued relevance of research and education to industry and government and help industry and government to be more responsive to new demands placed on them as a result of sustainable development in the building sector. In order to meet the needs for built environment practitioners skilled in the additional requirements of sustainable construction the following activities will be organised:

- The development of curricula and training programs to reflect the centrality of sustainable requirements in the creation of the built environment. Coupled with this is the need to develop new methods of teaching on two levels:
  - one level for students working within multidisciplinary and interdependent problem-solving framework in a Master of Science Curriculum;
  - one level for professionals with multidisciplinary integrated design methods, working in multidisciplinary teams and training in new technologies in a Post Graduate Curriculum;
  - a collaboration and exchange between professionals and students will take place by interactive workshops during the master and post graduate courses.

- An intelligent dynamical and adaptive multimedia portal will be developed to make the educational packages widely available to master students and building professionals.

The specific building practice and the required integrated design solutions will differ to a large extent for each country in terms of building methodologies and traditions, organisation of the building process and climatic circumstances. Therefore this action contains 15 universities representing all European climate zones, ‘old’ and ‘new’ member states, as well different representative building methodologies.
2. OBJECTIVES, SCOPE AND METHODS

2.1 Objectives and scope

The overall objective of IDES-EDU is to create students and post graduate education and training courses at educational institutes for Integral Sustainable Energy Design of the Built Environment. In order to realize this, IDES-EDU has the following objectives:

- the development of Master Courses and Post Graduate Courses for Integrated Sustainable Energy Design of the Built Environment at 15 European educational institutes including training packages, based on horizontal themes (EU wide around themes based on EU perspectives and visions, derived from relevant directives and policies) and based on vertical themes, based on the specific needs from stakeholders, especially in the building sector and implement these Master Courses in the participating educational institutes. The continuous professional development for the building sector is specifically dedicated to architects and consultants and engineers on building science and building services;
- the implementation of these courses with common end-terms, accreditation and a framework for common certificates in 15 countries. This includes the certification and accreditation of the courses on national level as well frameworks for European certification for participants and for buildings designed in multidisciplinary teams;
- the organization of exchange and collaboration between the students and professionals, involved in these courses by workshops to come to a mutual exchange of experience, approach and understanding;
- the elaboration of detailed designs by students in design course, in order to bring the educational material of IDES-EDU into practice and to experience working in multidisciplinary teams.
- the realization of some of the building designs during the time of the project on at least two institutes (Zuyd University and University of Ljubljana);
- the development of an intelligent dynamical and adaptive multimedia teaching portal for e-learning and further European dissemination to other educational institutes, branch organizations related to the buildings sector;
- the monitoring of the results of the IDES-EDU action in terms of realized educational packages, progress and achievements per institute and in total, number of students involved in the action, number of participants in the post graduate courses and feedback from the stakeholders with measurable results from stakeholders (number of trainees, students employed).

This should also lead to an increasing European awareness, promotion and implementation of EPBD and NZEB construction and retrofitting and creating commitment on Integral Sustainable Energy Design in the Built Environment.

The strategic and long term objectives of IDES-EDU is to contribute to optimized market orientated implementation of the EU directives on EPBD, NZEB principles and promotion of renewables. This will also facilitate the process to reach the EU targets on longer term for the built environment by delivering specialists on academic level, trained and educated in integrated sustainable energy design and working in multidisciplinary teams. This substantially enhances the efficiency in the building process and will lead optimized building concepts in terms of energy efficiency, integration of renewables, thermal comfort and health, and costs effectiveness. This action will also lead to the start of an essential transition in the building process. In this transition the current fragmentation of the building process, i.e. working in a traditional non-integrated way leading to non- or sub-optimized solutions, will be taken away.

The students exchange program with other educational institutes, not directly participating in this action as partner, is supposed to lead to a European wide dissemination of the results of this action. It is expected that each educational institute, participating in IDES-EDU, will establish an exchange program with at least four other institutes. In this way at least 60 educational institutes will be involved on (mid) term in this action.

The collaboration with European umbrella organizations such as REHVA (HVAC industry and engineers), will disseminate this action in the building sector.
2.2 Methods: The Integrated Design Process versus the Traditional Design Process

If generalized, the Traditional Design Process (TDP) often proceeds like this: The architect and the client agree on the design concept consisting of the form concept, orientation, fenestration and the exterior appearance like characteristics and materials. Then, the engineers and consultants are asked to implement or design technical systems for the building. This procedure seems simplistic mainly because the “active” actors in the process are limited and they are implemented linearly see figure 1. In a linear process it is often difficult or even impossible to optimise the design according to e.g. energy and indoor environmental issues, because the expertise comes in late in the process and the architectural concept is fixed. Nevertheless, this approach is mostly used, however the reasons for doing so is not clear. On one hand, the barrier of integrating Integrated Design Process (IDP) in praxis could be because the architects protect their professional domain and the engineers do not want to intrude on the architectural domain and vice versa. Another barrier could be that the professions are not trained to work in an integrated way and simply stick to what they know. The complex design process has become even more evident when designing energy-efficient (or nearly-zero energy) architecture because more parameters come into play and the solutions are much more interdependent than in standard building design fulfilling the conventional level of performance.

![Diagram of Traditional Design Process versus Integrated Design Process](image)

**Figure 1: The Traditional Design Process – a linear approach versus The Integrated Design Process – an iterative approach**

In the Traditional Design Process the design often results in:
- unused potential of solar gains, resulting in higher heating demands;
- exposure of glazing to summer sun, resulting in higher cooling demands;
- unused potential of day lighting due to a lack of appropriately located/dimensioned glazing, or lack of features to channel daylight further into the interior of the building;
- exposure of occupants to discomfort, due to local overheating or glare in areas lacking adequate shading;
- non-efficient use of area due to lack of integration of equipment in the building;
- higher investment and life cycle costs due to add-on of equipment during advanced design and even operation stages;
- lower architectural and use value due to lack of alignment with technical equipment;
- less efficient or unnecessary HVAC systems.

In recent years a number of different approaches to IDP have been developed including some with slightly different names like:
An Integrated Design Process is often identified by the following parameters:
- an iterative process;
- considers and optimizes the building as an entire system including its aesthetic and functional aspects, technical equipment and surroundings;
- all actors of the project cooperate across disciplines and agree on far-reaching and crucial decisions jointly from the beginning;
- the design concept is subject to iterations early in the process, which is done by a coordinated team of specialists.

2.3 Methods: Philosophy of the education and courses
The main goal is to educate specialists on academic level, trained and educated in integrated sustainable energy design and working in cross-disciplinary teams. Therefor it is important that teachers as well as students approach the training from an integrated point of view. The candidate will be specialist within one field (e.g. from a bachelor degree in architecture) and be informed by several other topics to be able to interact in a cross-disciplinary team, see Figure 2. For this to become a success the students need to be introduced minimum to the fundamental educational packages and try to work in cross-disciplinary teams around a practical building case. The philosophy is that the individual topics are seen form multiple points of views and new topics are met by an open mind. Every decision in a design process affect several other parts of the building design, therefore seeing each profession as solving separate aspect individually (the “traditional” way of thinking) is no longer enough to be able to fulfill the stricter energy demand to the built environment of the future. The integrated approach and cross-disciplinary skills of the candidates will result in well-functioning low energy architecture which does not compromise the indoor environment and the architectural qualities. To able to teach and learn how to work fully integrated, teacher as well as student needs to cross own professional borders and be open-minded.

![Diagram of professional roles](image-url)

Figure 2: Shows the overall conceptual idea of the cross-disciplinary profile. Each column represents an expert within a professional field, e.g. an architect or an mechanical engineer. During the master developed within the IDES-EDU project the candidate should have expert knowledge within at least one field and be informed by other fields marked by the red oval-shapes – a cross disciplinary profile.

2.4 Methods: Pedagogical approach
Each institution has different teaching traditions and to support implementation the pedagogical approach in the project of IDES-EDU is optional. The materials in the educational packages contain presentations in PowerPoint with notes and some descriptions of exercises, workshops and seminars.
The developed material should be seen as a toolkit which each institution can customise to be able to fit it into either an existing curriculum or to start up a full cross-disciplinary master. The only mandatory approach is the practical educational package (will be described further in the next chapter) which has to be solved by project work in cross-disciplinary teams. It is believed that “learning by doing” is the proper approach to be able to learn how to work cross-disciplinary.

2.5 Impact on building design and the challenges of different work methods

By approaching the design process in a more integrated way the whole design concept will be more holistic. It means the climate, strategies to optimise the indoor environment and energy use are thought together into a common concept avoiding fragmentation, incoherency and/or technologies that are “add-on’s”. The quality of the concept and final building design is highly dependent on the competences and communication in the design team and the view on design processes in general. Even though a design process holds other actors than architects and engineers like; clients, contractors and users, the first two will be used to explain the different approaches to design.

Table 1. Examples of quantitative and qualitative issues relevant in an architectural design process.

<table>
<thead>
<tr>
<th>Quantitative issues</th>
<th>Qualitative issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statics</td>
<td>Aesthetics: spatiality, texture and materiality, light and shadow</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>Functionality as regards to context, users etc.</td>
</tr>
<tr>
<td>Indoor environment</td>
<td>Users, everyday life, activities</td>
</tr>
<tr>
<td>Economics</td>
<td>Atmosphere</td>
</tr>
<tr>
<td>Etc.</td>
<td>Physiological requirements</td>
</tr>
<tr>
<td></td>
<td>Cultural expectations</td>
</tr>
<tr>
<td></td>
<td>Etc.</td>
</tr>
</tbody>
</table>

Traditionally, architects acted alone on the design of the building and such a design process usually is a cognitive process where the architect conjectures an approximate solution to structure the understanding of the problem and test its resistance. Architectural design problems have a large number of solutions open, mainly because the field of architecture takes qualitative and quantitative issues into account at the same time and they inform each other, which means they cannot be solved individually, see examples in Table 1. At the same time, every assignment is unique because relevant issues such as functional programme, local climate and site etc. vary in each case. Today, especially the competences of engineers have to come into play in the architectural concept because form concept, orientation, fenestration etc. influence performance of the building.

Therefore the approach to the design processes is challenged. Engineers often have focus on the solutions having an analysis/synthesis (A/S) approach where the architects have focus on the problem having a conjecture/analysis (C/A) approach. In an A/S approach the problem is firstly broken down and analysed in sub-problems and individual problems. The individual solutions and sub-solutions are then synthesized until achieving the overall solution.
In a C/A approach one proposes an idea that is holistic in nature before attempting to conduct any analysis. The two (competing) approaches or paradigms can result in conflicts when combining them in an IDP. When designing sustainable architecture it requires that architect and engineer overlap their knowledge and skills and share the character of a designer, it stresses the necessity for each discipline to cover basic and essential knowledge and skills of the other, resulting in architects and engineers with a new character, different from the traditional one.

To design energy efficient architectures is not just a matter of timing, like bringing all participating together from the beginning, or the use of common language. It is also about the approach to designing a building in itself that needs to be addressed – and especially in education.

Therefore, the project of IDES-EDU put an effort in educating in integrated design approaches, alongside improving the common knowledge and skills about energy efficient architecture. The candidates will hopefully influence design approaches in practise and thereby the industry will hopefully overcome the barriers of implementing IDP.
3. THE COURSES

3.1 Structure

The IDES-EDU project intends to educate, train and deliver specialists who will be able to follow the principles of the integrated design approach. Since the project address both students and professionals from various countries working in the building sector, the structure of the IDES-EDU course must be flexible but also coherent. Each institution has different teaching traditions and to support implementation the pedagogical approach in the project of IDES-EDU can be adapted to local approaches. The materials in the educational packages contain presentations in PowerPoint with notes and descriptions of example of exercises, workshops and seminars. The developed material should be seen as a toolkit which each institution can customize to fit into either an existing curriculum or to start up a full cross-disciplinary master.

The courses are classified into three educational packages Fundamental, Theoretical and Practical Educational Packages as shown in figure 3.

![Diagram showing the structure and relation between the educational packages.](image)

Figure 3. Structure and relation between the educational packages

The illustration shows the content of the educational packages and the interrelations between its modules. On the left the interrelations are shown between the different modules, the dashed box is not a direct part of the educational packages, but it is an essential part of the integrated approach.

Right: The modules in each packages to which there are listed learning outcome and developed teaching material.

3.2 Qualification framework for MSc within IDES-EDU

During the MSc programme in „Integrated design of near-zero energy built environment“, the students will develop the ability to create a near-zero energy built environment that satisfies aesthetic and technical requirements. The students will also develop the knowledge and skills needed to plan, conduct, and manage a building project in co-operation with a cross-disciplinary design team and stakeholders.

After completing the MSc programme in „Integrated design of near-zero energy built environment“ the students will have gained:

- Conduct, and manage a building project in cooperation with a cross-disciplinary design team and stakeholders.
- Develop the ability to create a near-zero energy built environment that satisfies aesthetic and technical requirements.
- Gain an understanding of the principles of the integrated design approach.
- Gain the ability to create a near-zero energy built environment that satisfies aesthetic and technical requirements.
- Gain an understanding of the principles of the integrated design approach.
- Gain the ability to create a near-zero energy built environment that satisfies aesthetic and technical requirements.
- Gain an understanding of the principles of the integrated design approach.
- Gain the ability to create a near-zero energy built environment that satisfies aesthetic and technical requirements.
Knowledge
- Knowledge of terminology, principles and challenges related to sustainable architecture, more specifically energy efficient, nearly zero energy and zero emission buildings and built environment.
- Knowledge of the interactions between built form and greenhouse gas emissions, energy use, supply and generation, climate change and resource scarcity.
- Understanding of the importance of various design choices and their impact on the energy use and greenhouse gas emissions of the design.
- Knowledge of principles for integration of energy systems in architectural design.
- Knowledge of sustainable architectural design based on the highest international research and references.
- Knowledge of and critical attitude towards engineering and architectural theories, methods, and Thorough understanding of the changing role and responsibility of building professionals in society.
- Competence to participate in cross-disciplinary design projects and assume professional responsibility for sustainable building projects.
- Competence in models for cross-disciplinary design processes that facilitate their successful functioning.
- tools related to sustainable architectural design to create buildings with substantial engineering and architectural qualities.

Skills
- The ability to make advanced integrated design proposals, including the ability to synthesise complex requirements of building functions, structure, physics and systems in a coherent architectural design that promotes occupant health, comfort and well-being.
- The ability to master and apply appropriate scientific engineering and architectural theories, methods of investigation, assessment and evaluation tools required to achieve a sustainable energy-efficient, low-emission building project.
- The ability to critically evaluate the strengths and weaknesses of theories, assessment, evaluation tools and methods and their results.
- Cross-disciplinary practice necessary to ensure a successful functioning of energy-efficient, low-emission systems in architecture.
- The skills required to negotiate stakeholder requirements within the constraints imposed by environmental specifications, cost factors and building regulations.

General competence
- Thorough understanding of the role of architecture and the built environment in creating an integrated physical framework for a low-emission society: the interaction between people, buildings and the environment on different levels of scale and time.

3.3 Fundamental Educational Packages

The fundamental educational package contains several modules on diverse topics which create the basis for working more advanced with designing energy-efficient (nearly zero energy) architecture, also taking into account quality of indoor environment. The cornerstone is the module of Integrated Design Approach. The module introduce the students to the theoretical understanding of design processes and how designers think, which cover both the TDP and the IDP to illustrate the difference and importance of new approaches. The lectures also contain presentations of building examples from practice when working with the IDP. However, more general integrated concepts are also presented to illustrate the possibilities by working integrated.
Additionally, workshops are suggested to be carried out in groups, which train the student in understanding the principals and outcome of integrated design. Additional modules within this fundamental package are dedicated to Whole Building and Renewable Energy Concepts (WBREC), sustainable buildings, architectural quality, indoor environment, market and exploitation and EPBD. The integrated aspect within this educational package is obvious if the interrelations between the individual modules are considered. Architectural quality as well as the resulting module of WBREC are interrelating with the cornerstone of IDP. In addition the IDP must ensure that the quality requirement of the indoor environment (hydrothermal, air quality, acoustic, lighting, user behaviour and more) is met. In order to ensure a coherent structure for individual master and postgraduate courses the fundamental package is considered to be mandatory.

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**Educational Package: Integrated Design Approach**

**General Description:**
The module of Integrated Design Approach within the Fundamental Educational Package will introduce the students to the theoretical understanding of design processes and how designers think, which will cover both the “traditional” and the integrated design process (IDP) to illustrate the difference and importance of new approaches. The lectures will also contain presentations of building examples from practice when working with the Integrated Design Process. However, more general integrated concepts will also be presented to illustrate the possibilities by working integrated. Additionally, workshops in groups are carried out. They will train the student in understanding the principals and outcome of integrated design.

This course module is closely related to the practical educational packages, where integrated design approach is tried out in practise. The understanding and skills of performing integrated design come primarily from “learning by doing”. The module is also highly connected to the module of cross-disciplinary teamwork, where an understanding of what it means to work in cross-disciplinary teams, what mechanisms are on stake and how communication can be improved etc. is achieved.

The assumption for a high quality of this educational package, it is necessary that the students (the groups) consist of a combination of different disciplines. It will be important in the discussions and workshop, which will illustrate the diversity of needs and wishes in the different disciplines. It is important they both represent the more artistic, creative approach and the more technical approach. This also goes for the teachers of this educational package.
Main objectives:
At the end of this course, the student will:
- understand the principals of how designers work and think;
- understand the theoretical principal of different design approaches and be able to distinguish;
- understand the procedure and have knowledge about the integrated way of thinking;
- understand the principal of developing integrated design concepts.

Intellectual skills:
At the end of this course, the student will be able to:
- distinguish between a conventional and an integrated design process;
- describe and discuss the principal of integrated design approaches

Professional/practical skills:
At the end of this course, the student is able to:
- discuss and communicate how to practise integrated design approaches theoretically;
- identify key characteristics of integrated design concepts;
- identify how the new integrated design approach contribute to the development/innovation of own profession.

Suggestion for Pedagogical Approach:
The course will be based on:
- theoretical lectures including discussion sessions;
- workshop, which contains discussion sessions about the presented theories and more “hands-on” discussions based on building cases. All workshops will be carried out in groups.

Educational Package: Whole Building and Renewable Energy Concepts (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.

Educational Package: EPBD (recast, 2010/31/EU)

General description
Generally, there are currently no courses covering this subject in general. The existing courses cover the EPBD (91/2002/EC) and the local (Hungarian) implementation. In all EU countries the calculation and certification courses are based on the national regulations.

Energy efficiency is one of the greatest challenges Europe has to face. Energy related emissions account for almost 80 % of the EU's total greenhouse gas emissions, buildings use about 40 % of the total energy use.

EPBD (91/2002/EC) was the key directive reducing energy consumption in the Member States. Connected with the EPBD a package of CEN standard was prepared. The EPBD was implemented in the Member States, the Commission decided the recast. Principles of 91/2002/EC are kept, but clarified and improved in their effectiveness. The Energy Performance of Building Directive recast (31/2010/EC) was published on 16th of June 2010 and came into force on 9th of July, 2010.

It is important that students have at least a basic understanding of the energy related directives, the energy strategy for Europe. For other aspects a more detailed knowledge is required for the national calculation of the energy performance of buildings, for the way of the national energy certification of the buildings and for the inspection of the heating and air-conditioning systems.

Main objectives
Objectives of the course are to teach the student:
- the basic knowledge of the energy related EU directives;
- the basic knowledge of the EPBD and EPBD related CEN standards;
- the deep knowledge of national regulations and calculations;
- to compare the different methods of calculation, certification and inspection.

Intellectual skills
At the end of the course the student is able:
- to understand the environmental and energy strategy of Europe;
- to aim achieving nearly zero-energy buildings.

Professional and practice skills
At the end of the course the student is able:
- to calculate the energy consumption of the building based on the CEN standard;
- to calculate the energy consumption of the building based on the national standard;
- to use a common language comparing the results;
- to know the process of the inspection of heating and air-conditioning systems.

Suggestion for Pedagogical Approach
This course has 6 lectures of 3 hours each (18 hours).
Practice in Lecture 3 (calculation of energy performance of buildings) – 3 hours
Exam: Yes (written or oral)
Assignment: elaboration of a case
Educational Package: Sustainable Building

General Description:
The aim of the package “Sustainable Building” is to introduce and present:
- how building professionals can contribute to a sustainable environment by means of design, construction and operation on the building, neighbourhood and city scale;
- appropriate distribution of responsibilities and roles in building projects, ensure integrated design, and optimise synergies between the building and its surroundings and users.

Main objectives:
After completing this course, the students will be able to:
- identify the requirements and skills needed to plan, execute and manage a sustainable building project in co-operation with an interdisciplinary design team and stakeholders.

Intellectual skills:
After completing this course, the students will be able to:
- understand the changing role and responsibility of building professionals in society, including the need for continuously updated knowledge of, and critical attitude towards the industries, organisations, regulations and procedures involved in developing sustainable building projects

Professional/practical skills:
After completing this course, the students will be able to:
- distinguish methods of investigation, assessment and evaluation required to achieve a low-carbon building;
- synthesise complex requirements of building functions and systems necessary in order to provide health, comfort and well-being, as well as protection against climate.

Suggestion for Pedagogical Approach:
- the Theoretical lectures including case studies and discussion sessions;
- workshops including case studies and discussion sessions. All workshops will be carried out in groups course will be based on:

Educational Package: Outdoor Environment

General Description:
A building, as big and complex as it could be, can ultimately be regarded as a thermodynamic system that exchanges mass and energy with the outdoor environment. The knowledge of the outdoor environment is, therefore, of paramount importance in the design phase of a building and its installations, since it determines many of the boundary conditions with which they operate.
The outdoor climate conditions pose challenges and offer opportunities to the designer for achieving an optimal energy efficiency and sustainability of the final construction.
In this package the fundamentals concepts about the outdoor parameters that influence the energy demand and the energy efficient design of buildings will be introduced and analysed.
Evaluation method and climate parameters will be presented together with sources and tools to quantify their value.

Main objectives:
- supply the basic knowledge about the outdoor environment quantities (relevant for the integrated design approach) and analyse their influence on buildings;
- introduce the main physical (meteorological) quantities used to characterize the outdoor environment (solar radiation, air temperature, relative humidity, wind, ground temperature, atmospheric radiation);
- define and illustrate the main climatic parameters (heating/cooling design temperature, sol-air temperature, degree days, Test Reference Years, Meteonorm data,...);
- provide sources, methods and tools for assessing and analysing the outdoor environment parameters;
- provide basic knowledge and methods for assessing the potentialities of exploitation of the outdoor environment resources (e.g. wind and solar energy);
- identify possible critical elements of the outdoor environment relevant for the building design.

**Intellectual skills:**
- knowledge about the main, relevant, meteorological quantities and climate parameters, usually adopted to describe and analyse the outdoor environment (with a special focus on buildings and energy related topics);
- knowledge about the basic concepts of the outdoor environment analysis;
- ability to understand the influence of outdoor climate on the indoor climate and on the energy demand of buildings;
- basic knowledge about RES opportunities.

**Professional/practical skills:**
- capability of finding and/or evaluating the main meteorological quantities;
- capability of finding, understanding, defining and assessing the main climatic parameters;
- capability of assessing the incident solar radiation on surfaces (anyhow oriented) from typical meteorological data or from calculations;
- capability of analysing meteorological data related to wind, solar radiation, temperature;
- capability of performing evaluations about RES exploitation and opportunities.

**Suggestion for Pedagogical Approach:**
The module is based on different teaching and learning methods:
- theoretical lecture;
- simple numerical exercises;
- practical exercises (these will be developed in the “practical educational packages”).

**Educational Package: Indoor Environment**

**General Description:**
The course of Indoor environmental quality (IEQ) within the Fundamental Educational Package will introduce the students to the theoretical background of indoor environmental aspects. It familiarizes students with particular components of indoor environment, their effects and perception by a human, its effect on productivity and though on economic benefits of better IEQ. For four main IEQ components- thermal comfort, indoor air quality, lighting and acoustics – in four lectures it gives definitions, describes modelling, important ideas and values for the design, way of possible assessment and effects of discomfort. In each of these lectures a relevant list of valid standards is available. One lecture is devoted to monitoring and evaluation of IEQ. It reveals different approaches to IEQ assessment. It describes possible approaches to evaluate all of the four IEQ components and it includes description of measurements and appropriate measuring equipment. The student will also obtain a general view on when and how to run a monitoring procedure of IEQ on which level, how long and what components to involve. Last but not least the course speaks about user’s behaviour its effect on IEQ and final energy consumption.

**Main objectives:**
At the end of this course the student will
- understand the indoor environmental issues in a building context;
- understand IEQ effects on building occupants and the building itself;
- understand IEQ assessment principles;
- understand the role of user’s behaviour in building energy performance;
- be able to identify possible sources of discomforts.

**Intellectual and professional skills:**
At the end of this course the student will be able to:
- analyse the problem concerning IEQ;
- identify particular components and relevant values;
- design monitoring procedure to assess IEQ;
- settle values to measure and take the measurement;
- process data obtained from a measurement;
- design measures to improve IEQ.
**Suggestion for Pedagogical Approach:**

Course includes 7(14hrs) theoretical lectures and 1 (3hrs) seminar. Regular attendance of the lectures and seminars is expected. Additional domestic work on the assignments from seminar would probably be necessary. Exam will be written.

**Educational Package: Architectural Quality**

**General Description:**

The “Architectural Quality” package introduces and presents how to create more architecture for less CO2:

- architecture and the built environment can create a physical framework for a future zero energy/emission society;
- a high quality environment for society and its citizens also can deal with challenges of climate change and resource scarcity.

**Main objectives:**

After completing this course, the students will be able to:

- transform various performance criteria into a coherent architectural programme and design for the different stages of the life cycle of a building project, taking into account aesthetics, technical requirements and social factors.

**Intellectual skills:**

After completing this course, the students will be able to:

- understand the role of architecture and the built environment in creating a physical framework for a low-carbon society: the interaction between people, buildings and the environment.

**Professional/practical skills:**

After completing this course, the students will be able to:

- distinguish the parameters necessary to create climate-adapted, energy-efficient buildings that satisfy aesthetic, technical and social requirements;
- assess co-benefits and challenges that arise in interactions between built form and land use, energy demand, supply and generation, climate change and resource scarcity.

**Suggestion for Pedagogical Approach:**

The course will be based on:

- theoretical lectures including case studies and discussion sessions;
- workshops including case studies and discussion sessions. All workshops will be carried out in groups.

**Educational Package: Market, exploitation and organisation of integrated RES**

**General description**

In practice it occurs that in complex projects, integrating Renewable Energy Systems and rational use of Energy in buildings, the technology is often not the main problem and the biggest challenge. However, the organisation of the process and the way how to organise the energy exploitation are major barriers. Designing and constructing (near) energy zero buildings and combining these with a RES only make sense if it is feasible in a sound economic way. Crucial in this process is to have a good understanding of the way how to identify the reference situation as starting point for exploitation models and for a further elaboration of business cases and how to identify the demarcation and boundaries of the different systems. Typical problems in integrated systems, combining RES on the supply side and energy efficient buildings on the demand side are:

- the conflict between high investments in the infra-structure versus the low energy demand (i.e. low profits);
- the organisation of the process (which key actors are necessary) and how to combine different interests, how to come to allocation of costs, risks, benefits etc.;
- how to promote and ‘sell’ the system to decision makers and end-users;
- the side constraints like legal aspects, permits, ownership etc.
It is important that students have at least a basic understanding of the different aspects that play a role in the integrated design process, for a number of aspects this means that the knowledge will be on very basic level (not in detail, but enough to have an understanding and to identify the problems and the specialist to solve it). For other (more technical) aspects a more detailed knowledge is required (like how to optimise and balance energy performances on supply and demand side in relation to the economic and financial aspects).

Main objectives
Objectives of the course are to teach the student:
- the basic principles of energy exploitation, understanding of basics of NPV calculations, price scenarios (inflation, energy costs and investments costs), nature of costs, cash flows, benefits;
- the basics of the financial and economical parameters necessary for assessment of energy concepts (buildings and community systems);
- the basics of the possible legal constraints;
- the basics of organisation structures and key actors.

Intellectual skills
At the end of the course the student is able:
At MSc level:
- to identify the demarcation of RES/buildings/building services as basis for the energy exploitation and marketing;
- to identify and to describe the reference situations for further exploitation and business cases;
- to make comparisons and optimisation of buildings concepts both technical as economical;
- to use and to interpret tools like load duration curves to optimise building and community concepts;
- to describe and to make an inventory of the necessary financial and economical parameters.
At Post Graduate level:
- to identify the necessary key actors and stakeholders in the process and to understand their different roles in the process;
- to have understanding of the possible conflicts between investments on the supply side and the limited energy use on the demand side;
- to understand the basics of tax and grant mechanisms (as understandings, not in detail);
- to understand the basics of legal constraints such as competition law, environmental permits, exploitation permits etc. (as understandings, not in detail).

Professional and practice skills
At the end of the course the student is able:
- to apply exploitation tools and to provide basic input for business cases;
- to assess the different options for energy exploitation;
- to contribute the technical input parameters for a business case;
- to provide the necessary key actors and stakeholders in the process with the necessary information on exploitation and marketing;
- to make a risk analysis and to come to proposals for risk mitigation;
- to provide solutions and to use tools (like heat load duration curves) to solve possible conflicts between investments on the supply side and the limited energy use on the demand side.

Suggestion for Pedagogical Approach
This course has 2 + 2 lectures of 3 hours each. Exercises in class, practice in lecture 2 (energy exploitation models, excel, risk analyses and mitigation), Seminars and interactive cases: 2 for MSc level, 1 for PGr level.
Assignment: elaboration of a case

3.4 Theoretical Educational Packages

The second main part of the IDES-EDU teaching material is the theoretical educational packages. The main topics of building technologies like heating/cooling, ventilation, lighting and energy production are the content of this package.
At the end of this course, the student will be able to:

Since the theoretical educational package covers more specialized topics from the building technologies, compared to the fundamental package, all the materials are not considered to be mandatory. Therefore the contents of the theoretical package can be chosen depending on the background of the master course and postgraduate course students, allowing a high grade of flexibility. This flexibility allows each individual institution to implement the topics according to their educational background as well as to their implementation possibilities in terms of national accreditation requirements.

**Educational Package: Heating/Cooling**

**General Description:**
The Heating and Cooling module within Educational Package is an advanced course of building services focused on analysis and concept of building energy systems – heating and cooling with respect to indoor environmental quality and building energy performance. Different ways about how to create indoor environment are discussed. Lectures contain fundamentals of applied thermodynamics, theory of indoor environmental principles and climate design conditions. One part discusses the passive ways of keeping IEQ and it offers different passive heating/cooling strategies and techniques for the building design. All parts of active heating/cooling systems are introduced and described with their characteristics including designing and sizing aspects. Different approaches to heating/cooling control and commissioning and operation issues are also mentioned. The accompanying seminars are focused on practical knowledge about the topic.

**Main objectives:**
Understanding of the issues of building energy distribution systems focused on heating and cooling in connection with IEQ requirements and building energy performance with respect to integrated design approach.

**Intellectual skills:**
At the end of this course, the student will be able to:
- understand principles of heating and cooling strategies for buildings;
- determine designing conditions in terms of thermal comfort and energy performance;
- identify possibilities of passive way of keeping IEQ;
- select optimal active heating/cooling system;
- choose an optimal control strategy of the system
- understand commissioning and operational issues;
- identify the area for integrated approach aspects.

**Professional/practical skills:**
At the end of this course, the student will be able to:
- optimize heating/cooling loads;
- create building energy concept;
- size the heat emitters and cooling system;
- size the piping network;
- specify requirements on control system.
**Suggestion for Pedagogical Approach:**

Course includes 11 (22hrs) theoretical lectures and 6 (12hrs) seminars following several topics from the lectures.

Regular attendance of the lectures and seminars is expected. Additional domestic work on the assignments from seminars is essential. Exam will be written. Final evaluation combines evaluation from seminars and from the exam.

**Educational Package: Ventilation**

**General description:**

All buildings need a supply of fresh air, not just to provide an appropriate air quality for the health and comfort of the occupants, but also to control condensation, to remove pollutants, and to ensure a safe and efficient operation of some combustion appliances. The amount of the supplied fresh air should match the needs of the building and its occupants. Achieving an energy efficient standard for ventilation requires consideration of both the building fabric and the efficiency of the ventilation system. Ventilation should be thought as a part of an integrated design approach for achieving energy efficiency, whether in new or in existing buildings.

**Main objectives:**

The main objective of this Educational Package is to provide a comprehensive knowledge of ventilation systems, air quality and challenges concerning the utilization of numerical methods in building design. The development of the ventilation systems and the strategies are presented against a background of knowledge about air flow, air pollution and existing numerical methods. The lectures are developed for the students of mechanical engineering, HVAC engineers, architects, building designers, contractors, civil estimators, energy auditors, facility managers and for general audience.

**After completing this module, students will:**

- understand key concepts about natural, mechanical and hybrid ventilations and regulations concerning ventilation;
- acquire knowledge and skills in air flow calculations and physical modelling, in simulation tools (CFD, COMIS, CONTAM…), and in the sizing of the ventilation systems;
- distinguish different types of ventilation systems’ components (natural, mechanical, hybrid…) as well as principles of energy efficient ventilation strategies;
- distinguish and choose the design strategies for successful building ventilation in the integrated design approach evaluate the impact of the outdoor climate and understand the relation between indoor air quality, thermal comfort and energy efficiency.

**Intellectual skills:**

This course will lead the student to be able to:

- describe and discuss the effectiveness of ventilation strategies in buildings and their influence on indoor air quality, thermal comfort and energy efficiency;
- distinguish the difference between basic ventilation concepts (infiltration, natural, mechanical, hybrid…) and the types of ventilation systems (simple flux MCV, double flux MCV, variable air volume (VAV), constant air volume (CAV)…);
- describe the components of ventilation systems and the characteristics of an efficient ventilation design with the correct vocabulary;
- give and critically discuss some examples of buildings with successful ventilation strategies;
- discuss latest developments, current research trends and challenges in the field of building ventilation.

**Professional/practical skills:**

This course will lead the student to be able to:

- carry out basic air flow hand calculation useful in first estimates;
- use computer simulations in a productive way in the analysis, the design and the transformation of architectural spaces for ventilation purposes;
- carry out an annual analysis of air flow in complex spaces using simulation programs;
- take decisions concerning the building design based on the use of the acquired tools (hand calculations or simulations) and critically discuss their choices and its impact on heating and cooling demands and day lighting;
- transmit verbally and graphically the concepts of different types of ventilation, using the appropriate vocabulary and drawings;
- highlight improvements in the field of ventilation through research and consulting questions.

**Suggestion for pedagogical approach:**
People learn from a variety of methods and employ different learning styles. It is well established that people learn best when learning takes place because of intrinsic rather than extrinsic factors. The pedagogical approach employed in this module will provide global comprehensive theoretical courses. Practical works will be oriented on the test beds availability within the department. In the case of an absence of practical exercises within the structure, it will be replaced by mini-projects to implement the theory.

**Educational Package: Lighting**

**General Description:**
Day lighting a building describes the conscious effort to admit natural light into a building. The objectives for doing so are manifold, ranging from a desire to create healthful and stimulating spaces to efforts to reduce energy use for electric lighting and cooling. Integrated with electric lighting, day lighting is an essential component of a good and healthy indoor environment.

The history of architecture has shown that light is a determining element of architectural creation. However, the development of electric lighting and cooling systems in the 1930s transformed the fundamental role that natural light traditionally played in the design of architectural spaces. This development allowed designers to isolate the built form from natural light considerations. Today, it is possible to build spaces without any transparency (or without any opacity!). These technological transformations have also modified the role of the architect as the Master of the luminous character of architectural space. Today, numerous architects rediscover the formal possibilities of natural light as a key aspect to integrate in sustainable, healthy building design.

The interaction of daylight and building form is also an important contributor to the aesthetic experience of a space and day lighting holds today an established position within architectural practice and education. Also, it is important to understand that design decisions regarding openings (size, orientation and properties) not only affect daylight quality and quantity in a space and the resulting electric lighting consumption: they also have a definite impact on heating and cooling loads, thermal comfort and the natural ventilation potential in a space. A versatile lighting and shading solution is essential to ensure a good balance between indoor thermal comfort and natural illumination.

This course will address predominantly topics related to day lighting buildings. However, key issues related to the planning and calculations of electric lighting installations including daylight-electric light integration will also be covered in depth.

**Main objectives:**
At the end of this course, the student will:
- understand key concepts about human vision, visual perception, non-visual effects of light, photometry, lighting calculations, measurements, physical light modelling and simulation tools;
- understand and master key design principles and strategies for successful daylight harvesting and integration in building design;
- distinguish components of daylight systems as well as electric lighting installations and principles of energy efficient architectural lighting design.

**Intellectual skills:**
At the end of this course, the student is able to:
- describe and discuss the influence of the circadian cycle (psychological and biological) in relation to daylight and all concepts related to visual comfort and vision related health.
- describe and discuss the physical parameters which influence light quality and quantity in a space.
- describe material properties in relation to light/daylight in a space.
describe and critically discuss the qualities of a day/light installation, using the correct vocabulary; day lighting systems (glazing systems + shading systems) and technology; electric/daylight integration strategies and technologies.

- distinguish the difference between basic lighting terms e.g. illuminance, luminance, exitance, contrast, daylight factor, discomfort glare, disability glare, daylight autonomy, etc.
- describe day/light sources with all their specificities and discuss the relation between the source characteristics and its effects e.g. difference between direct vs. skylight, overcast vs. clear sky, isometric vs. parallel beam, etc.
- name and critically discuss the work of some light masters (architects) who have integrated daylight in a meaningful, conceptual way in the design of a building;
- discuss current research trends and challenges in the field of architectural day/lighting.

**Professional/practical skills:**
At the end of this course, the student is able to:

- carry out appropriate light measurements (e.g. with a lux and luminance meter) in a full-scale space and use this information in a meaningful way for analysis and transformation of the space;
- carry out basic lighting hand calculations useful in first hand estimates;
- use graphic tools and physical scale modelling in a productive way in analysis, design and transformation of architectural spaces;
- carry out initial shading analysis using BIM programs;
- carry out an annual daylight and glare analysis of complex spaces using simulation programs;
- carry out an annual estimate of building energy demand for lighting using hand calculation or simulation programs;
- carry out day lighting analysis according to the Green Building Council Rating Systems (LEED protocols – Credits 8.1 and 8.2);
- influence design decisions directly based on the use of the tools (hand calculations, graphic tools, physical modelling or simulations);
- communicate verbally and graphically an architectural day/lighting concept, using the appropriate vocabulary;
- identify, qualify and integrate various electric lighting systems and schemes in a day/lit building concept;
- formulate relevant research and/or consulting questions and tasks in connection with day/lighting in buildings.

**Suggestion for Pedagogical Approach:**
The course could be based on:

- theoretical lectures (maximum 12 lectures, 36 hours of lectures including small exercises);
- exercises in class (e.g. on photometric and daylight metric calculations, sizing of electric lighting installations, etc.);
- short formative tests;
- one longer exam (2 hours) covering theoretical aspects (photometry, standard lighting terms).

**Practical assignments:**
Examples of assignments:
Assignment 1: Analysis and representation of three full-scale rooms with three window configurations using measuring devices based on observation, and visual comfort + daylight metrics analysis
Assignment 2: Modification of an existing architectural space for daylight utilization and verification with simulation software.
Assignment 3: Sizing and representation of an electric lighting installation as a function of day lighting in an architectural space.
Assignment 4: Prepare a presentation for a 'client' to explain the advantages of choosing the most adequate solution regarding lighting, shading and including costs for a project and a given project phase.

**Educational Package: Energy Production**

**General Description:**
In the last decade, we pay great attention to technologies that can improve energy efficiency of buildings. Thus, an important contribution to the objectives of the EU's secure energy supply and climate change mitigation can be expected, because more than a third of all final energy is converted
in buildings. Research and engineering achievements are proof that the buildings represent a major potential, both in terms of energy savings, as well as the use of renewable energy sources. To ensure adequate indoor living comfort, three forms of final energy must be provide: heat, cold and electricity. These energy carriers could be supplied through community centralised systems or can be produced by decentralized systems integrated into the building. Such decentralised systems ensure higher efficiency of energy transformations, increased efficiency of renewable energy systems and offer temperature dependant cascade operation of building service systems. Thus, the building does not become a mere zero energy house, but can supply energy to the other consumers.

**Main objectives:**
Module presents technologies for conventional and sustainable decentralized energy production in buildings, integration of such systems in district systems and the methods for energetic, environment and economic evaluation of such technologies. Three energy carriers will be examined: heat, cold and electricity. After completing the course, students will:
- understand the importance and the problems of energy supply in modern society;
- distinguish between non-renewable and renewable energy sources and get knowledge;
- about environmental impact of those energy source;
- distinguish between district (central) and decentralized systems for heat, cold and electricity supply in buildings;
- acquire knowledge about physical principles and efficiencies of advance technologies for heat, cold and electricity supply in buildings;
- acquire knowledge and skills for modelling of performance of decentralized energy supply systems in buildings.

**Intellectual skills:**
After completing the course, student will:
- understands the importance of rational use of energy and environment protection in modern society;
- understands the importance of energy conservation and sustainable energy supply in buildings;
- distinguish between centralized and decentralized energy supply systems;
- be able to describe and discuss the properties of fossil fuel and renewable energy sources powered heat, cold and electricity generators;
- understands the physical and thermodynamic processes in heat, cold and electricity generators;
- be able to discuss and propose concept of decentralized energy supply systems in buildings and their integration into centralized community systems;
- be aware of the latest research trends in field of sustainable decentralized energy supply systems.

**Professional/practical skills:**
After completing the course, student gets skills for:
- understanding advantages and disadvantage of different energy supply systems;
- classifying the technologies for building integrated energy supply systems;
- selecting energy supply system based on viability of district systems and local renewable energy sources;
- carry out basic calculation of design and evaluate devices and systems for the conversion of fossil and renewable energy sources;
- using computer simulation tools for evaluation of decentralized heat, cold and electricity generators based on local conditions;
- interdisciplinary collaboration with experts from other professions involved in buildings energy supply systems;

**Suggestion for Pedagogical Approach:**
Course includes theoretical lectures in the classroom with multimedia tools and teaching methods. Each theoretical lecture will be followed with lab exercises which includes basic calculations of decentralized heating, cooling and electricity supply systems. Short researches are presented in the seminar work. Visit of the best practice examples will be organized. Prerequisites are defined in the Rules of the examination and evaluation of student knowledge. Pedagogical approach encourage regular attendance of lectures and exercises, additional domestic work of complex tasks, the use of
supplementary teaching aids and pre-lab work prior to implementation. Student must pass class tests and examine. The exam is written and oral. The methodology of determining an overall evaluation of the course takes into account student’s individual work.

3.5 Practical Educational Package

The third main part of the IDES-EDU teaching material is the practical educational package. The practical educational package comprises practical methods such as design projects, project work (Problem-Based Learning (PBL) and group work and therefore can be considered the other cornerstone in educating cross-disciplinary candidates. The package aims to transfer the idea of IDP to the IDES-EDU students through practise. Only if the students can experience the integrated design idea through cross-disciplinary teamwork, with learning-by-doing (or PBL), they will understand the impact of integrated design. Therefore the practical educational package is considered to be mandatory.

In the project work (group work) ideally the team members has different professional background to be able to experience the cross-disciplinary approach. Project work encourages the students to engage in self-directed endeavors of exploration. It involves a process of transformation, one filled with challenges and unknown problems. The problem in the MSc within IDES-EDU is to develop at building design which is optimized in terms of energy efficiency, integration of renewables, thermal comfort and health, and costs effectiveness. The project work is also a dynamic, stimulating and socially challenging process where the students, working collaboratively, have to organize work, make decisions and evaluate their results. The project work involves negotiations, dialogues and inquiries relevant to the theme of the building design, and the student draw on lectures, courses and various resources that are available in the course of the semester.

The practical educational package includes a module about cross-disciplinary teamwork, where the student are introduced to knowledge of methods and tools in order to perform teamwork across different disciplines, e.g. between an architect and a mechanical engineer. The module improves the students’ ability to perform cross-disciplinary teamwork within an IDP in practise. The term cross-disciplinary means that a team member is an expert in one field and has basic knowledge in the other fields. Different disciplines also mean different languages. For example the meaning of the word “design” may be understood differently by an architect and by an engineer. The architect may associate definition of space with e.g. walls, windows, daylight and atmosphere, whereas the engineer may associate proper dimensioning of a heating appliance. This simple language example shows that the architect is more dedicated to the whole building, where as the engineer is more focused on a detail. The module cross-disciplinary teamwork aims to give the student knowledge, skills and competences to be able to carry out a project in cooperation with other profession and close the gap between different professions – then the condition for carrying out integrated design is realized.

In order to emphasize the importance of the practical educational package the interrelations of cross-disciplinary topics are demonstrated in figure 4 for the example of solar heating & cooling. The arrows in this figure show the interrelations between the topics. A topic like this can be used for simulation studies with the students. With the help of proper simulation tools (with different grades of detail) the students can experience in a safe environment the effects of different parameter changes and can evaluate how strong the examined interrelation is. Based on these self-studies the students develop step by step the meaning and power of integrated design from a technical (e.g. calculated performance figures) and architectural (e.g. opaque vs. non opaque areas) point of view.
The module of Cross Disciplinary Teamwork package within the Practical Educational Package introduce the students to the practical and theoretical understanding that each design process with the complex network of different designers requires creation of a certain “language”. In the sustainable design process each of the disciplines depends on each other – simultaneously and in cross-reference.

In order to meet the goal of a sustainable driven design, this process must be supported by “the key players” – who will cooperate in a complex network. This network should be set against the background of the Integrated Design Approach, idea of Commissioning etc. showing milestone elements which should be set forth as vital – red flag areas.

Figure 4: Interrelations of cross-disciplinary topics for the example solar heating & cooling emphasizing the connection of architectural and technical aspects within the integrated design approach

In general project work comes from problem-oriented project work. It is a particular brand of problem based learning according to which the students are working in groups in a self-directed manner. A group typically consists of 2 - 5 students. In the MSc within IDES-EDU it is formed on the basis of setting a cross-disciplinary team. By definition, project work deals with real life problems, and the nature and development of the project is negotiated in a continuing dialogue and discussion within the group under the supervision of a teacher. The role of supervisor is mostly held by a faculty member serving as a resource for groups of students engaged in project work. Each student group has one or more supervisors for a project. In other educational contexts this type of role might be known as an advisor or facilitator. The idea in project work is to encourage the students to engage in self-directed endeavours of exploration. That involves a process of transformation, one filled with challenges and unknown problems. The problem in the MSc within IDES-EDU is to develop at building design which is optimised in terms of energy efficiency, integration of renewables, thermal comfort and health, and costs effectiveness. The project work is also a dynamic, stimulating and socially challenging process where the students, working collaboratively, have to organize work, make decisions and evaluate their results which will be further described in the following chapter. The project work will involve negotiations, dialogues and inquiries relevant to the theme of the building design, and they should also draw on lectures, courses and various resources that will be available in the course of the semester.

Educational Package: Cross-disciplinary teamwork

**General Description:**
The module of Cross Disciplinary Teamwork package within the Practical Educational Package introduce the students to the practical and theoretical understanding that each design process with the complex network of different designers requires creation of a certain “language”. In the sustainable design process each of the disciplines depends on each other – simultaneously and in cross-reference.

In order to meet the goal of a sustainable driven design, this process must be supported by “the key players” – who will cooperate in a complex network. This network should be set against the background of the Integrated Design Approach, idea of Commissioning etc. showing milestone elements which should be set forth as vital – red flag areas.
The lectures contain presentations of building examples from practice, designed and constructed with four different set of focuses:
- focus on the architectural / aesthetic aspect;
- focus on the technical aspect – structure engineer;
- focus on the technical aspect – other technical disciplines engineers;
- focus on the economic aspect – investor’s point of view with impact on other solutions.

Theoretical managerial concepts are also being presented, showing how cross disciplinary issues can be perceived from the point of view of different actors. Group workshops will also be carried out. These should train the students to understand the importance of the cross-disciplinary network hidden behind the integrated design approach.

This theory and educational values should be applied to a project at every level of its existence, and include following spheres:
- common language;
- values and policy goals;
- theoretical structure commenting the idea of sustainability, including goals to be included in the real life communities and tasks.

**Main objectives:**
At the end of this course, the student will:
- be able to identify the ways in which the teamwork problem shapes the design process and will be able to integrate basic issues into the teamwork design process;
- understand cross-disciplinary networks in design process;
- understand different approaches and working attitudes of designers, while maintaining one single set of final aim(s);
- understand the principle of developing “a common” language for the design team.

**Intellectual skills:**
At the end of this course, the student is able to:
- develop basic management skills allowing teamwork and cross-disciplinary cooperation;
- describe and discuss principal working strategies: architectural and engineering concepts;
- distinguish between the important level of different design demands and set forth priorities depending on the main aim of the project;
- describe and discuss principals of teamwork in general and cross-disciplinary teamwork.

**Professional/practical skills:**
At the end of this course, the student is able to:
- discuss cross-disciplinary teamwork in design processes;
- identify key elements in specific cross-disciplinary teamwork;
- identify the contribution of different approaches to one’s own discipline.

**Suggestion for Pedagogical Approach:**
The course could be based on:
- theoretical lectures (Lecture 1, Lecture 4);
- practical case studies (Lecture 2, Lecture 3);
- workshops containing discussion sessions based on set forth issues (Workshops 1-4);
- process report prepared within a group showing different experiences and perspectives of understanding teamwork.
4. THE IDES-EDU INTELLIGENT TEACHING PORTAL

An important objective of IDES-EDU is to create an intelligent dynamical and adaptive teaching portal to give access to all the educational material. In order to realize this, the development of the portal main objectives were:
- selection and evaluation of the didactic concepts;
- selection of tools;
- developing the framework of the Multimedia Teaching Portal;
- production of the Multimedia Teaching Portal.

First a selection and evaluation was made of the most suitable didactic concepts. This includes detailed discussion and exchange of ideas about pedagogical approaches and how modern multimedia teaching including e-learning techniques and the internet can be used. As a result the framework for a multimedia teaching portal was created with a number of selected most relevant education packages included. The nature of this framework is that it can be expanded with other educational packages Portal offers the possibility to ‘link’ the educational packages to technical references and standards. The educational approach in IDES-EDU project is characterized by teacher and student integration of centeredness. The teacher is viewed as an authority figure and students are parallel involved in decisions/actions in regard to learning. IDES-EDU educational approach provides opportunities for students for independent, self-supported work, for developing abilities, skills and competences (problem recognizing and solving competences, communication skills, ability to self-supported learning, teamwork, etc.) needed in modern world. IDES-EDU educational approach emphasizes following six aspects of learning process: active, cumulative, individual, goal-oriented, self-regulating, and socially embedded. An IDES-EDU didactic method is a teaching method that follows a consistent scientific approach or educational style to engage the student’s mind. Main ideas of the IDES-EDU didactic concept are as follows:
- the efficient didactic activity centered on learning is interactive, and it is based on the student’s interaction with the information through diverse applications;
- the teacher’s role is modified by the meaning of his development into a collaborator, team colleague, manager of learning situations, and designer of learning experience, tutor. The teacher’s role is changed from a simple transmitter of knowledge, from a basic source of information for the students and for all the answers of their questions as an expert in the teaching subject, into a learning facilitator, trainer, mentor, co-participant in the students’ learning activity;
- the student’s role is modified equally from a passive receiver of information who has to memorize and to reproduce knowledge in a solitary way, into an active participant in the learning process itself. The student produces and classifies knowledge, participates also as a novice and also as an expert, depending of the situation, at the learning activity on class and cooperates with his colleagues to achieve the learning task;
- the educational process is focused more and more on the relation, investigation and research, becoming interactive and motivating;
- the usage of the new technologies implies collaboration, communication, diverse ways to express, access to knowledge and relevant information, respecting everyone’s rhythm and the style of learning, real learning contexts;
- the new learning environment offers sensorial stimulation (multimedia, audio – video, variety of different modeling instruments, intelligent library and computer learning systems, etc.) assure the development of the whole personality of the student.

Pedagogical approaches and didactic concepts can range from enabling access to and authoring of a learning resource to elaborate software systems managing (e.g. learning management system, learning content management systems, learning repositories, adaptive learning hypermedia systems, etc.), managing (human resource management systems; tools for self-directed learning, intelligent library and tutoring system, etc.) the learning process of learners with technical means and different systems integration.

The next step was a selection and evaluation of suitable computer aids and structures, which allow for a communication process between the students and the course instructor, depending on the existing technical framework in the target country. As a preparation for the MTP working session an inventory took place of the learning environments currently in use at the universities and the specific requirements and needs, Therefore different Virtual learning environments have been analyzed. As a result of this inventory Moodle was selected as e-learning environment. The platform was made
operational for the project as well as the intelligent e-library. The Moodle platform can be found by link: 
http://moodle.vgtu.lt/IDES-EDU

Before log in, all modules of IDE-EDU can be seen:
Whole Building and Renewable Energy Concepts (BREC);
Indoor environment (IE);
Outdoor Environment (OE);
Lighting (Lighting);
Market, exploitation and organization of integrated RES (MEO);
Sustainable Building (SB);
Ventilation (Ventilation);
Integrated Design Approach (IDA);
Heating Cooling (HeatCool);
Energy Production (EP);
EPBD (recast, 2010/31/EU) (EPBD);
Architectural Quality (AQ)

To log in:  
username: 33507    password: 20790

For each educational package following additional information is available:
- calculators;
- design and construction guides;
- open source software;
- video.

For the development of the framework of the Teaching Portal four main activities have been performed as follows: definition of interface requirements (user interface), depending on the selected technical systems and on the separate learning modules; testing and evaluation of the navigation structure and presentation possibilities from the students' point of view (including communication opportunities); design of tests and self-control systems (considering study and examination guidelines, improvement of the students' motivation); elaboration of the an Intelligent Library and Tutoring System. Intelligent Library and Tutoring System has the ability to personalize, maximize reuse, index, analyze and integrate valuable information and knowledge from a wide selection of existing sources. All other available tools can be easily being adapted or utilized in the Multimedia Teaching Portal. Other key elements are already available (i.e., Intelligent tutoring system). Intelligent tutoring system is a learning technology that dynamically adapts learning content to objectives, needs, and preferences of a learner by making use of his expertise in instructional methods and the subject to be taught. The IDES-EDU portal is crucial for the European implementation. E-learning is a very efficient but also energy and environmentally friendly way for an efficient and wide implementation in EU. Innovative Multimedia Teaching Portal functions are as follows:
- a consolidated view of educational packages was judged insufficient; learners wanted personalization and customization. Therefore, Multimedia Teaching Portal provides personalized capabilities to its learners;
- it is designed to use distributed learning materials, to provide services from a number of different sources;
- the Portal will have a feature for automated compilation of education packages. Subsystem will be able to compile a rational education package for students and professionals. Much data had to be processed and evaluated in carrying out the multi-variant development and multiple criteria analysis of a rational education package. Numbers of feasible alternatives can be as large as 100,000;
- the Multimedia Teaching Portal can be found by link: http://iti.vgtu.lt/ieepppt/

The task “Production of the Multimedia Teaching Portal“ three main activities have been performed as follows: selection of the most education packages to be included; selection of relevant technical references and standards to link; creation of the multimedia teaching portal based on the Intelligent Library and Tutoring System.

The teaching portal is the general carrier for information of the project, for all institutes, and is also the most important instrument for implementation of the courses carried out during the action.
5. IDES-EDU STUDENT DESIGN COURSES

5.1 Framework of the IDES-EDU student design courses

The design courses
To gain practical experience and skills with the actual design of Nearly Zero Energy Buildings and working in multidisciplinary teams an IDES-EDU design course was organized during the second half of the project. All universities have participated in this design course.

At the start, each university has defined a general framework for the design course, based on the specific possibilities, the boundary conditions on the locations. These frameworks are presented in the results of each design course.

The common target for the design courses is Nearly Zero Energy Building. The students have to calculate the total energy demand of the building for all operating end uses (heating, cooling, lighting, ventilation, appliances,..) in KWh/m2a. Also the fraction of the total annual operating energy provided by on-site renewable energy production is calculated as a percentage from the total energy demand. This percentage has to be nearly 100% to be a zero energy building. The students can choose to make the energy demand as low as possible in combination with building integrated energy production.

The students had to work in multidisciplinary teams in the design courses to elaborate integrated design. The design courses were differently organized by each partner. In some cases it was a summer course, a workshop, or project work.

The designs were also presented in attractive posters.

Realization of education and training building objects
During the project some building objects were actually realized and constructed.
This was the case in Heerlen the Netherlands, Ljubljana Slovenia Budapest Hungary, Zuyd University, Heerlen the Netherlands, will realize in total four building objects.
In all the cases there was an active participation of the students, not only in design but also in construction, commissioning and monitoring.

Budapest University of Technology and Economics, Zuyd University and University of Ljubljana will transfer their knowledge on organizing the building and design process to the other participants. The buildings have a dynamical character; once the basic frame has been completed the buildings will be modified constantly to conduct tests and experiments. They will also serve as local platforms for testing and monitoring new innovative products with a special focus on local innovative SME’s.

5.2 The realized buildings

Design ‘Bent to the Sun’
Zuyd University, Heerlen, the Netherlands

General Framework:
The students had to design a building for the District of Tomorrow in which living and working is integrated. The building has to be zero-energy on a yearly base. This is for heating, cooling, ventilation, lighting and appliances. On a district level the site has to be zero-water. Therefore different measures must be taken on building level so this can be realized. For materials was demanded that 25% of the building materials must be renewable building materials which can grow back in maximum of 50 years’ time.

The District of Tomorrow:
The District of Tomorrow is an innovative program in which education, research, business and government create an inspiring environment together, for the transition to a sustainable built environment in the European Science and Business Park Avantis in Heerlen / Aachen. In this innovative program sustainable techniques will be designed, studied and tested, which can be applied
in the existing cities and neighborhoods in the Euregion. In ‘The District of Tomorrow’, four building objects will be developed, produced, exhibited, exploited and monitored by students, researchers and companies. Zuyd works in this project together with 60 regional companies.

Figure 5: Bent to the Sun, Heerlen, the Netherlands

Evaluation:
The students started the assignment with the idea of making an energy efficient building without looking like one. After a few weeks and some calculations they came to the conclusion that it is quite impossible to realize a net zero building without an integral design. This was a good learning moment for the young architects.

Energy indicators:
Energy demand for space heating, 13 kWh/(m2a) PV panels providing the equivalent to 100% of primary energy used for heating, cooling and DHW.

Energy design:
The building has a very low energy demand for space heating, 13 kWh/(m2a), which make it a “Passive House". This is done by a compact design, passive solar gain in winter by big openings in the south facade, Sun shading in summer by the fixed overhang, and the sloped south facade, well insulated facades and roof, the facades are made out of wooden frameworks with insulation in between and insulation on top, wooden window frames with triple glazing and a thermal bridge in the middle of the frame, the basement is made out of concrete which is insulated on the outside, the concrete is made out of 90% rubble granulate, because of the high mass of this Construction the temperatures will not be too high in summer in the office, windows in the back facade and solar tubes in the front, ensure the basement of enough natural daylight.

Energy exchange:
Mechanical ventilation system with heat recovery
Horizontal ground exchanger: small tubs are horizontally put under the parking ground, so they can be used as a source for the heat pump.
Floor heating, the heating and cooling is done by integrated Floor heating which is used for heating and cooling. In the wooden floors, a “dry” system is used.
Night ventilation: In summer the heat recovery of the mechanical ventilation is turned off in the night, so that cool night air can enter the building. The warm air inside is extra ventilated by thermal differences in the stairwell, and an automatic hatch in the roof.
Smart grid: all the buildings are connected to a smart grid on site. The produced energy on site is distributed and divided between the buildings. The smart grid is connected to the electricity grid to exchange overproduction, and use electricity when there is not enough electricity produced on site.

Design: ‘Self Sufficient Living Cell’
University of Ljubljana, Slovenia

**General Framework:**
The ultimate goal was self-sufficiency and mobility of the Cell. Therefore it consists of five modules, each with its own unique role: residential unit, bedroom in the attic, sanitary unit with shower and toilet, technology unit with kitchen, solar heating and photovoltaic systems and rainwater collection and supply system and the attic of the technological unit with a hot air solar heating system. All units are made by timber frames. Several insulation materials were used such as mineral wool, cellulose and vacuum panels. Students were involved in all building phases, including workshops organized by industrial partners.

**Technical concept:**
The cell is heated by three different solar heating systems while for the power supply photovoltaic system is installed. A system for collecting rain water is also added, waste water is treated in a constructed wetland. Therefore, the unit is not connected to any public municipal system. Cell was built from five functionally related units, which provides the required mobility. All units have been designed with energy systems, in collaboration with more than twenty industrial partners, on the polygon in the Middle Gameljne near Ljubljana. At the end of May all units were transported to a location in the park at Trnovo near Finžgarjeva Street in Ljubljana.

![Figure 6: The Self-sufficient living cell, Ljubljana, Slovenia](image)

**Energy indicators:**
The energy end use demands for all operating end uses (heating, cooling, lighting, ventilation, appliances,...) is 40 kWh/m²a (Q\text{e} + W\text{e}).

Energy needs for heating: \(Q_{\text{NH}} = 28 \text{kWh/m}^2\text{a}\) (at min. \(T_{\text{indoor}} = 17.5^\circ\text{C}\), internal gains 4 W/m²)

The fraction of total annual operating energy (from E2) provided by on-site renewable energy production is 100%.
Cell mobility:
The base of the Cell mobility is its modular design. Cell consists of five modules, each with its own role: residential unit (1); bedroom in the attic (2); sanitary unit with shower and toilet (3); technological unit with kitchen (4) where heating and photovoltaic system and rainwater collection system is situated; and the attic of the technological unit (5) with a hot air solar heating system.

Promotion:
Since the opening in May 2012, project was presented in several articles and TV shows and at international and domestic conferences. Even more important is that Cell attracts very different visitors: from general public to experts, from primary school pupils to professional scholars and university students, from Slovenia and abroad

Heating system
The basic heating system is a solar thermal system with flat-plate solar collectors (1), which are a source of heat for floor and wall heating of living unit and heating radiator of sanitary unit. Living unit is additionally heated with an air solar collector (2), which is a part of the ventilation system of this unit. Living unit is also heated with solar radiator "(3), a mobile receiver in which the heat is stored in paraffin during phase change. Sanitary unit is also heated with the air vacuum solar collector (4). In addition the electricity, which is stored in batteries of PV system, could be used for heating water used in floor heating system.

Integrated building services:
Each of the modules was equipped with systems of building installations before transporting on the final location. This enables "plug-and-play" operation of all systems, after the installation of residential units on the final location. Installations between modules are equipped with technology of "quick connectors". Only the largest elements were transferred separately, for example rainwater tank and batteries of the photovoltaic system.

Ventilation:
In addition to natural ventilation, two mechanical ventilation systems are used in the Cell. Natural ventilation of the living area and the attic is designed separately and is used out of heating season. The window on the facade has smaller part, which can be left open even when it rains or when there are no residents in the Cell. Roof window has a ventilation cavity with protection against precipitation. Due to large height differences between windows, natural ventilation is more intense than usual.
**Smart monitoring:**
The self-sufficient living cell is equipped with a smart monitoring system. This is a user interface with free access. It is adjusted for monitoring of energy flows in the cell. The data shown by the Smart Monitor is generated in the controller, which sets up a website. The user connects his mobile device to the Smart Monitor with wireless Wi-Fi connection.

**Student's evaluation:**
Aleksandra: ‘I've decided to participate in this project already at its first presentation. For students of architecture such opportunities, when at the end building is actually standing, are rare. The idea to build a residential building that isn’t connected to any of the public supply systems was very interesting. During the design process we have learned a lot about the thermal comfort requirements. We were wondering if we'll be able to meet the requirements and if the real performance measurements will confirm our calculations. I'm glad that our building is placed in the centre of Ljubljana where everybody can visit it’.

Uroš: ‘The workshop immediately caught my attention. I saw an opportunity to learn about new construction technologies and use them in architectural solutions. Our building was designed as a self-sufficient, supplied by its own production of heat, electricity and water, as well as responsible waste and waste water management. The project is aimed not only as a study of environmentally friendly construction, but we also want to acquaint general public with these issues and our solutions.’

**Teacher's evaluation:**
Saso Medved: ‘At the Faculty of Mechanical Engineering, we revised curricula to include a series of innovations. Among other things, we believe that the "modern engineer", to addition to their expertise, already during the study at our faculty, needs to gain the ability to co-operate with colleagues in other disciplines. Equally important is the collaboration with industrial development departments. This applies to all areas of engineering, including energy engineering. So I am pleased that our students are also involved in the project and that they've designed the technologies of sustainable energy supply. The project confirms my belief that the work of our graduates is important for Slovenian society and economy.’

**Design: 'Odoo—project Solar Decathlon Europe 2012’**
Budapest University of Technology and economic, Hungary

**General Framework:**
The Solar Decathlon Competition is an international innovation competition between the best universities all around the world, organized by the U.S. Department of Energy and the Spanish Government since 2002. The main goal of the contest is to popularize the usage of solar energy in architectural solutions, to call into being the social and market support of green technologies, to raise awareness among students for renewable energy and energy-efficient structures and the aesthetic and organic integration of solar technologies into building structures. Odoo project from Budapest University of Technology and Economics, the first ever Hungarian team competing on the Solar Decathlon Europe international competition ended up on the 6th place after all in the ranking of the 18 houses in the international field. French, Spanish, Italian and German teams were ahead of the Hungarian team, and other twelve teams from Spain, Romania, Denmark, China, France, Brazil, Japan, Italy and Portugal were behind.

**Energy indicators:**
The energy consumption is 5.775 kWh/ year
The production of energy by PV cells is 13.301 kWh/ year
Project:
The main goal of the contest is innovation in all fields: to popularize the usage of solar energy in architectural solutions, to call into being the social and market support of green technologies, to raise awareness among students for renewable energy and energy-efficiency. As the name of the competition "decathlon" represents: the final result consists of 10 different categories, in which Odoo project won several awards, such as "engineering and construction" 2nd place, "comfort conditions" 2nd place, "energy efficiency" 3rd place, "sustainability" honourable mentioned 4th place, and the project got two honourable mentions in "interior design" and "artificial lighting" categories. On the public's favourite choice the project won the 4th place.

In the end of the competition the house and the team returned to Hungary, and the students reassembled their work in the campus of the university. The Odoo project has been awarded in Hungary as well: with the "Junior Prima Prize" in two categories: architecture and environmentalism, and the team was honoured with the Rector's praise of the university. On the "Media's Architectural Prize" event Odoo project was presented by two architects of the team, and finished on the second place on the award.

The house will be researched and the project will be integrated in the education of the different cooperating faculties of BUTE, and of course it's been open for the interested visitors in Budapest, who has been constantly asking the students about the built in technologies, and materials.

![Figure 7: The Odoo Building, Budapest](image)

**Evaluation by students:**
'We'd suggest to all the students in the university: during your studies participate in a complex project like this one. Look around on your professional field, look for the program that suits your competences and interests the best. Develop yourself, step out from the everyday education-routine, and get the professional and life-experience you'll use in your whole life, and you can enter the labour market with self-confidence. Participate in teamwork where you can develop yourself, not just professionally, but your personal skills, and where you can have unforgettable experiences for a lifetime.'

**Evaluation by teacher**
'Our university considers every initiative that serves Research and Development, we believe that scientific development is one of the most significant conditions of competitiveness and sustainable development. As a research university our mission is to coordinate and develop all the skills, competences and intellectual capacity concentrated at the university by the students and educational members, and serve the expectations of the society and the professional requirements. The Odoo project is a unique sample of combination of teamwork, and self-organizing, autodidactic, mentored education. The students from almost all fields of the university (coming from 6 of the 8 faculties) create something new together, they realize a new form of cooperation, the different professions are forced to make decisions together and the students learn how to take responsibility. As professors, we believe that this kind of cooperation based on interdisciplinarity is the future of an innovative education, when the educator and the educated person can develop themselves together.'
6. IDES-EDU REFERENCE STUDENTS

6.1 Introduction

With 15 universities participating in the IDES-EDU project across Europe, it can be difficult to get a general impression of the students’ experience of education regarding energy in buildings. Therefore 1-2 Reference Students were identified at each university to form the IDES-EDU Student Reference Group. This group was responsible for keeping a good dialogue with the teachers and the Monitoring evaluation team (NTNU) throughout the semester and for encouraging fellow students to participate in the Five-Minute Feedback Form or other forms of feedback.

Prior to the final workshop the students of the reference group reviewed lecture slides and courses. Students selected subjects to review based on their background, field of work, and to some extent based on their common interests too. While some students had experiences from courses using the IDES-EDU material, others were familiar with the same topics though in their respective universities. The students were asked to assess and discuss a range of questions, amongst others:
- are the intended learning outcomes for the course accessible and understandable?
- do the intended learning outcomes feel relevant and achievable?
- do the students have the necessary prerequisite knowledge?
- how do students work on the subject? Do you have any suggestions for improvement?
- are the elements of the lecture constructed in a manner that supports the learning process?
- are any of the elements particularly challenging?
- is the lecture relevant for becoming an expert on energy in buildings?
- does the lecture meet your expectations? What can be improved?
- do you have any comments to particular slides? (Feel free to comments directly in the slides)

In the end of the project a physical meeting of the IDES-EDU Reference Student Group was organized in Maastricht, along with the final meeting of the IDES-EDU project.

6.2 General Framework

Applicants were selected based on their experiences with energy in buildings related courses. Students interested in multidisciplinary project work, integrated energy design, or educational aspects were encouraged to apply by IDES-EDU partners. Past experience from course evaluations or a student reference group was appreciated as part of the selection criteria. Students participating in the joint reference group, representing their respective universities, came from a wide range of disciplines and academic traditions, and with diverse professional experiences. Most students had a background from established (generic) programs in architecture, environmental physics and building engineering on Bachelor- and Master-degree level, while some were currently taking part in relatively new MSc programs more articulated on energy in buildings related topics.

Many of the students had previously been engaged in sustainability related projects and had some experiences from multi-disciplinary problem solving and teamwork. During their education many of the participants had acquired experiences from several institutions and university exchange programs (ERASMUS, summer school etc.). Moreover, students expressed such opportunities as positive experiences that helped broaden their view, critical abilities and self-reflection. This was also mentioned as a motivation and possible outcome of being part of the work in the joint reference group.

6.3 Main messages of the reference student group

Between their recruitment in Spring 2013 and the final workshop, the reference students were made familiar with the IDES-EDU course quality framework. The work of the reference student group culminated in a workshop in Maastricht 23-27 June 2013, arranged in coordination with the final meeting of the IDES-EDU project at the same location and time. The workshop was organized in such a manner that the students had time to develop their own group work, while facilitating for discussion, presentation and interaction with the IDES-EDU partners.

The reference student group defined a range of main messages and priorities based on discussions in the forum prior to the meeting, and the joint introduction of expectations, goals and visions during the final workshop:
- what am I delivering to a building project (added value) from my education?
encourage students to work with other disciplines and to be aware that all disciplines should be involved;
integration as a way of dealing with increasing complexity and specialization;
provide students with the tools and skills to balance specialist/ holistic approaches;
not to educate unison, let students build on their skills and identities as experts/generalists;
both architects and engineers are influenced by “funny” stories during education. Being taught about the supremacy of your own logic prevents integration from happening;
architects and engineers need to be familiar with the other’s language and way of thinking;
generate secure learning environments and sustainable shared values before plunging into cross- disciplinary teamwork;
education that provide continuous capacity to deal with the demands of construction sector and society at large – so that students gain “up-to-date” and relevant competence from building professions;
by following the “IDES-EDU Course quality framework” first generations of graduates become living examples.

6.4 Students key messages

The target of the workshop is to evaluate and comment on the course framework and educational packages developed within the IDES-EDU project. The students first positioned their vision on the most important key innovations in relation to the IDES-EDU results:
- integrated design process;
- sustainability approaches;
- urban design;
- climate zones – passive strategies, active systems and comfort;
- working with tools;
- specialist vs. generalist practitioner;
- renovations, transformations of old buildings and financial aspects;
- economics, laws and regulations;
- connection with professionals;
- reaching the public.

The integrated design process is a new topic for the courses developed in the project, as well as the idea of cross-disciplinary teamwork and organization. It is realized in design theory as well as in workshops. As a general remark regarding sustainability approaches, the students notice:
- meeting needs and requirements are essential in sustainability approach;
- design should be made for people;
- these principles have been covered in different lectures;
- however, the emphasis is mainly on technical aspects;
- there is a need also to include social sciences perspective.

Urban design and NZE community planning is becoming more important when moving towards nZEB. (Renewable) energy systems planning is often moving to a district level, especially when utilizing locally available renewable energy sources. This is not covered directly in the learning material, although some lectures have a relation with community planning.

Another discussion point is the focus on different climate zones, especially in relation to the possible application of passive strategies. It is considered as an important theme and it should also give guidance to the application of low tech solutions versus high tech solutions and passive versus active solutions. It should be covered in all modules.

Finally the profiles of professional were discussed, i.e. specialist vs. generalist practitioners. There should be a balance between scientific and practical approaches. Some IDES-EDU modules are addressing experts, some contain a more holistic approach and knowledge. The students recommend a more practical design advice, workshops and references. This can be implemented as most of the educational packages have seminars and workshops.

The results of the evaluation as well the results of the discussions in the workshop were presented by the students at the end of the day at the ‘Sustainable Café’.
6.5 Detailed notes

How to use the slides?
- continuous adjustment according to new topics and development of existing research topics;
- instead of 15 continuously mathematical slides, rather include more practical advice, good and bad examples, rules of thumb and applications in different climates. This would improve many presentations, especially in the ‘theoretical packages’;
- what are you offering to professionals, life-long learning;
- slides, are they independent of context?
- the slides are not intended for beginners or independently (not a text book). The idea is that an experienced specialist (professor) uses the slide, and adapts them to context and own expertise.

Urban design
- not addressed in the program: How to link supply side to demand side, neighborhood scale;
- outdoor environment; External boundary conditions; context and natural:
  - building level: Designer at the building level, context is often given, but even then you have different options and may have an influence. If you are a consultant at urban scale, political level and;
  - district scale: in the future it becomes more usual to plan energy systems on a district level.

Climate zones – passive strategy
- outdoor environment; Southern Europe deals with urban heat islands problem, while some of these effects may be favorable in North;
- Scandinavian climate becomes more similar to Mediterranean (however, more extreme weather conditions are a severe liability for all);
- difficult to predict performance, balanced ventilation is a safer bet;
- if we accept that the indoor environment will be more flexible in part of the year, adaptive comfort and controllable technical systems may form a good basis for comfortable and energy efficient buildings;
- if we only rely on passive strategies, we are likely not to meet modern requirements for comfort, thus combined, or hybrid solutions are necessary. Different approaches to integration were discussed.
  - typical Low-Energy buildings: Comfortable in winter, overheated in summer;
  - for cross ventilation or stack: Outdoor pollution, and the safety issues with open windows;
  - maintenance issues, as many designs that draws on passive, bioclimatic principles with intentions of ‘low tech’, but end up as ‘high tech’. As these designs may require even more sensors, control strategies and automation devices to work.

Tools
- teach students to be critical, ‘cabbage in – cabbage out’;
- energy, mismatch – heating and cooling.

Sustainability approaches
- we are building for people;
- no social scientists in the developing of material?
- theoretical approach, too much scientific;
- holistic approaches too.

Occupants and stakeholders, reaching the public
- transition management, changing habits;
- how to include this in education?
- how can education help us on this topic?

Financial aspect
- often not prioritized at Universities;
- general overview of economy and cost, where to find it in the different modules.
7. SUCCESS STORIES

7.1 Large interest from both universities as training providers

Numerous national and international presentations on the IDES-EDU project raised an enormous interest from universities and training providers to use the education and training material. A large scale action for continuous professional development has been initiated by REHVA and CHRI. It concerns training of engineers, architects and other professionals in NZEB principles by national REHVA organizations in 12 EU countries. In this action there is a collaboration with Architects Council Europe (ACE) and its national members, CECODHAS Housing Europe and its national housing federations and iiSBE, the International Initiative for a Sustainable Built Environment. In this action about 2000 engineers and 5000 architects could be involved by 2020.

7.2 Successful collaboration between engineers and architects

IDES-EDU has educational packages and lectures both for architects as for engineers. It has also specific educational packages that are dedicated to the collaboration of engineers and architects and working in cross-disciplinary teams (like Integrated design Approach, Whole Building Renewable Energy Concepts, Sustainable Building and Cross-disciplinary Teamwork). In this way the IDES-EDU project initiated a successful collaboration between architects and engineers for a defragmentation of the design process.

7.3 IDES-EDU as an initiator and accelerator for establishing knowledge alliances

One of the reasons for the successful implementation of the IDES-EDU project is the collaboration with national consortia formed by representatives of the building sector. The has led to a new basis of collaboration between universities and local business partners in knowledge alliances in a real Life Learning Lab setting.

Figure 8. Learning in a Real Life Lab Environment
A real Life learning Lab gives better fit students for the regional market and makes tech-studies more attractive. It also supports companies in their innovation process and brings in state-of-the-art knowledge and market experience. It has benefits for university staff by combining theoretical knowledge, research experience, using experiences to update the curricula. For students it offers capacity to work on the real-life cases; educated in a field of knowledge that the market of tomorrow needs. IDES-EDU stood on the basis of a new European pilot on knowledge alliances, the European Real Life Learning Lab Alliance (EURL3A), running under DG EAC. Also Zuyd University, University of Ljubljana and Czech Technical University are partners in this knowledge alliance. It is a collaboration between the local business sector and the educational sector where students work together and study together with professionals.
8. Recommendations for further actions

8.1 Challenges related to definition and evaluation of learning outcomes

Development of educational packages is irrevocably related to discussion and careful evaluation of expected learning outcomes. Aiming to support the education of architects and engineers with solid competency in energy-efficient building design requires experience and knowledge related to physical projects as well as co-operation processes – cross-disciplinary teamwork. Students might learn more from experimenting and failing than from safely repeating established routines. The question is, how is this learning experience facilitated and graded?

Experience has shown that students usually have very ambitious goals related to energy and resource use, but it is a big challenge for them to translate theoretical knowledge into energy and environmental project design, even in the protective environment that constitutes the design studio. The transition from facts to engineering practices must be planned and practiced through small analysis tasks, case studies and reflection and dialogue for it to make sense. This combination of problem-based learning supported by factual information, often related to a limited subject at a time - such as location, material or design - can help students in a clear manner. Such exercises require knowledge of and close cooperation between building practice and research among the teaching staff.

In general, there are three main approaches to learning: a surface approach, mainly based on repetition and memorisation aiming for reproduction during the exam; a procedural deep approach aiming for familiarity with applications and problem-solving procedures and the ability to transfer them to other, similar problems; and a conceptual deep approach relating learning to underlying theory, aiming to gain a deeper understanding. Ideally, the IDES-EDU educational packages would aim to facilitate all three learning approaches in parallel, accustomed to the performance level of the individual student. However, students appear to tailor their learning mode to the type that is perceived as most appropriate during that course. Students may give up on a conceptual deep approach when they perceive that a procedural deep approach or even pure memorisation is more useful to get good grades, a scholarship or similar type of incentive. A large focus on design procedures, assessment methods and evaluation tools may thus help students to master the tools and skills they need in practice to solve problems, but may also reduce their chances of really understanding the problem, taking a critical point of view, and potentially revolutionise the building industry.

8.2 Recommendations to policy makers, external stakeholders and educational institutions

The attention that the topic of energy use in buildings currently receives can be used to build awareness and knowledge about energy and resource use in the building industry and general public. Many experts now make an extra effort to establish solutions that can be implemented in short term, such as guest lectures, and making additional material available online. Such measures are often the result of personal engagement of distinct members of staff, and thus person-dependent and fragmented. In order to have a long-term effect, however, this extra effort that many now provide needs to be supported and institutionalized. IDES-EDU provides an opportunity for investigating such institutionalisation, ensuring the exchange of experiences and development of knowledge between institutions across Europe, including the evaluation and improvement of curriculum, teaching methods, learning and assessment in architecture and engineering education. In addition, a network of national consortia of academic actors, public institutions and the construction industry provide a continuous update of the program’s relevance to architectural and engineering practice.

8.3. Knowledge Alliances and Real Life Learning Labs as knowledge hubs

The IDES-EDU universities see the need for implementation of energy efficiency in buildings and energy supply, also concerning their own building stock. However, the organization of this process is often complex and in many ways, especially on campus scale, similar to energy efficient community planning. The main barrier for universities is that their core business is education, and not energy policy or energy exploitation. Moreover, internal collaboration is necessary between the several faculties together with the facility management and administration, deans and external collaboration with the building sector and ESCO services.
One of the features in the IDES-EDU project is the collaboration with the building sector within national consortia. In a number of cases this has led to the establishment of Knowledge Alliances with the (local) business sectors, using Real Life Learning Labs as interconnecting hubs for knowledge exchange to the business sector. Universities have a significant advantage with their pool of specific high level competences and state of the art knowledge of in house experts for all aspects of sustainable build environment. At the same time, learning and working of students in a real life learning lab situation makes the education process of the students much more efficient and will equip students also with very practical skills. Furthermore, involvement of students in the planning, implementation and assessment of integrated energy solutions will raise a large awareness of students on the importance of NZEB construction and retrofitting. In this way students will become the green entrepreneurs of the future for the construction industry.

The first experiences with the formation of knowledge alliances within the IDES-EDU project, by interconnected hubs for knowledge exchange and competences management, are very promising. The challenge for these Knowledge Alliances is bringing together universities as the knowledge ‘provider’ and private sector as the knowledge ‘consumer’.

A knowledge hub at individual university, in practice defined as RLLL: Real Life Learning Labs, could also facilitate the preparation of work needed for upcoming refurbishments investment projects for university buildings as well as on other buildings. Possibilities for student learning by doing will be exploited to their full potential – with working on buildings students will spend their days in by real life problem solving based learning. The vast industrial experience, applicable solutions and market overview will be combined with knowledge transfer from other hubs, working with students and teachers from different departments in order to start the transition to NZEB.

8.4. Need for continuous professional development in NZEB principles

Construction and renovation of Nearly Zero Energy Buildings requires specific knowledge and skills on several disciplines like architecture, building sustainability, renewable energy supply, energy efficient heating, cooling and ventilation, lighting, indoor environment, whole building renewable energy concepts, etc. To come to optimal energy concepts and, especially for renovation, to come to cost effective solutions, it is necessary to have also an understanding of LCA, energy exploitation and market issues. Next to it, it is important to have an understanding of real energy use in practice versus the calculated energy performance in order to realize NZE buildings in practice and not only ‘on paper’. This means an understanding of all the influence factors, determining real energy use of NZE buildings and the role of quality control and commissioning in the total design, construction and operation process. To come to successful design and construction processes for NZE buildings an integrated design approach should be followed in a multi-disciplinary team environment as proposed by IDES-EDU. All parties involved in this process need a good basic understanding of NZEB principles and the role of the several disciplines that are needed to realize NZE buildings. Also training and education in non-technical issues is necessary, especially on organizational management, legislation, procurement and financing. Training courses on NZEB principles should also contribute to raise the productivity of building constructions and especially renovations by improved organizational management. This means also training courses for coordinators and decision makers of construction and especially renovation of NZEB. Also this training should concern both engineers as architects.

The IEE IDES-EDU project offers the essential basis education material on these NZEB design principles and on cross disciplinary teamwork. The educational packages contain training material both for technical experts (HVAC engineers, energy experts, building physical experts etc.) as for architects and experts on sustainable building. The educational packages offer basic material, which can be translated, modified, customized and combined to specific needs for professional development. As all the relevant and necessary training material is available a swift start can be made by twinning technical partners, (for example from the IDES-EDU team or from relevant previous IEE projects) (with training providers the technical partners will develop the training courses and provide the trainers and/or train the trainers. By working with these experienced training providers, the courses will be recognized by the sector. It offers also the unique possibility to use the potential of existing training courses, for example to update these by integrating the new education material, and using accreditation structures.
9. DISCUSSION AND CONCLUSIONS

In Europe, energy and climate policies started to take shape from the 1990s onwards culminating with the ambitious 20-20-20 climate goals aiming to be met by 2020, and the EU Low Carbon Roadmap 2050 with the ambition of converting EU into a competitive low carbon economy by 2050. As a result, pressure is put on building designers to design buildings with high standards of energy efficiency, performance and comfort.

The IDES-EDU project aims to support requirements of the EPBD by implementing an integrated approach to energy-efficient building design into both architectural and engineering education. IDES-EDU reveals the existing situation in architectural and engineering education across Europe.

A new approach is offered on creating and implementing curricula and training programmes that will educate, train and deliver experts in Integrated Energy-efficient Building Design which are able to work in cross-disciplinary environments. The aim is also to accredit several new master programmes at a great number of European universities. It will support international collaboration among academic institutions and collaboration with professional bodies.

Real implementation of a new educational approach and designing approach faces several challenges within the current educational system and also in practice. If the integrated design approach and cross-disciplinary teamwork should become a common approach in the building industry, all key actors in the process have to agree on it and require it. By putting 15 European Universities together in a project like this and develop at common idea is one step on the way. Next step is to get the first candidates on the market and influence the existing businesses to agree and require new ways of working and thinking in building design.

The question is, how can we create space in education schemes for architects and engineers that will allow successful implementation of integrated design programs? It is the ultimate challenge to implement the whole educational programme for many of the participating educational institutions on master level. However, all institutions implement parts of the educational packages. The least challenging program to implement seems to be within postgraduate education where a training institute or organisation will add this program to its courses and offer it to a wide professional public. In any case the level of success depends highly on the attitude to the integrated approach. People involved – faculty managers, coordinators, teachers etc. – need to acknowledge the importance of integrating knowledge, skills and competences from different disciplines in one education; need to acknowledge the importance of cross-disciplinary teamwork and the importance of learning by doing – e.g. PBL with cross-disciplinary teamwork around a practical building case. It is important that involved parties are open-minded and connect their own field of specialisation with other building disciplines.

Another question is what could be the possible role of the student and professionals educated with IDES-EDU packages in future design teams? In a design team efficient sharing of information is desirable and essential to design energy-efficient (nearly zero) buildings without compromising indoor environment and architectural quality. It is important to have knowledge about dialogue management and skills to determine appropriate timing and assess importance of each partial task in the design and construction process. Therefore, the educational approach implemented within the IDES-EDU project supports required skills for architects, engineers and other members of the team. Firstly, the student will get a basic knowledge of each professional field. Secondly, absorb the idea of integrated design and practise the ability to engage in cross-disciplinary team work, giving valuable expertise on their own contribution to a building project, and the advantage of timely co-operation with others. As a result, professionals graduated from such an educational program will provide the best prerequisite to become invaluable members of a design team, especially when working on buildings with minimal energy and resource use. The candidate could even hold a role of facilitator or project manager in the design team balancing the broad knowledge field and competences in cross-disciplinary teamwork. However the challenge of distributing and taking on responsibility is always present - responsibility for particular methods, tools, solutions, equipment and their proper functioning. As boundaries between professions become less strict in an Integrated Design Process and a lot of interactions appear, contracts and other forms of working agreements with detail specification of territories are needed. However each discipline should still be open-minded to enter other fields of expertise with new knowledge and allow innovation.
To assess if the IDES-EDU project is really strategically successful and sustainable, there are two important questions.

The first question is, will the labour market accept integrated specialists?

The fact is that the building industry has an urgent need for specialists with knowledge and experience in integrated design in order to reach even more strict building requirements in terms of energy and quality of indoor environment towards the aim of EPBD by 2020, and Low Carbon Europe by 2050. Therefore, it is believed that the demands for the candidates will automatically emerge. Cross-disciplinary teams will provide higher quality work in the design stage, improving buildings' performance throughout their entire life cycle. Although the design process will be more complicated and demanding than most actors in the building industry are used to, hopefully through time the industry will recognise that it will result in reduction of difficulties during project design, construction phase and even during operation of the building – and then again reduce the cost.

The second question is whether the IDES-EDU approach in education can in fact change existing scheme of building designing process. The IDES-EDU team common opinion is this is one of the most important steps towards fulfilling the energy and indoor environmental demands of the future. The more people that are acknowledged with the integrated design approach and topics related to that and the more its aspects and benefits are implemented by the design team the better the chances are that EU’s ambitious 20-20-20 climate goals will be met. Nevertheless, the role of the market is considerable.

Finally, cross-disciplinary working in teams and in an integrated design approaches are still quite unknown phenomena in Europe, not only in building practice but also in education. Despite the fact that there are definitely substantial differences in teaching methods and approaches, the IDES-EDU project shows that it is possible to develop and implement an integrated Master and Post Graduate course for nearly zero energy building on a European level. The IDES-EDU team as well as the students involved, are convinced that this project will contribute and facilitate the way to Nearly Zero Energy Building construction and retrofitting, as a common, daily building practice.
Integrated Design Approach Course plan

Lecture 1: Introduction to Integrated Design Approaches
Introduction to the overall concept of integrated design process (IDP) by lecture and video from http://designsynthesis.betterbricks.com/. 
Syllabus: 

Lecture 2-3: Integrated Design Approaches in detail
A selection of three methods of integrated design approaches is presented in detail. Experiences from projects designed with the above presented methods are presented. Additionally, holistic building concept/solutions (whole buildings and/or part of buildings) are presented to exemplify that high architectural quality and good solutions of technical character can coexist. 
Syllabus: 

Very low energy buildings knowledge management models, theories and strategies are introduced. Three case studies illustrating the IDA successfully have been used in practice is presented. Follow-up discussion session about the presented MCDM methods and practical application. 
Syllabus: 
- Intelligent Systems. Available at: http://iti.vgtu.lt/imitacijosmain/praktmoksistem.aspx

Lecture 5: Introduction to design thinking vs. empirical analytical thinking
The following two lectures describe how designers (architects) work in practices and how that is different from empirical analytical thinking (positivistic thinking, engineering). An introduction to this knowledge will illustrate different concepts of thinking which have to work together in an integrated design approach in practice and thereby strengthen the student’s ability to perform integrated design in practice. Two different beliefs within the understanding of design methodology

ANNEX I DESCRIPTIONS OF THE LECTURES – COURSE PLANS

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“Conjecture/Analysis” vs. “Analysis/Synthesis” approaches are outlined. Follow-up discussions on how different disciplines work and think differently.

Syllabus:
- Darke, J. 1979, The primary generator and the design process, Design Studies, vol. 1, no. 1, pp. 36-44.

Lecture 6: Introduction to design thinking vs. empirical analytical thinking
Introduction to design thinking. The notion of how designers think when they are in action is outlined, which contains the explanation of the concepts “Reflection-in-action” and “Knowing-in-practice”. The lecture introduce that design problems are often ill-defined and with a great level of complexity. The design process has little direction and problem and the solution are interdependent – they inform each other. Follow-up discussions on how different disciplines work and think differently.

Syllabus:

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. They will identify the different elements coming from different disciplines and discuss the level of integrated design.
Whole Building and Renewable Energy Concepts (WBREC) Course plan

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. Description and definition of net zero, near zero and plus energy buildings and the interplay between building energy demand and renewable energy production. Solutions for and examples of very low energy buildings and (near) net zero energy buildings.

Syllabus:

Supplementary literature:
- www.activehouse.info;
- www.iea-shc.org/task40/;
- www.boligplus.org.

Lecture 2: Design Strategies for Reduction of Energy Demand
Design considerations and application of a design strategy. Description of the integrated building energy design approach and of the characteristics of integrated building concept. Design strategy for energy efficiency, i.e. for optimum building form, for reduction of heat losses, for increasing building airtightness, for reduction of the need for cooling and the importance of reduction of electricity use. Examples of building construction and envelope solutions.

Syllabus:

Supplementary literature:
- integrated Building Design, Per Heiselberg Aalborg University, Department of Civil Engineering, DCE Lecture Notes No. 017, 2009.

Lecture 3: Design Strategies for Utilization of Climatic Principles
Description of climatic design principles and strategies for utilization of passive energy technologies. Design strategies for use of daylighting, passive cooling (solar shading) and natural cooling in relation to optimum choice of building construction and building envelope solutions. Utilization of night ventilation and heat modulation by thermal mass. Importance of dynamic control of glazed façades in relation to climate and user needs.

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 (energy for heating, cooling, ventilation, lighting, DHW). To identify how passive strategies can be exploited to reduce energy need.

Syllabus:

Supplementary literature:
Lecture 4: Energy Use Control and Occupant Impact


Syllabus:

Supplementary literature:

Lecture 5: Building Integrated Renewable Energy

Examples and development stage of renewable energy solutions for buildings. Interplay between building energy demand, the energy supply system and the building integrated renewable energy system. Building integration of renewable energy production, especially PV. Building and energy supply grid interaction including time dependent import/export of energy, load matching between demand and production and economic impact of grid interaction.

Syllabus:

Lecture 6: Whole Building Design and Simulation Tools


Syllabus:
- building energy and environmental modelling CIBSE AM11 (London: Chartered Institution of Building Services Engineers) (1998);
- energy efficiency in buildings CIBSE Guide F (London: Chartered Institution of Building Services Engineers) (2004);
- fundamentals ASHRAE Handbook (Atlanta, GA: American Society of Heating, Refrigeration and Air Conditioning Engineers) (2009);
Lecture 7: Built Examples

Description of a number of built examples worldwide to illustrate the building concepts and design strategies.

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.

Syllabus:
- www.activehouse.info;
- www.iea-shc.org/task40/.

**EPBD (recast, 2010/31/EU) Course plan**

**Lecture 1: Climate targets, EU energy policy**
Global warming, CO₂ emission, general introduction
Kyoto Protocol, European Climate Change Programme, Climate Action Plan
Energy related EU directives

**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 15217 Energy performance of buildings – Methods for expressing energy performance and for energy certification of buildings
EN15603 Energy performance of buildings – Overall energy use and definition of energy ratings
National certification method

**Lecture 5: Inspection of heating and AC systems**
EN 15378 Heating systems in buildings – Inspection of boilers and heating systems
National method for inspection heating and air-conditioning system

**Lecture 6: EPBD recast – 2010/31/EU**
Cost-optimal minimum energy performance requirements
Requirements of technical building systems
Nearly zero-energy buildings

**Literature**
EPBD (91/2002/EC), EPBD (recast, 2010/31/EU), CEN standards, national regulations
Sustainable Building Course plan

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

Lecture 2: Resource efficiency
This lecture reviews the main methods for achieving resource efficiency in buildings, through design and material selection.
Syllabus:

Lecture 3: Climate change mitigation and adaptation
This lecture addresses the impact of buildings on climate change and the corresponding need for buildings to adapt to climate change. Even with imminent mitigation actions, society will have to face a certain level of climate change impact. The long lifetime of buildings and the built environment necessitates adaptation of new and existing buildings to current and future climate change impact to reduce vulnerability and increase resilience and robustness.
Syllabus:
- EEA (2012) Urban adaptation to climate change in Europe. Challenges and opportunities for cities together with supportive national and European policies. European Environment Agency Report 02/2012. Pdf at http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change/ (pages 6-10; 13-16; 18; 21; 31; 36; 47; 59-60; 77; 82; 85; 89-91);

Lecture 4: Sustainable Building Rating Tools
This lecture presents an overview of the most common sustainable building rating tools.
Syllabus:
- U.S. Green Building Council (USGBC), www.usgbc.org;
- RIAS Byerly Hall (LEED Case Study), http://green.harvard.edu/node/2553.
**Lecture 5: The neighbourhood scale**
The impact of individual buildings on sustainable development, resource efficiency and climate change, while necessary and useful, is limited. In order to create a more widespread benign impact, the neighbourhood and city scales need to be considered to increase energy efficiency in buildings and building clusters, infrastructure and urban form.

Syllabus:

**Lecture 6: Life cycle management**
This lecture addresses management of energy efficiency in buildings throughout their entire life cycle, from early design stages to operation, renovation, transformation and demolition.

Syllabus:

**Lecture 7: Quality Control and Commissioning**
Commissioning is the process of ensuring that a building is in perfect working order and performing exactly as its designer intended and its owner/occupiers require. There is a growing attention for energy efficiency and CO2 reduction but at the same time also for indoor environmental quality and health. Trends in in NZEB and deep renovation leads to the application of advanced and more complex building services, more complex relation between building, architecture and building services. Performances of realized IAQ, thermal comfort, Acoustical quality, etc. This lectures addresses the role of commissioning and quality control to realize a healthy sustainable NZE building in practice.
Outdoor Environment Course plan

The package “Outdoor Environment” is divided into 8 lectures:

**Lecture 1: Introduction**
This lecture introduces basic concepts about the outdoor environment. Difference between climate and weather, difference between meteorological quantities and climate parameters will be addressed. Meteorological quantities, relevant for the sustainable and energy efficient design of buildings, will be defined (air temperature, relative humidity, ground temperature, wind, sky – atmospheric – radiation, solar radiation). Significant climate parameters, like design temperatures, degree days, typical and/or design days, typical months, typical meteorological year, sol-air temperature, are presented. Parameters, classification, generalities about the influence of the outdoor environment on the indoor environment and the energy performance of buildings will be described.
Syllabus: understand the difference between weather and climate, know the meteorological quantities relevant for energy efficiency in buildings, know the mechanism with which the outdoor environment influence the energy efficiency and energy design in buildings.

**Lecture 2: Meteorological Quantities and Climate Parameters**
This lecture introduces and defines the most relevant meteorological quantities and climate parameters. Definition of the air temperature; variation of the air temperature due to daily and seasonal cycles; variation of temperature as a function of latitude and altitude; influencing factors at meso and micro-scale; statistical analysis of air temperature (max, min, daily average, ...); assessment of the design day profile; estimate of the daily temperature profile. Introductions to ground temperature; estimate of the time profile over the year at different depths. Relative humidity; daily variation of RH; influencing factors at meso and micro-scale. Definition of the atmospheric radiation; simplified formulas for the assessment of the atmospheric. Hints about measurements of meteorological quantities. Introduction to the fundamental climate parameters. Definition of the sol-air temperature, scope and use of the Tsol-air and its assessment. Design conditions: definition, scope and use. Design conditions for heating and cooling systems: differences of concepts and approach. Design conditions for heating and humidification. Design conditions for cooling and dehumidification. Summer design day. Extreme design conditions and their use. The degree day concept; use and aim of the degree days. Heating and cooling degree days. Building dynamic energy simulation and required meteorological data. Typical days/months. Typical Meteorological Year - TMY; Test Reference Year - TRY. International Weather for Energy Calculations (IWEC). Tools to artificially generate TMY. Tips about the use of climate parameters.
Syllabus: know and understand the fundamental meteorological quantities (air temperature, relative humidity, ground temperature, atmospheric radiation). Understand the causes that determines air temperature variations; know static data about air temperature. Know how to assess the ground temperature time profiles vs depth. know and understand the fundamental climate parameters (sol-air temperature, design conditions, typical day, months, year). Capability of choosing the correct climate parameter for the intended analysis. Ability to find and manage meteorological quantities and climate parameters.

**Lecture 3: Solar Energy and Solar Radiation**
Syllabus: know and understand the fundamental properties and features of the sun and of solar radiation. Know the spectral features of the solar radiation. Ability to assess the relative position of sun and earth. Capacity of calculating the solar angles and solar position at any time and location on the earth. Understand and use solar plots. Capability of assessing the profile angle and performing a study of the shadings. Ability to determine the extraterrestrial radiation on horizontal and tilted surfaces.
Lecture 4: Available Solar Radiation
Syllabus: knowledge and capacity to use solar data. Understand the effect of the atmosphere on the extraterrestrial solar radiation. Knowledge of clear sky models and capacity to assess the clear-sky radiation. Influence of cloudy days. Assessment of beam and diffuse components of the solar radiation from the knowledge of total solar radiation. Ability to determine hourly radiation from daily data and to assess the solar radiation incident on sloped surfaces (anyhow oriented and located on the earth. Understand and use the concept of utilisability.

Lecture 5: Outdoor lighting
Syllabus: knowledge and capacity to use outdoor lighting data. Understand the effect of different sky types on the light quality and quantity. Understand and quantify the effect of orientation and external obstructions on day lighting.

Lecture 6 - Wind and Wind Energy
Syllabus: knowledge and capacity to “read” and use wind data. Understand the effect of the factors influencing the mean wind speed at micro and meso-scale. Ability to use simplified models to “translate” the reference mean wind speed, measured at the weather stations, into local mean wind speed. Capacity to assess the vertical wind speed profile. General knowledge about wind energy and wind turbines basic concepts.

Lecture 7: Urban Heat Island Effect and Mitigation Techniques
The Urban Heat Island (UHI) effect: physical characteristics. Analysis of the causes and impacts of the urban heat island effect. Measuring the heat islands. Mitigation techniques focusing on the use of appropriate materials and increased vegetation: cool roofs, greenery; estimate of their potential benefits in terms of improved urban environmental quality and reduced ambient temperatures . Presentation of case studies.
Syllabus: Understand the meaning of Urban Heat Island (UHI) effect and know the basic principles. Knowledge about the cause that generates the UHI. Understand what are the factors allowing a mitigation of the Urban Heat Island effect. Ability to judge the general impact of such factors.

Lecture 8: Comfort Indices and Interventions for the Outdoor Environment
Syllabus: Know the basic concepts and features of the urban microclimate. Understand the principles of microclimatic design. Know the fundamentals about the thermal comfort in outdoor spaces and how to quantify it.
Indoor Environment Course plan

Lecture 1: Introduction
The first lecture is an introduction to indoor environmental issues. It explains what the indoor environmental quality (IEQ) is and what are its components that we are dealing with. It speaks about human’s reception and perception. It describes human’s systems and senses and possible discomforts experienced indoors as an effect of different IEQ components. Productivity is discussed from different points of view in the next part of the lecture. Factors that effect IEQ are listed and examples are given. Economic benefits of better IEQ are mentioned. The last part of the lecture deals with different factors that can affect all the components of IEQ and two approaches to evaluate these effects are mentioned – a component related and a holistic approach. Standard EN 15251 is mentioned as it deals with all the components of IEQ in terms of designing and assessment of IEQ.

Syllabus: IE components, human reception and perception, discomforts, adaptation, diseases and disorders, productivity, interactions, indoor environmental factors, factors influencing IEQ, component related approach, bottom-up holistic approach, criteria for classification (EN 15251)

Lecture 2: Thermal Environment
The second lecture is focused on thermal environment. It defines thermal comfort for a human body and how to model it. It explains factors and values that form perception of thermal comfort. A great part of the lecture is devoted to different ways of thermal comfort assessment according to valid standards. It gives optimal value ranges for thermal comfort depending on the level (category) of requirements on the space. It mentions also adaptation and adaptive model of thermal comfort on resultant acceptable range of temperatures, its role in applicable standards and its effect on energy performance.

Syllabus: Thermal Comfort, modeling thermal comfort, PMV, PPD, local discomfort, environmental indices (air temperature, MRT, operative temperature, humidity, psychrometry, effective temperature,….) adaptive model of thermal comfort, EN ISO 7730, EN15251, ASHRAE 55 – 2004, design conditions

Lecture 3: Indoor Air Quality
The third lecture describes indoor air quality. It gives definition and how to assess it. In detail it deals with perceived indoor quality, its modeling and assessment and factors that influence it. Further it lists factors affecting the quality of indoor air coming from outdoors and indoors. Then it describes particular indoor pollutants in details and it gives the limits of its concentrations. The next part of the lecture shows how to model indoor environment in terms of IAQ. The process of running the building in a way of best IAQ is discussed. It describes measures and procedures that should be taken in prevention, ventilation, air purification, monitoring, operation and cleaning. The last part of the lecture deals with sick building syndrome and building related illness.

Syllabus: Indoor air quality (IAQ)- definition, assessment, perceived IAQ, generalized comfort model (olf, pol, decipl units), perceived IAQ and CO2 concentration, age-of-air, factors affecting IAQ (external, internal) common indoor pollutants and their sources (human metabolism, odors, exterior air pollution),IAQ limits, modeling of IAQ, IAQ problems (prevention, ventilation, air purification, monitoring and operation, maintenance), sick building syndrome (SBS)

Lecture 4: Lighting environment
This lecture speaks about light and lighting environment. It describes light, its perception by human eye and issues connected to this process – vision, adaptation and accommodation. Next part of the lecture is focused on measures and units of light – luminous flux, luminous intensity, illuminance and luminance are mentioned. Quality of light is discussed then. Terms like modeling ability, directionality, colour temperature, colour rendering, contrast, glare, illuminance levels, and uniformity are explained with examples. A greater part is devoted to different types of glare and how to avoid or deal with it indoors. The last part mentions the influence of light on human’s health and lists standards and rules on visual comfort.

Syllabus: Light, physiognomy of human eye, accommodation, adaptation, vision, measures and units of light (luminous flux, luminous intensity, illuminance, luminance) perceived brightness, quality of light (modelling ability, directionality, colour temperature, colour rendering, contrast, glare, illuminance levels, uniformity), lighting and health, standards.
Lecture 5: Acoustical environment
The fifth lecture is focused on acoustical environment. The first part is more on acoustics. It starts with general definition of sound and definition of noise. Then it describes 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 (building) acoustical quality. It deals with room acoustical quality, sound insulation between rooms, background noise levels and issues connected. Standards on acoustical comfort and their requirements are mentioned.
Syllabus: Sound, Isofores, noise, sources of noise, sound pressure level, acoustical comfort, room acoustic quality, reverberation time (definition, target values) sound absorbing materials, undesirable echo’s and reflections, reflectogram, sound insulation between rooms, flanking sound, sound leaks, installation noise, background noise levels, noise radiation.

Lecture 6: Monitoring and evaluation of indoor environment
This lecture deals with monitoring and evaluation of IEQ. It reveals different approaches to IEQ assessment. It shows possible approaches to evaluate all of the four IEQ components and it includes description of measurements and appropriate measuring equipment. It describes the process of direct data obtaining from people (users) using questionnaires. It gives a general view on when and how to run a monitoring procedure of IEQ on which level, how long and what components to involve.
Syllabus: Empirical approach (field surveys), analytical approach (climate chamber), Comfort survey, Thermal comfort measurements (standards, indoor parameters, equipment), IAQ measurements (analyzing methods of IAQ, chromatography, spectrometry, photometry, mass spectrometry, chemical sensors, sorbents), equipment), Lighting measurements, Acoustics measurements, Questionnaires, IEQ monitoring procedure.

Lecture 7: User’s behaviour and user’s interaction
The last lecture discusses the role of user’s behaviour in final performance of a building. In many cases the user has the possibility to interact with the whole building and he does so, which may have a very important impact. Possible influences of user on different factors (IEQ, energy consumption) are discussed. Description of measurements of user’s behaviour follows. This lecture contains a lot of examples of the effect of users’ behaviour.
Syllabus: User behaviour, user interaction, influences of the user, effects of user behaviour, measurements of user behaviour, examples, conscious user.

Seminar 1
This exercise is focused on IEQ evaluation of a working space. Measurements of different values describing IEQ components will be taken. The original assignment is based on evaluation of IEQ in terms of thermal comfort and indoor air quality in a small office (laboratory cabin). Basic measurements include measuring of air temperature, globe temperature, air velocity and surrounding surfaces temperature. Students should process obtained data, assess IEQ and design measures to enhance IEQ. This seminar (exercise) can be (will have to be) modified according to actual situation – using a real office, lecture hall..., measuring different values depending on available measuring equipment.
Architectural Quality Course plan

Lecture 1: Architectural Quality and energy efficiency
This lecture gives a general introduction to architecture, architectural quality and its link to energy efficiency.
Syllabus:

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.
Syllabus:

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 synergies to take into account.
Syllabus:

Lecture 4: Landscape and site resources
This lecture reviews 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.
Syllabus:

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. This lecture identifies the main parameters to take into account.
Syllabus:

Lecture 6: How buildings learn
Buildings can have a lifetime of 50-100 years, built environment even longer. During this period, the functionality and materials of the building change due to loss of performance, new use or users, or simply change of fashion. This lecture identifies techniques for creating buildings that are able to adapt to such changing conditions, increasing their lifetime and reducing the need for demolition.

Syllabus:
Market, exploitation and organisation of integrated RES Course plan

**MSc level:**

**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
How to define the reference situation (and the meaning of its significance)
How to make a risk analyses, models for risk assessment and risk mitigation

**Seminar I: Energy exploitation in practice I**
(Prerequisite: knowledge of TRNSYS)
Case: demonstrating the conflict between high investments in the infra structure and the low energy demand (i.e. low profits), 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

**Post Graduate level:**

**Lecture 3: Organisation structures**
Key actors in the process, different forms for energy exploitation
Energy exploitation companies, energy production companies
Role of ESCO's including definitions (EPC, TPF etc), ESCO market in Europe, short introduction to the ESD

**Lecture 4: Constraints**
Legal issues (short introduction), competition law, environmental permits, exploitation permits, ownership, liability, market risks, chain risks
Impact of tax mechanisms (short introduction), impact of grants (short introduction)

**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

**Literature**
For development of ESCO business: [http://re.jrc.ec.europa.eu/energyefficiency](http://re.jrc.ec.europa.eu/energyefficiency) and IEA implementing agreement DSM
Heating/Cooling Course plan

Lecture 1:
Objectives: The first lecture starts with introduction to the building and energy issues. Then it discusses basic laws of thermodynamics emphasizing heat transfer. Next part describes climate conditions for heating and cooling design purposes focusing on outdoor temperatures’ distribution and solar processes. A short description of indoor environmental quality (IEQ) in heating/cooling context follows. A greater part of this lecture is devoted to the determination of heating and cooling loads. Possible ways of energy calculations are shown. The last part deals with different building concepts and some possible heating, cooling and ventilation systems solutions for buildings.
Syllabus: Introduction: Buildings and energy, state of the art, review of applied thermodynamics: basic laws, heat transfer modes - conduction, convection, radiation, transmission; review of applied fluid mechanics: types of flow; governing equations; climate design conditions for heating/cooling design: design temperature, frequency distribution of outdoor temperatures, degree-days, solar radiation; indoor environment: thermal comfort + heating/cooling aspects of thermal comfort, adaptation; energy calculations; nearly zero energy building; examples of building heating and ventilation systems solutions.

Lecture 2, 3: Passive heating and cooling
Objectives: The first step to design an energy efficient building is to minimize its demands. The second and the third lecture show possible approach to building concept design using passive techniques to optimize heating and cooling loads. These techniques should be taken into account before designing any active system. At first the lecture discusses the role of construction and material used, it speaks about building mass, heat storage and special materials like VIP and PCM are. Following part is focused on different elements and strategies that may help to keep higher energy performance of the building. Different techniques like night ventilation, ground heating/cooling, evaporative cooling, cool and green roofs are described. For each of these an example of use in a real building is added. Lecture three presents ways of passive solar energy use. The end of the lecture (or lecture three) is devoted to the issues connected to solar shading.
Syllabus: Construction and material: building mass, heat/cold storage, facades, special materials use: VIP, PCM; night ventilation; ground heating/cooling; evaporative cooling; cool roofs; green roofs; solar energy use: passive systems (solar window, conservatory, solar chimney, trombe wall); solar shading

Lecture 4, 5: Active Space Heating and Cooling
Objectives: When all of the possible passive techniques have been considered, it is time to design an active system to provide indoor environmental quality. These two lectures describe different space heating and cooling systems. It covers heat emitters, radiant heating/cooling, thermal activated building structures and air heating/cooling systems. For all of these systems basic characteristics are given, real examples are shown and possible problems highlighted.
Syllabus: Heat emitters (radiators, convectors, tubular, radiant stripes, dark and light infrared radiant pipes, stoves); Radiant heating and cooling in building surfaces: Floor heating; Wall heating/cooling; Radiant ceiling heating/cooling; Thermal activated building structures; Heating of outdoor surfaces; Air heating/cooling: fundamentals, examples.

Lecture 6, 7: Heat distribution network
Objectives: Lectures 6 and 7 describe the issue of heat distribution network. It starts with the design strategy of a water based heating system. 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.
Syllabus: Water based heating systems: principle, classification, geometry, operational temperature, output, Cooling systems: design concept, principle, temperature, geometry; piping network: materials, insulation, linear dilatation; Safety devices: heating, cooling

Lecture 8, 9: Heating and cooling systems control and operation
Objectives: Lectures 8, 9 deal with the control and operation of heating/cooling systems. At first fundamentals of control are explained and classification according to EN 12828 is mentioned. 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 and intelligent buildings. The last part deals with commissioning, operation and energy audit. Syllabus: Fundamentals of control: control circuit principle; heating systems control: classification – en 12828, examples; technical background, controllers, actuators, output control; cooling systems control: source control, distribution network control; predictive control; intelligent buildings; commissioning; operation: operation, remote management; energy audit.

Lecture 10: Design and Analysis Tools
Objectives: Lecture 10 focuses on calculations connected to heating/cooling systems design. It discusses 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. It starts with tools just for pipe network design then it moves on to modelling and simulation. Several tools for whole building energy performance simulation are mentioned. A case study on the use of energy simulation tool for the design is presented. The lecture ends with description of CFD simulation tools. The very last part is devoted to the procedure of using simulation and it mentions when it is convenient to use it for the design.
Syllabus: Hydraulic calculations (two-pipes, one-pipe systems - pipes diameter, pressure loss, control valves settings, pump power, hydraulic stability); Calculation tools; Modelling and simulation – energy performance: (tools, ESP-r, IES, TRNSYS, IDA, ENERGY +, Design Builder); Modelling and simulation – IEQ: CFD (Flovent, Fluent, ...)

Lecture 11: Parametric models and the latest developments
Objectives: Lecture 11 deals with parametric models. It discusses 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. The whole procedure is shown on a case study of a single family house. The last part of the lecture being at the same time the last part of the whole course is devoted to latest trends and development in a heating /cooling field. In general it speaks about different ways of energy saving potential in buildings.
Syllabus: Parametric models; design of experiments; parametric models for heating and cooling; parametric models' development; case study; the latest trends and developments in a heating/cooling field.

Seminars
There are six seminars supposed. During the seminars three assignments will be explained and consulted.

Seminar 1, 2: Building analysis, H/C needs and loads optimisation
Objectives: Assignment 1 is focused on understanding of principle of heating and cooling load calculation (kW) and annual H/C energy need calculation (kWh), using realistic building in real situation. After calculation of initial version of the building, student will find critical building parameters affecting energy needs and loads. Based on this analysis students will optimise the building parameters to minimise the energy needs and loads. Outcomes of this seminar will be floor plans drawings in the scale 1:50 - 1:10, table of rooms (purpose, temperatures, design heat and cooling load) and report about energy needs optimisation.
Syllabus: design heat and cooling loads, annual heating and cooling energy needs, design indoor conditions, design climate conditions

Seminar 3,4: Space heating and cooling concept and emitters design
Objectives: Assignment 2 is focused on designing of space heating and cooling concept and sizing of the heating and cooling emitters. Creating several alternatives evaluated by multi-criterion analysis students will find optimal solution for given types of rooms. To integrate the emitters into the building structure students will find critical details. Outcomes of this assignment will be report about H/C concept alternatives and multi-criterion analysis, table of rooms with the technical specification of the heat and cooling emitters and floor plans drawings with heat and cooling emitters.
Syllabus: space heating and cooling concept, heat emitters design
**Seminar 5,6: Hydraulic system design**

Objectives: Assignment 3 is focused on hydraulic heating system design. For selected part of real building will student design geometry of 2-pipe water heating system and draw plans and hydraulic scheme. This system will size according to velocity and find critical branch for pressure loss calculation. In the final will be pump parameters specified. Outcome: Plan of local heating system, pipe dimensions design, pump design.

Objectives: Hydronic heating system, pressure losses calculation, circulation pump design
Ventilation Course plan:

Lecture 1: Typical ventilation design concepts and strategies
This lecture introduces basic concepts about ventilation background, presenting which are the reasons to ventilate an enclosed space. The two ways of building ventilation are introduced, notions about ventilation and air quality. To understand the importance of the comfort ventilation systems in low energy buildings it is first necessary to be clear about relationship between insulation and air tightness. While this may appear obvious, it is experience that there is a great deal of confusion about the contribution the two make to energy efficient buildings, and their interrelationship. The two natural mechanisms of ventilation and three-pronged recommended strategy for ventilation develop forward the students’ knowledge in this field. Energy use in the building sector accounts for 40% of EU’s energy requirement and offers the largest single potential for improving energy efficiency, so energy impact of ventilation and evaluation of required ventilation rate are discussed.
Syllabus: understand the basic concepts about ventilation, know the two ways of building ventilation, understand the importance of the comfort ventilation systems in low energy buildings, and know two natural mechanisms of ventilation and which the energy impact of ventilation is.

Lecture 2: Natural ventilation
This lecture is dedicated to natural ventilation principles and strategies. The role of the ventilation in buildings is to maintain acceptable levels of oxygen in air and to remove odors, moisture, and internal pollutants. It may also remove excess heat by direct cooling or by using the building thermal mass. The advantages and disadvantages of natural ventilation are presented together with the technical solutions which can be applied. For a better understanding of this theoretical part few relevant case studies are described.
Syllabus: understand natural ventilation principles and strategies, know the role of the ventilation in buildings, understand the advantages and disadvantages of natural ventilation, know the technical solutions for natural ventilation.

Lecture 3: Mechanical (forced) ventilation
Mechanical ventilation is the active process of supplying air to or removing air from an indoor space by powered equipment such as fans and blowers. Buildings with mechanical ventilation use fans to supply air to, and exhaust air from, the rooms. Depending on demand, the supply air may be heated, cooled or humidified. The ventilation system may be equipped to recover heat from the exhaust air. The system may also re-circulate extract air. The description of supply-only ventilation system (SOV), extract-only ventilation system and balanced ventilation system is provided, together with the advantages and disadvantages of each method. Most manufacturing plants use fans and blowers for ventilation and for industrial processes that need an air flow. Fan systems are essential to achieve mechanical ventilation. Fans and blowers, basic acoustic terminologies are presented during this lecture also. Without attention to sound and vibration control, the design, installation, and use of HVAC systems can result in complaints due to an unacceptable acoustical environment. Noise sources, design criteria and air filters come to complete the knowledge for this part.
Syllabus: understand mechanical ventilation principles and strategies, understand 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
Displacement ventilation takes advantage of the difference in air temperature and density between an upper contaminated zone and a lower clean zone. Displacement Ventilation backgrounds are presented together with its characteristics. As in piston ventilation DV method also relies on the displacement of room air by a fresh supply of outdoor air but in a less discreet way than in piston ventilation. Displacement ventilation is used in buildings with large occupancy and internal heat gains where mainly cooling is required. Unlike piston ventilation where the driving force is mainly the momentum of supply air, here momentum is usually small and buoyancy is the dominant force in the creation of room air movement. There are upward and downward displacement ventilation systems. A comparison between displacement ventilation and mixing ventilation reveals the differences between the two methods. Ventilation effectiveness is a description of an air distribution system’s ability to remove internally generated pollutants from a building, zone, or space. Ventilation Effectiveness, Design Considerations (Thermal Comfort, Humidity Control, Acoustics, Designing with
AHUs and RTUs, Diffuser Type, Layout and Location). DV Supply Air Methods are also discussed within this lecture. Case Studies have the goal to better understand the theoretical part and are discussed at the end of the lecture.

Syllabus: understand displacement ventilation principles and strategies, understand the advantages and disadvantages of displacement ventilation vs. mixing ventilation, know the ventilation effectiveness, design considerations, understand the displacement ventilation method applied in case studies.

**Lecture 5: Hybrid ventilation systems**
Reasons for ventilation and consequences of poor air quality, IAQ strategy, ventilation volume, natural ventilation, mechanical ventilation, typical energy consumption for different types of office buildings are presented in the introductory level of this lecture in order to prepare the student for achieving and understanding hybrid ventilation system, which are the main object of the lecture. Hybrid ventilation combines features of both mechanical and natural ventilation. The simplest often used definition of hybrid ventilation is “ventilation system that uses natural air intake through wall inlets in combination with mechanical extraction”. Although the mentioned ventilation systems certainly belong to the hybrid ventilation systems, the group of hybrid ventilation systems is considerably wider with the decisions quite different and strongly connected with the architectural design of the building. Ventilation strategy, Demand Controlled Hybrid Ventilation, Flow versus time over the year, Flow stability, Ventilation for IAQ, Classification, Hybrid ventilation strategies, Components for hybrid ventilation concepts, Natural ventilation concept based on wind effect, Development stages for hybrid systems are the next levels presented during this lecture. Detailed classes of hybrid ventilation systems, Variability of Flow Pattern, optimization, and case studies come at the end to fix the presented acknowledgments.

Syllabus: 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, understand the hybrid ventilation method applied in case studies.

**Lecture 6: Simulating and predicting ventilation effect in buildings**
Ventilation modeling strategies are presented, starting with nodal modeling, (multi-zonal), zonal models, CFD in ventilation design, ventilation simulation tools. At the end of the lecture case studies with applied ventilation simulation strategies are discussed.

Syllabus: 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, Critical Barriers, Building design are discussed during this lecture. Syllabus: the student achieves acknowledgments regarding designing natural ventilation systems.

**Lecture 8: Sizing mechanical ventilation systems**
Introduction, Components involved, Air Flow Generalities, Calculation of Flow Rate, Air Change Rates, Ventilation Design Methodology, Sizing Methodology, Sizing procedure, Design Criteria, Ventilation Calculations, Number of Fans and Grilles, Drawings, Size Ductwork, Methods of designing ductwork and fan, Size ductwork, Pressure Loss in Fittings, Duct Sizing Table, Some Duct Sizing Aids, Equivalent Diameter, Types of fan, fan capacity diagrams, choosing fans, Characteristic curves of a fan, Choosing fan, Size Grilles and Diffusers, types of grille and diffuser, duct cleaning, cleaning phases, Heat loss by ventilation, Minimize the impact of the mechanical, Mechanical extract supply are the acknowledgments presented.

Syllabus: the student achieves acknowledgments regarding designing mechanical ventilation systems.

**Lecture 9: Sizing displacement and hybrid ventilation systems**
Design Concept, Design Concept- Chilled Ceiling Panels, Component Selection, Installation, Cooling Flow Rate, Design Procedure and examples are discussed during the lecture.

Syllabus: the student achieves acknowledgments regarding designing displacement and hybrid ventilation systems.

**Lecture 10: Commissioning, control and measures in ventilation**
Testing of Ventilation System, Recommended Procedure for Initial Ventilation Test, Recommend Procedure for Periodic Testing, Measurement of Volumetric Flow Rate, Pressure Measurement, Instruments Used for Pressure Measurements, Hood Static Pressure, Equation for Flow Rate, Velocity Pressure are discussed. For other than standard conditions, equivalent velocity pressure, Pitot Traverse Method, Air Velocity Measuring Instruments, Rotating Vane Anemometer, Swinging Vane/Thermal Anemometer, Tracer Gas Method, Calibration of Air Measuring Instruments, Corrections for Non Standard Conditions, Difficulties Encountered in Field Measurement, Sensors, Blower door test, Cleanliness criteria for ventilation systems, Design principles of a clean ventilation system, Installing a clean ventilation system, Verification of the cleanliness of ventilation system, Report and documentation, Filter as a Biotope, Filtration – costs, Why Air filters - Ventilation system, Why Air filters - Hygiene (IAQ), We know – example, Air Filters – IAQ problems, Perceived air, Standards – Recommendations, Hygienic aspects – Design, Acceptability of filtered air, Air filters-possibilities are the next levels during this lecture. Air Filtration today – tomorrow and case studies come in the end to clarify the lecture purpose.

Syllabus: know commissioning, control and measures in ventilation at design level.

Lecture 11: Latest developments in ventilation
Invited researchers: Soren Aggerholm (SBI, Denmark), Claude-Alain Roulet (EPFL, Switzerland), Mat Santamouris (NKUA, Greece), Francis Allard (ULR, France), Christian Ghiaus (INSA, France) will present to the students important conclusions about ventilation systems achieved from experience.

Syllabus: latest developments in ventilation.

Practical assignments, e.g.:
Assignment 1: Analysis of the indoor air distribution in three full-scale rooms with three different window openings using simulation software (Fluent, Flovent, OpenFOAM, Energy-Plus, TrnSys, CONTAM...)
Assignment 2: Modification of an existing architectural space for natural ventilation and verification with simulation software
Assignment 3: Sizing and representation of a mechanical ventilation system in a simple building
Lighting Course plan

Lecture 1: Introduction to lighting and daylighting –
- Regulations, certifications and directives (45 + 45 minutes, introductory level)
Historical perspective on day lighting and lighting in buildings, daylight and sustainability, day lighting credits in certification systems (LEED and BREEAM), luminous efficacy issue in relation to light and daylight, additional benefits of day lighting, electricity use for lights in buildings, strategies for reducing electric light consumption, etc.

Lecture 2: Perception, visual and non-visual effects of light (45 + 45 + 45 minutes, introductory level)
Visual perception, vision, physionomy 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 (UGR, DGI, DGP, etc.), direct/indirect glare, norms and rules to ensure visual comfort, absolute luminance, luminance ratios, illuminance uniformity, etc.
Visual and non-visual pathways in the brain, non-visual effects of light, spectral distribution of the non-visual response, photobiology, circadian cycles, third receptor, hormones, melatonin, cortisol, blue and red light, update on recent photobiology research

Lecture 3: Photometry and colour (45+45 minutes, introductory level)
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, candelas, nits, brightness, inverse square law, cosine law, Lambert’s law
Colour vision and perception, colour theory, spectral power distribution, correlated colour temperature (CCT), colour space, color rendering index (CRI), colorimetric systems, brightness (lightness), saturation, hue

Lecture 4 and 5: Electric light sources, luminaires and architectural lighting strategies (45+45+45 minutes, introductory and design level)
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
Light fixtures, luminaires, direct, indirect, direct-indirect, indirect-direct, diffuse, indicatrix of diffusion, ballasts, conventional ballasts, electronic ballasts, maintenance factor, utilization factor, light output ratio (LOR), utilance, application efficacy, time of use, simple calculation of the building energy demand for lighting through the LENI index, other simple lighting calculations
Architectural lighting design, electric lighting installations, general lighting, localised lighting, task lighting, ambient lighting, accent lighting, architectural lighting, decorative lighting, lighting transitions, light distribution

Lecture 6-7: Daylighting design strategies (45+45 minutes, introductory level)
Daylight utilization and related energy savings, benefits and risks associated with daylight utilization, luminous efficacy
Sky types, CIE overcast-, clear-, intermediate sky, daylight availability according to climate, daylight factor, daylight factor calculation and analysis, direct component, externally and internally reflected components, climate-based day lighting metrics, useful daylight illuminance (UDI), daylight autonomy, continuous daylight autonomy, maximum daylight autonomy, daylight saturation percentage.
Passive and active day lighting systems, site and orientation, plan or section depth, floor plate geometry, windows, window area, position, shape, glazing type and characteristics
Partitions geometry and characteristics, visual protection, shading devices, daylight redirection systems, skylights, light tubes, light distribution/reflection, atria, courtyard depth

Lecture 8-9: Daylight design and evaluation tools (45+45 minutes, design level)
Validation strategies and methods, manual calculations, equation of Trezenga & Loe (LumCalcul),
Lumen method, DF method, graphical method for the evaluation of daylight conditions (Barbara Matusiak), graphic tools (design nomograms, BRS Daylight Factor Protractor, dot charts, NB Method, Graphic Daylight Design Method (GDDM), Collection CIE 2000 on glare)
Radiosity, ray-tracing, photon-mapping, Radiance Lighting Simulation System, Evalglare, Autodesk Ecotect, Daysim, other programs (Leso-DIAL, Genelux, Lumen Micro, Calculux, Adeline, Superlite, Lightscape Viewset, Radiosity, ReLux, Daylight 1-2-3). Predicting electric lighting energy use, advanced glare analysis, modeling light and health phenomena, modeling advanced materials, modeling occupant behavior.
Physical models (real sky, sundial, artificial sky, mirror box sky, hemispherical sky), spreadsheets, light measuring devices, photocells, luxmeter, luminance meter, spectroradiometer, artificial skies, etc.

**Lecture 10, 11: Commissioning and control and latest trends in lighting research (45+45+45+45 minutes, introductory level)**

Lighting control systems, occupancy control, presence control, absence control, infra-red, movement, ultra-sound, daylight or photelectric dimming, switch-off, constant, step dimming, integration of day lighting and electric lighting, commissioning issues, etc.
Latest trends in lighting research and development, active day lighting systems (Parans, etc), light tubes and pipes, specific daylight redirecting systems, algoritmic controls, etc.
Energy Production Course plan

Lecture 1: Energy carriers
Overview of energy demand and supply on the world and national scale will be presented. Primary energy sources – fossil fuels, uranium and renewable energy sources will be described and reserve of non-renewable and potential of renewable energy sources will be explained. The connection between energy demand and environment impacts will be addressed. Efficiency of technologies for converting primary energy sources into the final energy carriers will be shown. Scenarios of energy demand and supply together with climate scenarios in 21 century will be presented.
Syllabus: Energy demand and supply in modern society, fossil fuels, origin and transforming in final energy carriers, supply of fossil fuels; U 235 and nuclear power plants, renewable energy sources – solar, biomass, wind, hydro, geothermal, ocean energy, global potential of RES, hydrogen production, transportation and storing, waste as fuel, climate scenarios, how to achieve 2K climate scenario.

Lecture 2: Heat generators – fossil fuels and biomass
Heat represents dominant demand in buildings. Ventilation, space heating, air-conditioning, tap water heating system all needs heat. More over advance systems for cooling also need heat for the operation. Heat is generated in buildings mainly by combustion of fuels in heat generators. In heat generator or boilers, internal (chemical) energy is transformed into heat by oxidation. Such reaction can be achieved by using solid, liquid or gas fossil fuels as well as solid fuels made from biomass. Different technologies of boilers regarding to the fuel type will be presented in the lecture. Flue gases are by products of heat. Flue gasses consists substances dangerous to the environment, especially to the atmosphere. There are several technologies enable reduction of such substances in flue gasses, for example condensation boilers or low-NOx burners. They will be presented in lecture as well.
Syllabus: Combustion of fossil fuels and biomass, stehiometrics of burning, modelling of emissions, technology of oil and gas boilers, technology of biomass boilers, incinerators, environment protection technologies (reduction of CO, SO2, NOx in flue gasses), condensation techniques, efficiency of the boilers at nominal and reduced power, sizing the boilers.

Lecture 3: Heat pumps
Buildings become much more energy efficient in last decades. This results bought in lower heat load and heat demand. Lower temperature for heating and smaller device is needed in such buildings. That’s why heat pumps become very popular nowadays. Heat pump is a device that takes unuseful heat from cold environment in winter time and convert it into useful high temperature heat for space heating and tap water heating with addition small amount of electricity to run the compressor. In most cases heat pumps take heat from surrounding air, earth or ground water. Heat pump can be combined with ventilation systems in compact units or can be used for cooling during the summer period as well. In such way, the economics of heat pump can be essentially improved.
Syllabus: Thermodynamic cycle and thermodynamic limitations of heat pumps, mono-and bivalent operation of heat pumps and bivalent temperature, efficacy of heat pumps regarding to the temperature of heat source and temperature of heat carrier; heat sources, heat sources properties, sizing of heat pumps and heat exchangers, heat pumps in compact ventilation units, heat pumps and environment issues.

Lecture 4: Solar collectors
As mentioned in lecture 4, buildings become much more energy efficient and lower heat load and heat demand of buildings is result of that. Besides the space heating, heat is needed for tap water heating. Curiosity is, that heat demand for tap water heating in such building is larger than heat needed for space heating. Since tap water is needed all year, solar heating is one of the most effective way for decreasing energy consumption for heating in buildings. Such systems consists several components such as solar collectors, heat storage, pipelines, pumps, safety and regulation units. Meanwhile liquids (water or mixture of water and non-freezing fluid) are most often used, air can be also used as heat transfer fluid. Solar collectors will be describer in this lecture.
Syllabus: Potential of solar energy, solar radiation on tilted surface, heat transfer in solar collectors, improving of solar collector efficiency, solar collectors technologies

Lecture 5: Earth heat exchangers for air pre-heating and pre-cooling
Low energy building and particularly passive buildings must be ventilated by mechanical system. Frequently ground heat exchangers are attached to such systems. Ground heat exchangers are made from pipe buried 1 to 2 m beneath the ground surface. Fresh ventilation are flows through such heat exchanger and pre-heated during winter and pre-cooled during the summer. In such a way, condensation of water vapour in recuperator of ventilation system, can be avoided and no mechanical cooling is needed during the summer. In larger system water filled ground heat exchanger can be use for reducing energy consumption for operation.

Syllabus: Modelling of time dependant ground temperatures, heat transfer in air and water ground heat exchanger, all year efficiency, sizing of ground heat exchangers, possible microbiotic problems. Most often heat pumps use mechanical electricity driven compressor to compress working fluid. This increase electricity load and demand. Instead of electro motor, gas driven absorption or gas driven engine can be used. Such devices will be described in the lecture.


Lecture 6: Cooling compressor
For conventional cooling of the buildings cold water is used as energy carrier. In most cases it is produces by compressor cooling units. In the lecture principles, environment aspects and efficiencies of such devices will be presented.

Syllabus: compressor cooling cycle, nominal and all year efficiency, outdoor heat exchangers, sizing of the boilers and cooling units

Lecture 7: Evaporative cooling
One of the most used bionics principle in building service systems are evaporative cooling. This is a process of water evaporation driven by internal energy of surrounding air. The result is heat transfer from air into water droplets, causing the decrease of air temperature. That's why the grass fields, water layers and especially the trees, mitigate urban climate heat island. Unfortunately during evaporative cooling, air becomes moistened and probably causing unpleasant indoor living condition. But evaporative cooling can be implemented for cooling of the buildings if such process is used for moistening and cooling of extract air and that fresh air can be cooled by heat exchanger. Evaporative cooling can be implemented in so called open cycle solar cooling. In this case fresh air is dried first using adsorption/absorption mater and after that moistened with water spray or fog and therefore cooled without danger to be to humid. Solar energy or waste heat could be used to drying adsorption/absorption mater in continuous process. Such units could be integrated into ordinary air conditioning systems as well. Thermodynamic fundamentals, modelling of evaporative cooling systems and components of such systems will be presented in the lecture.

Syllabus: thermodynamic processes of evaporative cooling, influence of climate on evaporative cooling, presentation of process in x-t diagrams, modelling of heat and vapour transport in system components, sizing of systems, examples of market available solutions of conventional air-conditioning and solar driven systems, economics of evaporative cooling

Lecture 8: Solar cooling
Evaporative cooling cloud be sufficient for most of the buildings with quality shading devises if climate is moderate and dry, conventional cooling system operates with water cooled from 5 to 10°C using compressor chillers are still widely use. It is quite often that during the summer, surplus of heat emerge in the building, like waste heat from cogeneration or surplus heat from solar heating system. In this case systems, that convert the heat into cold, can be used. These are so called sorption cooling systems. In this case electricity driven compressor is replaced by pump and mixture of two liquids (in case of absorption cooling) or solid and liquid (in case of adsorption cooling) responsible for endothermic chemical reaction. Such replacement results in much lower electricity consumption providing similar low temperatures of cooling water as in case of conventional systems. Heat needed for cold heat generation can be produced by high efficient flat or concentrated solar collectors as well. Sorption cooling system are well known for several years, but nowadays developments in field of down-sizing and using solar energy is most attractive from building applications.

Syllabus: 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, extract heat and temperature of cooling fluid, modelling of sorption cooling, market available
Lecture 9: PV electricity generation
EU directive on “Green electricity” established in 2003, provides legal basis and targets for electricity production from RES for all EU member states. It looks like that one technology, called photovoltaic, benefit mostly from this directive. Photovoltaic systems consist of large number of solar cells gathered in solar panels or modules, convert solar energy directly into electricity. Implementation of this technology grows rapidly in last two decades. In the lecture physical principles of generation and splitting the electrons by photons and voltage barrier in solar cell will be discussed. There are several
similar, but low efficiency in the range between 10 and 18%. Despite low efficiency of photovoltaic
from so called “feed-in-tariff” subsidies.
Syllabus: physical principles of solar cell operation, I-U curve of solar cell, theoretical limitation of solar
cell efficiency, influence of solar radiation and cell temperature on efficiency, types of solar cell, solar
modules, modelling of electricity production, sizing of off- and on-grid PV systems, economics of PV,
environment issues of PV systems

Lecture 10: Small scale cogeneration (gas-piston engine, gas-turbine, biomass – Stirling engine),
Fuel cells, Small scale wind turbines. In this century we will face fundamental changes in energy
supply systems. Not only because limited reserves of fossil fuels, but because wide implementation of
decentralized electricity production in so called smart grid systems. In such systems high efficiency of
electricity production can be reach by using waste heat. In most cases this are small and mid-size
cogeneration units driven by natural gas. Beside natural gas powered systems, technologies for direct
use of biomass and Stirling machine driven electricity generators are available and will be presented.
Syllabus: 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, economics of small scale
cogeneration. Today electricity is mostly produced from thermal (fossil fuel), nuclear and hydro power
plants. Among the technologies that ensure independent electricity production, fuel cells are one of the
most promising technologies. Fuel cell combines molecule of hydrogen and oxygen into molecule of
water and generate free electrons or electricity current. Hydrogen can be produced from natural gas,
but as well as from water using renewable electricity. Hydrogen can be stored and transported in gas
or liquid state and as hydride in solid storage. Fuel cell system could consists reformer which
produces hydrogen from natural gas or liquid biofuel, avoiding problems of storing and transportation
of the hydrogen. High efficiency of electricity production without environment impacts is the most
important advantage of this technology
Syllabus: Properties of hydrogen, production, storing and transportation of the hydrogen, principles
of fuel cell operation, types and efficiency of fuel cell, economics of fuel cell. Beside hydro power plants
wind turbines are mostly used technologies for electricity production from RES. In addition to the large,
hundred and more meters high turbines, small scale building integrated wind turbines could supply
electricity to consumers in the building. There are several technologies, mostly adapted to low wind
velocity in urban areas.
Physical principles of wind turbine operation, Betz coefficient, potential of wind in rural areas and in
cities, modelling of wind in urban environment, HAWT and VAWT aplications, integration of small
scale wind turbines into the buildings, environmental issues of wind turbines in urban environment.

Lecture 11: District heating, DHW and cooling systems, Large scale cogeneration
District heating systems are well known in the large cities as most popular and cheap source for space
and tap water heating. Most often they are constructed as cogeneration units. Nowadays district
heating systems become smaller since new technologies for pipelines were developed and limitations
regarding to the density of heat demand decrease. Several improvements of such systems can be
noticed in contemporary systems- heat demand and therefore economics of heat and electricity
production, can be increased by build-up the systems to enable tap water heating, by using hot water
transported in pipelines for absorption cooling of the buildings during summertime or by integration of RES systems, like solar and geothermal heating. Such systems will be described in the lecture.

Syllabus: Development and limitation of district heating system, technologies of pipeline distribution systems, sizing of heat substation, high and low temperature cogeneration, DHW preparation using district heating system, efficiency of cogeneration regarding to the heat demand, district cooling systems, district heat driven absorption in the buildings, integration of RES in district heating systems, feasibility studies of district heating cogeneration and cooling.
Cross-disciplinary teamwork Course plan

Lecture 1: Introduction to cross-disciplinary Teamwork – Main cross-disciplinary issues
(2 x 45 minutes, introductory level)
The first lecture starts with introduction to the main cross-disciplinary issues. It explains the basic cross-disciplinary terms starting with mono-disciplinary approach based on the zero disciplinary integration. Then it discusses the multi-disciplinary approach based on the integration by addition of disciplinary perspectives. Next it presents inter-disciplinary as a integration by a combination of disciplinary theories and methods. At least the trans-disciplinary approach is presented as an integration by a combination of disciplinary and non-scientific questions, theories and methods. Based on presented methods the cross-disciplinary teamwork is presented as a umbrella concept. In theory, in order to pursue cross sustainability education – there is a need to integrate a common language, that allows cross-disciplinary and cross interest group communication. During this lecture the main actors of the building process (Investor, Architect, Developer, Designer, User) are presented with theirs values, goals and needs. Based on their expectation the networks and decision-making process are shown. The strategies in such networks in hybrid organisations are highlighted.
Syllabus: 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
(2 x 45 minutes, presentation of the case studies)
The second lecture describes the basic Architects and Developers expectations. The first part of lecture presents a case from an architect’s point of view focusing on architectural aspect. The next part shows other cases focus on developer’s aspect (PM traditional networking). After presentation, the architects and developer values and goals are discussed. It shows the main actors of building process – architect and developer needs and point of view. Last part of lecture presents the language used by the architects and developers. Presentation used in this lecture shows case studies that highlight the specific architectural and developers aspects.
Syllabus: architect and developer values and goals, architect and developer needs, architect and developer expectations, architect and developer point of view, architect and developer technical aspects, architect and developer language.

Lecture 3: Case Study Presentation
(2 x 45 minutes, presentation of the case studies)
The second lecture describes the basic structural engineers and HVAC engineers expectations. The first part of lecture presents by cases, architects point of view focus on structure aspect. The next part shows other cases focus on HVAC engineer’s aspect (PM traditional networking). After presentation the structural engineers and HVAC engineers values and goals are discussed. It describes the other actors of building process – structural engineers and HVAC engineer’s needs and point of view. Last part of lecture presents the language used by the structural engineers and HVAC engineers. Presentation used in this lecture shows case studies highlight the specific structure and HVAC aspects.
Syllabus: 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
(2 x 45 minutes, introductory level)
The following lecture describes basics of teamwork. Selections of various cross-disciplinary networks are outline. The basics of teamwork are presented in detail. Rules of team building and teamwork are highlighting with several aspects including: goal statement, social contract, roles, interaction, interpersonal and inter-teams relations. The communication and information exchange are presented based on the experiences from existing cases. Last part of the lecture presents the rules of successful coordination meetings. Follow-up discussions on how different projects members think differently, different understanding of each other, what was the largest problem in communication, what was the main benefit, how to solve the design problems based on the teamwork rules.
Syllabus: teamwork, communication, information exchange, cross-disciplinary networks, team building, goal statement, social contract, roles, interaction, interpersonal and interteams relations, coordination meetings.

**Workshops & Follow-up discussion - Principles**

The second part of the course is practical workshops. Students will work in a team on a set of subject, e.g. preliminary concept design of a single family building – to be presented by representatives of different disciplines.

- 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 (e.g.) Architect – 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**

(2 x 45 minutes, summary level)

During this lecture students will summarised 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.

The schema for the activity analysis should be defined as follows: clarification, explanation, exploration, problem solving, closed question, feedback, presentation, negotiation, resolution and other activities – technical, scheduling.
ANNEX II REFERENCES AND SUPPORTING LITERATURE

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