



EU funds
for Malta
2014-2020



MASTER OF SCIENCE IN
HIGH PERFORMANCE
BUILDINGS



MCAST

Malta College of Arts, Science & Technology



MASTER OF SCIENCE
IN HIGH PERFORMANCE
BUILDINGS

V2 PROGRAMME SPECIFICATIONS



Operational Programme II – European Structural and Investment Funds 2014-2020
“Investing in human capital to create more opportunities and promote the well-being of society”

Project part-financed by the European Social Fund
Co-financing rate: 80% European Union; 20% National Funds



MCAST Master of Science in High Performance Buildings

MQF Level 7

90 ECTS

Programme Rationale

The built environment is responsible for up to 50% of our society's energy costs, coupled with a continuous increasing urbanisation in population: About 40-50% of the primary energy consumption worldwide is linked to the buildings, where we live in and work. This crucial amount is caused by the building industry, production of materials and structures, construction, as well as the operation of buildings, including their demolition and – if possible – recycling and/or reusing energy needs. According to statistics, in 1900, 10% of our society lived in cities, in 2007 this ratio increased itself to 50%, and finally, it is estimated that approximately 75% of our population will be living in settlements in 2050. As a cumulated result, the residents of our cities cause 80% of all carbon emissions, with coupled negative climate changes, environment pollution and energy supply shortcuts. The European Parliament's EPBD 2010/31/EU regulates that by 2021 all new buildings are to perform as nearly zero energy buildings. Furthermore, the EU is committed to reducing greenhouse gas emissions to 90% below the levels in 1990 by 2050. Besides political and legislative provisions, which react through strengthening efficiency and renewable source management measures, also cultural and business demands are starting to focus on environment protecting construction issues. As a result, the building industry will change decisively, requiring high performance architecture in buildings and settlements.

Today's common practice solves indoor comfort solely by technical systems, inducing significant inefficiency. Instead, passive design strategies should be combined with active components as a hybrid synergy unit that responds to local conditions and serves itself from local potentials. The challenge is to minimise the energy consumption, maintenance costs

and technical systems of both existing and new building stock, while ensuring a maximised comfortable and productive environment for the occupants. *Doing more with less, - is the future...* This holistic design approach widens the level of individual buildings into complete district and settlement scaled awareness in preservation and development. High performance design is no longer appropriate for achieving only new buildings but also must be considered in the context of existing building substance, comprising 95% of the built environment.

Optimal high performance buildings however require the use of smart design methods. With extensive analysis, knowledge and handling of the physical phenomena affecting the build environment, architects can have a profound impact on buildings' construction cost and operation efficiency, environmental compatibility, as well as health and comfort performance. In addition, appropriate applications of sustainable design principles impart buildings new appearance, - a kind of building physics driven 'updated' aesthetic quality.

To achieve a particular approach, the industry requires a new type of professional: an expert with specialised skills and advanced knowledge, playing a key role in an integrated design and construction process. Through learning the thought processes and work processes of complementing engineering disciplines, high performance building designer architects act as interfaces between disciplines as interdisciplinary-trained, leader-coordinator of design teams.

The Master programme gives graduates the opportunity to develop optimised building concepts, integrating various components of holistic design methodology, building physics, building climatology and comfort, energy-efficiency, environmental sources, building services systems, building aerodynamics, thermal and fluid dynamic CFD simulations, lighting design, building operation, as well as green urban modelling. The programme provides for advanced skills in specialisation and scientific research of building physics coupled architectural design, preparing learners for professional, as well as research and development settings at national and international levels.

The Master of Science in High Performance Buildings places an emphasis on being one of the most crucial pathways to an exciting and rewarding career in current and future sustainable construction.

The complexity of buildings has grown steadily over recent decades, ensuring that buildings and machines are designed independently from each other. User comfort and well-being is solely covered by technical apparatus, generating lowest efficiency rates in the building sector. Therefore, the overall goal of the programme is to train and educate higher knowledge and skills for designing buildings and systems not independently from each other, but combining them into a hybrid solution, working in unison, responding to on-site climate circumstances, supplying themselves from local energies. While minimising energy demand and CO₂-emissions, maximised occupants comfort should be achieved in new and existing buildings, as well as in district and settlement scaled projects.

The curriculum's content focuses on creating a robust comprehension in the field of building physics modelling methods in order to being able to understand and utilise physical phenomenon's laws and effects in the planning process. Consequently, building physics and natural science principles become not only deciding planning factors for seasonal operation performance, but also for aesthetic appearance of buildings. In this way, the design procedure is supported by calculations, thermal and fluid dynamic building simulations to meet the requirements of optimised buildings' high-performance.

Furthermore, the range of special theoretical study topics on holistic design methodology, energy, renewables, climate, comfort, aerodynamics, density in green urban planning and high-rise buildings, is complemented by additional exercises and project work design tasks, where acquired new knowledge and methods must be applied for building development. While theoretical study units - comprising mono-directional lectures - impart new information about principles, methods, examples and implemented case studies; practical study units activate learners to apply the acquired and examined hypothetical knowledge in practice: complementary exercises, calculations, simulations, modelling as well as project design deliver real - in competitive industrial situation applicable - know-how about HPB design.

Programme Learning Outcomes

For implementation of the described goals in high performing buildings (HPB) and settlements, a new type of experts are necessary, possessing special, advanced thinking skills to adapt and lead sustainable solutions in our built environment.

Conventional architectural planning know-how is expanded by utilisation of scientific and engineering related design and development methods. Absolvents acquire a unique, advanced qualification in building physics supported architectural design. During the course, a solid building physics modelling perception will be developed in learners' workflow, boosting their fundamental planning abilities to a next level.

After completion of the study, graduated integrate special aspects of HPB related physics and design methods into the regular planning procedure. This includes, for example, iterative design techniques, climate, comfort, energy-efficiency, environmental source management, technology, MEP (mechanical, electrical and plumbing), aerodynamics, energy and climate simulations, computational fluid dynamic simulations, lighting and building operation, as well as green urban modelling.

Learning objectives of 'high performance engineering based architectural quality' are handled in cross-disciplinary theoretical and practical training, including new engineering skills for architect individuals. This makes architecture graduates able to think and work as engineers of corresponding fields involved in design and construction, enabling to act as an interface between design participants and to strengthen the dialogue between the various professional disciplines, coordinating them in accordance with desired HPB project goals.

Meaning, this is the birth of a completely new design discipline: a borderland between artistic and scientific design.

Participants develop the ability to design holistically, to unify passive and active building technology solutions, and, in addition, to integrate building into a larger context: responding to, and taking advantage of current environmental circumstances, potentials and synergies.

Unique and essential feature of the curriculum is animating learners to apply actively the imparted and examined theoretical knowledge in the framework of practical exercises and design work. Planning tasks are structured in project study units, which will be elaborated through group work. Through the experience during practical study units, participants can efficiently implement methods, techniques and quantifications for high energy and comfort performance in real building projects in the contract market.

A further learning outcome is having a critical view on strategic operational facility management and property economics, whereby return on investment and operation principles are evaluated.

Acquired skills in specialisation and scientific research of energy-efficient, climate-responsive and environmental conscious construction prepare participants for professional and research-development positions at national and international level.

MQF Level Descriptors for Level 7

	Level 7 EQF	Level 7 MQF
Level Knowledge	Highly specialised and is at the forefront of knowledge in a field of work or study as the basis for original thinking and/or research. Critical awareness of knowledge issues in a field and at the interface between different fields.	1. Has comprehensive knowledge and understanding that is founded upon and/or enhances that knowledge typically associated with Bachelor's level; 2. Uses specialised or multi-disciplinary theoretical and practical knowledge some of which is at the forefront of a field of study. This knowledge forms the basis of originality in developing and/or applying ideas.



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Skills	Specialised problem-solving skills required in research and/ or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields.	1. Demonstrates specialised or multi-disciplinary knowledge that include reflecting on social and ethical responsibilities linked to the application of one's knowledge and judgements; 2. Can communicate to specialist and non-specialist audiences clearly and unambiguously reach conclusions which may be the outcome of research, self-study or experience; 3. Performs critical evaluations and analysis with incomplete or limited information to solve problems in new or unfamiliar environments and produces original research; 4. Develops new skills in response to emerging knowledge and techniques and demonstrates leadership skills and innovation in complex and unpredictable work and study contexts.
Competencies	Manage and transform work or study contexts that are complex and unpredictable that require new strategic approaches. Take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams.	1. Creates a research-based diagnosis to problems by integrating knowledge from new or interdisciplinary fields and makes judgements with incomplete or limited information; 2. Manages people and projects and demonstrates the ability to respond to the fast-changing business environment; 3. Demonstrates autonomy in the direction of learning and a high level of understanding of learning processes; 4. Has the learning skills to allow continuation to study in a manner that may be largely self-directed or autonomous.
Learning Outcomes	1. Knowledge and Understanding; 2. Applying Knowledge and Understanding;	1. Has the comprehensive specialised or multi-disciplinary theoretical and practical knowledge which forms the basis of original research, which may contribute to social and ethical issues;



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	3. Communication Skills; 4. Judgmental Skills; 5. Learning Skills; 6. Autonomy and Responsibility.	2. Demonstrates capability in using knowledge and skills, to adapt to the fast-changing business environment and to manage people and projects efficiently; 3. Communicates with specialist and non-specialist audiences clearly and unambiguously reaches conclusions which may be the outcome of original research, self-study or experience; 4. Performs critical evaluations and analysis with incomplete or limited information to solve problems in new or unfamiliar contexts, and produces original research; 5. Makes assessments of personal continuous professional development, takes initiative to undertake self-directed study and may proceed to further specialisation; 6. Is accountable and responsible for the original research within a personal social responsibility and/or business context for one's operations and for adapting the management of people and projects reflecting the dynamic nature of the environment in which one operates.
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Referencing Report - National Commission for Further and Higher Education. 4th Revised Edition February 2016

Overview of Study Units

First Year (Semesters 1 & 2: 30 ECTS)

1. High Performance Building (HPB) Design Approach
2. Building Climatology
3. Building Energy
4. Building Aerodynamics
5. Energy and Climate Dynamic Building Simulations

Second Year (Semesters 3 & 4: 30 ECTS)

6. Aerodynamic Building Simulations
7. High-Performance High-Rise Buildings
8. High Performance Settlements (HPS)
9. Project 1 – Building Design Project (HPB)
10. Project 2 – Settlement Design Project (HPS)

Third Year (Semester 5: 30 ECTS)

Dissertation

STUDY UNIT 1

High Performance Building (HPB) Design Approach

MQF Level 7

6 ECTS

E-learning: Yes

Rationale

Without fundamental knowledge about basic holistic building design approach, elementary planning methodology and architectural theory, it is impossible to 'go on the right path' in order to develop HPBs. The critical issue is to clarify the most important terminology in the context of sustainable construction, as well as to examine vernacular building technologies in different climatic and geographical regions. Vernacular technologies are intended for new building design, as well as being applicable in refurbishment planning of the existing building substance. These are inevitable premises to continue with widespread professional studies of HPB.

The main aim is to deliver specialised theoretical basics in complex contemporary and historical sustainable architecture. Synergies in design strategies are taught, along with the most important special design aspects and techniques. Components of elementary HPB design methodology will be deepened in further thematic study units.

The content of this study unit focuses on contemporary architectural design extending new, innovative factors, which essentially modify current planning into a multi-dimensional design process. Natural science and engineering contents complement architecture (geometry, function, structure and aesthetics) with topics of external and internal climate, energy, envelope theory, materials, aerodynamics, low-tech and high-tech technologies, bionics, furthermore efficiency increasing synergy effects and quantification methods.

Basic theoretical knowledge and methodology of a sustainable, comfortable, healthy and energy conserving – respectively carbon harmonising – building industry.

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Debate methodologically about building design philosophy;
2. Create a comprehensive holistic and iterative building design approach, a way of thinking, to use it in different project analysis settings;
3. Compare alternating sustainable building certification systems and to assess them in terms of, complexity, resolution, sincerity and importance;
4. Derive building typology as well as active and passive construction project strategies from efficient architecture history's influences;
5. Identify building physics 'driven' design aspects in the context of sustainability in terms of space organisation (building body, structures and operation (tempering, ventilation, supply));
6. Compare and critique different design supporting tools;
7. Analyse and develop basic, theoretical HPB concepts in the early design stage;
8. Specify and evaluate the most critical performance components in existing HPB building projects.

Content – Detailed

1. Understanding the HPB design fundamentals. A holistic, integral building design approach. Energy-efficient and climate responsive architecture theory. Sustainable construction history and terminology. Hybrid design field between architecture, engineering and natural science. Green building certification systems. Active House theory. This unit gives an integral overview on the holistic, sustainable, environment conscious and energy-efficient architectural and engineering design approach, in

addition to technologies. Fundamental terminology, energetic and climatic systems will be clarified. The basic design philosophy of the European Solar Charta, Active House theory and different qualifying systems (DGNB, BREEAM, LEED) will also be covered.

2. HPB design components. Energetic and climatic systems. Vernacular and high-end technologies. Building envelope theory. Building aerodynamics. Building bionics. LCA. Climate concepts. Design supporting tools and quantification methods. Efficiency increasing synergy effects. HPB typology. This synergetic design requires the integration of a further crucial point of view: learning from vernacular architecture (traditional building technology) and important efficient and environment compatible developments in architecture history.
3. Understanding HPB design methodology and its components. The ENERGIA DESIGN® planning technique. The multi-dimensional, 4D design process. Algorithmic steps. Planning in variations. Validation of concepts. Learners will meet a new engineering based building design method: the ENERGIA DESIGN® planning technique – developed at the University of Pécs, Hungary – which enables the designing of high performance, energy-positive buildings, structures and settlements. The method combines questions from the fields of natural science, engineering and architecture. Instead of using the standard solutions of the building industry, HVAC and electrical systems, space and climate are designed in unison, applying complex building physics modelling. Architectural space design (function, geometry, structure, and aesthetics) is further developed with the planning of energy and climate in 4D i.e. in space and time. Integrating physical and mathematical principals into architecture, widens the scope of design influencing factors: climate, energy, comfort, lighting, aerodynamics, low-tech and high-tech technologies, envelope technologies, bionics technologies, life cycle assessment (LCA), as well as time dependent building physics simulations. As a result, innovative, multi-functional building concepts can be elaborated, whereby the

maximum in comfort and energy-efficiency is guaranteed. In order to validate the concepts, quantification through dynamic energy, climate and fluid dynamics simulations must be carried out. The problem-solving matrix manages the systematically structured design process in algorithmic steps: concept – calculation – analysis - validation. Efficiency increasing synergies and multi-functionality will be detected and/or worked out during this multi-dimensional planning procedure. Implementing this approach induces a new design discipline, situated in the borderline area between architecture and the related engineering and scientific fields.

4. The seasonal operation management of a building is composed of so-called 'climate concepts', including space-climate zone organisation, orientation, structures and materials, heat transfer systems, heat generating central, natural and mechanical ventilation, passive and active lighting, as well as the energy supply concept.
5. Various design supporting tools allow for easy decision making in different planning phases: from simplified calculations to complex, high resolution simulations, including time dependent weather, user behaviour and operation. Energy and climate efficient building typology – a quick overview of reference HPBs provides the first impression of synergetic solutions in structures and buildings, highlighting their energy and comfort performance as well as the aesthetic qualities.
6. Analysis of HPB in case studies and design tools. Example analysis in different climates creates a broad understanding of technological and cultural sustainability. Exercises (examination): Example analysis of vernacular and contemporary energy-efficient, sustainable and environmental conscious strategies and solutions in selected projects and case studies. Problem formulation and discussion during lectures.
7. Exercises (examination): Basic comparison between different design supporting tools. Discussion during lectures.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of this study unit, the learner can:
1. Debate methodologically about building design philosophy.	1.1 Identify and distinguish between the different building design fields, goals, methods, factors and their combinations.
2. Create a comprehensive holistic and iterative building design approach, a way of thinking, to use it in different project analysis settings.	2.1 Achieve their own developed perception of synergetic building design. 2.2 Formulate problems and summarise fundamental design methods in a case study building examination.
3. Compare alternating sustainable building certification systems and assess them in terms of, complexity, resolution, sincerity and importance.	3.1 Demonstrate a critical view of qualification goals, possibilities and purposes. 3.2 Distinguish between assessment systems and their impact on building qualification.
4. Derive building typology, as well as active and passive construction project strategies from efficient architecture history's influences.	4.1 Create a theoretic diagnosis of advantageous strategies, concepts, methods and solutions by considering local conditions, structures, materials, energies and operation in a given efficient vernacular or historic building example.
5. Identify building physics 'driven' design aspects in the context of sustainability in terms of space organisation (building body), structures and operation (tempering, ventilation and supply).	5.1 Explain generic cause-and-effect mechanisms between room arrangement in building layout and section, solar radiation, natural ventilation, thermal performance and thermal mass in a basic, theoretical building case.
6. Compare and critique different design supporting tools.	6.1 Distinguish between the purpose and application of steady state energy calculations and dynamic thermal, fluid dynamic and lighting simulations.
7. Analyse and develop basic, theoretical HPB concepts in the early design stage.	7.1 Apply the acquired theoretical knowledge for a HPB concept in the framework of a case study building analysis procedure.

8. Specify and evaluate the most critical performance components in existing HPB building projects.

8.1 Summarise the special, innovative parameters in implemented ENERGIA DESIGN reference buildings in Hungary.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 - 8.1	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit.	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through external assessments through written and theoretical examinations. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit. Since this particular study unit provides fundamental new theoretical and methodological knowledge for learners, successful completion of a written examination is required by answering and solving questions, exercises, as well as theoretical problems (weighted at 100%). The exam contains tasks according to assessment criteria (1.1 - 8.1). An examination is a time-constrained assessment that will take place on a specified date and at a specified location.	A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.



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		The overall study unit grade is computed from the weighted mean of its components. The pass mark for a study unit is 50%.	
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STUDY UNIT 2

Building Climatology

MQF Level 7

6 ECTS

E-learning: No

Rationale

The detailed understanding and analysis of complex building physics is inevitable and a fundamental prerequisite for designing buildings at high comfort and energy efficiency level.

External climate (weather) circumstances, as well as indoor climate (comfort) conditions are the most important determining impacts on buildings' design in terms of space creation, structures, materials, services (heat transfer and ventilation) systems and operation management.

However, not all building climatology is created equal. What is required for a building on an island in the Mediterranean, will not be the same for a replicate building in the colder climates of North America. Therefore learners will be taught how implement building climate analysis, using complex external climate database values about the different climate zones of our planet with special regard to developing climate responsive building concepts, including architecture (space and structure) concepts, as well as climate concepts involving the seasonal operation of systems (basic level building services and basic energy supply plans).

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Apply the understood knowledge about the interaction between the external and internal climatic effect-mechanisms, which determine building design;
2. Evaluate the effects and consequences of different climate factors influencing climate-efficient building design;
3. Design in an international context to create construction scenarios in alternating climate regions, with special regards to the climate situation in Malta, using Meteonorm – climate database software;
4. Specify and evaluate the most important internal climate criteria on healthy and comfortable indoor environments;
5. Distinguish general from local thermal comfort variables and accordingly apply calculation methods and measurements;
6. Evaluate indoor air quality values in different buildings with various operation strategies.

Content – Detailed

1. Understanding climate responsive design theory. Climate responsive design. General climatology. Outdoor and indoor climate, weather and comfort theory. Building in different contexts – international and Maltese. Meteorological parameters. Cultural elements. Traditional architecture. Influence of actual trends in technique and society. Implementation climate aspects in early design stages. Learners will be taught about the extensive theory, background and techniques in climate-responsive design, general climatology, outdoor (weather elements) and indoor (comfort factors) climatology. Building climatology means building in different international contexts, considering climate factors such as meteorological parameters and cultural elements, e.g. traditional architecture or actual trends in technique and society. Building

climatology design factors will be implemented in the specific study unit, in international as well as in the national Maltese context. These factors must be integrated into the early planning phases, since in sketch planning the highest potential of efficiency and comfort incensement is possible.

2. Understanding building climatology and the outdoor climate. Meteorological and climate laws, cause and effect mechanisms. Climate elements, Climate factors. Site-specific potential of local conditions. Interdependency of climate elements. Geographical location factors. Topics include building related meteorological and climate laws, cause and effects. While climate elements describe the climate conditions and situation, climate factors are the circumstances which generate the climate: Macro, meso and micro climates. Climate analysis provides a survey of the local conditions' site-specific potential. Interdependency of climate elements: solar radiation, natural lighting (illuminance), air and soil temperature, absolute humidity, precipitation, and atmospheric flow. After understanding the functions and characteristics of different climate factors, such as geographical location, latitude, distance from the sea, height of location, city and land site, the learners will deepen their knowledge in regard to the effects of climate factors on building design.
3. Passive design aspects and active technological design components. Climate-responsivity emerges in passive design aspects, e.g. orientation, building body form finding, climate zoning in horizontal and vertical space organisation, building envelope structures (transparency, shading, daylight techniques) and in active design aspects such as room conditioning and energy supply solutions.
4. Understanding building climatology and the indoor climate. Thermal, olfactory and visual comfort. Overall cumulated comfort sensation. Zonal thermal and CFD comfort simulations. The next important component of building climatology is the climate of indoor spaces: room comfort – comfort theory, international standards (ISO 7730, EN 15251). Thermal comfort, human heat 'household' exchange, human internal heat production, metabolic rate (met), Fanger-indices, human activity level, productivity,

clothing (clo), heat exchange between humans and buildings, operative temperature, radiation asymmetry, vertical temperature gradient (thermal layering), surface temperatures, absolute and relative humidity, air velocity and draught effect.

Olfactory comfort, air quality comfort, thermal comfort, visual comfort. Overall cumulated comfort sensation. Adaptive comfort model. Zonal thermal and CFD comfort simulations.

5. Climate analysis. Exercise assignment: In the framework of this exercise, different climate regions will be analysed in respect of building construction. Climate graphs, a meteorological databank and psychometric charts will be applied and evaluated in order to create simple sketch plan stage building concepts (architecture, shape, space, structure and envelope) and climate concepts in regard to seasonal operation. This will include the application of the Meteonorm climate simulation software.
6. **Optional** exercise assignment: involves indoor comfort calculations, measurements in simple building cases in different climate situations to estimate the comfort quality level according to the related regulations and codes.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of this study unit, the learner can:
1. Apply the understood knowledge about the interaction between the external and internal climatic effect-mechanisms, which determine building design.	1.1 Understand comprehensive specialised theories about the background of building physics using a building climate-modelling viewpoint. 1.2 Utilise the interdependency effects of climate elements in building design: solar radiation, natural lighting (illuminance), air and soil temperature, absolute humidity, precipitation and atmospheric flow, as well as indoor comfort-climate environment requirements.

2. Evaluate the effects and consequences of different climate factors influencing climate-efficient building design.	2.1 Systemise the functions and characteristics of the different climate factors which affect building design: geographical location, latitude and distance from the sea, height of location, city and land site.
3. Design in an international context to create construction scenarios in alternating climate regions, with special regard to the climate situation in Malta, using Meteonorm – climate database software.	3.1 Develop climate-responsive buildings at an early design stage in different climate regions, applying passive design aspects, e.g. orientation, finding building body form, climate zoning in horizontal and vertical space organisation, building envelope structures (transparency, shading, daylight techniques) and active design factors such as room conditioning and energy supply solutions. 3.2 Create simple sketch plan stage building concepts (architecture, shape, space, structure and envelope) and climate concepts in regard to seasonal operation. 3.3 Apply Meteonorm climate simulation software.
4. Specify and evaluate the most important internal climate criteria on healthy and comfortable indoor environments.	4.1 Manage thermal comfort qualities and quantities such as human heat 'household' exchange, human internal heat production, metabolic rate (met), Fanger-indices, human activity level, productivity, clothing (clo), heat exchange between human and building, operative temperature, radiation asymmetry, vertical temperature gradient (thermal layering), surface temperatures, absolute and relative humidity, air velocity, draught effect. 4.2 Deal with olfactory, air quality, thermal and visual comfort factors and their combinations, and the overall cumulated comfort sensation.
5. Distinguish general from local thermal comfort variables and accordingly apply calculation methods and measurements.	5.1 Identify thermal comfort conditions and make the appropriate distinctions in building physics phenomena and simulation types.



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6. Evaluate indoor air quality values in different buildings and operation strategies.

6.1 Performs critical IAQ assessments in regard to CO₂-concentration dependent on the type of ventilation and type of building.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 - 6.1	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through the submission of internally assessed learner work, as well as external assessments through written and theoretical examinations. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit. This study unit provides new, specialised theoretical and practical knowledge for learners. Participants will pass based upon the successful completion of: - A project assignment (weighted at 50%) in the form of developing a sketch plan building concept design in different climate regions. - An optional exercise assignment (In the case of this additional project 25-25% for each project is	A short written review and feedback for learners about the project and optional exercise assignment. A grade (mark) based on the project's, and the optional exercise's, content quality A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.



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		taken into account) in the form of indoor measurements and hand calculations for indoor comfort estimations. - A written examination answering and solving questions, exercises, as well as theoretical problems (weighted at 50%). The exam contains tasks according to assessment criteria (1.1 - 6.1). An examination is a time-constrained assessment that will take place on a specified date and at a specified location. The overall study unit grade is computed from the weighted mean of its components. The pass mark for a study unit is 50%.	
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STUDY UNIT 3

Building Energy

MQF Level 7

6 ECTS

E-learning: No

Rationale

Malta's building energy regulations and legislation contents must be integrated in the curriculum with their most crucial, fundamental specific calculation methods. I need this material from Maltese building energy auditors or expert, since every member of the EU has to create its own definition of NZEBs (nearly zero energy buildings). In addition, in different countries, alternating national energy calculations are legislated and used for building energy qualification.

Important to mention that the MCAST teaching staff should teach this part of the curriculum content, after participating in the training of trainers programme.

Approx. 50% of the world's primary energy need is caused by building industries' activities, including construction, operation and demolition/recycling. According to prognosis, by 2050 the global primary energy consumption will be doubled, concurrently long-term supply of energy cannot be covered by – in near future depleting - fossil sources.

With the "20-20-20 initiative", the EU plans to reduce the level of energy consumption and CO₂-emission in 1999 by 20% and increase the renewable energy use and efficiency by 20% until 2020. The EU also proposes to reduce the carbon emission level of 1990 by 80-95% till 2050.

The legislative regulation background continuously tightens provisions, e.g. the EPBD 2010/31/EU directive prescribes that in all EU member states by 2019 all new public buildings, and by 2021 all new buildings must be nearly zero energy buildings (NZEB).

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Apply the imparted knowledge about buildings as holistic energy systems with a critical view in the analysis of building concepts and systems;
2. Consider and evaluate interdependencies between architecture, climate, energy and HVAC systems in HPB design through understanding real, reliable and efficient interaction between 'house and machine';
3. Implement the ideas and concepts of energy-efficient passive and active design solutions in building energy concepts;
4. Develop standard building technology system (HVAC) concepts;
5. Solve building energy related calculations in the field of heat load of air flow, heat loss by transmission, solar heat gain, inner heat load, heat storage, heating and cooling, ventilation and lighting (by daylight);
6. Optimise building energy concepts with help of quantified feedback that serves as a decision-making "tool" in design steps.

Content – Detailed

1. Understanding building related energy theory. Basic knowledge of building energetics. Thermodynamics. Thermal qualities of the building envelope. Renewable energy sources and corresponding building services systems. Energy generation (heat and electricity). Active room conditioning strategies and systems. Passive building design strategies. Passive room conditioning strategies.

Installation concepts. Energy flows in buildings. Efficient and reliable interrelation between house and machine. Energy conservation and efficiency. Learners acquire detailed knowledge and understanding of building related energy theory and calculations methods at different levels. Basic knowledge of building energetics; energy levels, cycles and flow systems, thermodynamics, respectively. Interaction between air and operative temperatures and solar radiation, between external air temperature and passive ventilation and thermal insulation, respectively. Thermal qualities of the building envelope, efficiency generating structures and materials indoors and in the building envelope. Thermal bridges. Thermography building diagnostics.

2. Renewable energy sources and corresponding building services systems, heat pumps, combined heat and power generation (CHP), solar systems, geothermal systems, heat exchanger systems, fuel cell. Energy generation (heat and electricity).
3. Active room conditioning strategies: heat transfer systems in rooms, room conditioning, heating, cooling and mechanical ventilation systems and their effect on energy consumption. Installation concepts, sizing of systems, central, decentral systems. Building services systems design and conception. Energy flows in buildings, energy concepts for supply, transfer, distribution, storage and losses.
4. Effects of passive building design strategies on energy demand: space planning, building body shape finding, orientation, placement in site, neighbour environment, thermal mass and structures. Passive room conditioning strategies: natural cooling, night cooling, soil-air heat exchanger, earth probes, soil collector, ground water and hybrid systems.
5. Interaction between building technology (HVAC systems, MEP) and passive, architectural solutions, building structures, façade and room organisation, A/V-ratio, glazing ratio, orientation, etc. Understanding the efficient and reliable interrelation between house and machine.

6. Advantageous energy savings of climate mechanisms, efficiency strengthening effects and energetic synergy effects. Energy conservation potential analysis, optimisation strategies. Energy economy, financial effects on investment and operation. User (occupant) behaviour and its energetic effects. Building operation management and building load management. Building energy qualification standards, norms and codes. Zero and energy plus buildings, active houses, smart building. Building load management.
7. Acquiring building energy calculation methods. Steady-state energy balance. Energy balance estimations as a basis for the first functionality check of projects. Decision making support. Maltese energy legislation code system (covered by the Maltese energy auditor). Complex building physics modelling, dynamic energy and climate calculations and applicable software.
8. Identifying solutions in building energy calculation methods. Exercises assignment: Learners are taught and practice stationary, simplified, estimative building energy calculations (rough approach) and building services system optimisation. Steady-state energy balance, losses and gains (loads), simplified energy balance estimations as the basis for the first functionality check of project concepts and decision making support, respectively. Complex building physics modelling, dynamic energy and climate calculations and the applicable software. In the exercise learners are taught and practice stationary, simplified estimative building energy calculations (rough approach): forms of energy and main energy fluxes for steady state energy balance (gains, loads, transmission, airflow, storage, mechanical ventilation, heating, cooling and daylight). Energy and HVAC system concept optimisation with help of calculations.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of this study unit, the learner can:
1. Apply the imparted knowledge about buildings as holistic energy systems with a critical view in the analysis of building concepts and systems.	1.1 Perform critical evaluations and analysis of buildings and HVAC systems using a building energy-modelling way of thinking. 1.2 Use specialised theoretical knowledge about energy levels, cycles and flow systems, building envelope, efficiency generating structures and thermography diagnostics. 1.3 Understand the building energy standards of HPB-s.
2. Consider and evaluate interdependencies between architecture, climate, energy and HVAC systems in HPB design through understanding the real, reliable and efficient interaction between 'house and machine'.	2.1 Support the design process with knowledge of the interaction between air and operative temperatures and solar radiation between the external air temperature and passive ventilation and thermal insulation. 2.2 Integrate the interconnection between building technology (HVAC systems, MEP) and passive, architectural solutions, building structures, façade and room organisation, A/V-ratio, glazing ratio, and its orientation into HPB design.
3. Implement the ideas and concepts of energy-efficient passive and active design solutions in building energy concepts.	3.1 Create active energy concepts with renewable energy sources, corresponding building services systems, heat pumps, combined heat and power generation (CHP), solar systems, geothermal systems, heat exchanger systems, fuel cell and energy generation. 3.2 Create active energy concepts using space planning, building body shape finding, orientation, placement in site, neighbour environment, thermal mass, structures, natural cooling, night cooling,

	soil-air heat exchanger, earth probes, soil collectors, ground water and hybrid systems.
	3.3 Consider theoretical user behaviour and building operation concepts.
4. Develop standard building technology system (HVAC) concepts.	4.1 Elaborate on MEP engineering design and conception, energy flows in buildings, energy concepts for supply, transfer, distribution, storage and losses. Heat transfer systems (room units), room conditioning, heating, cooling and mechanical ventilation systems and their effect on energy consumption. 4.2 Size systems including central and decentral systems, on a basic, conceptual level.
5. Solve building energy related calculations in the field of heat load of air flow, heat loss by transmission, solar heat gain, inner heat load, heat storage, heating and cooling, ventilation and lighting (by daylight).	5.1 Compute steady-state energy balance, losses and gains (loads), and simplified energy balance estimations as the basis for the first functionality check of the project concepts and decision making support. 5.2 Understand Maltese building energy legislation and the calculation method (covered by the Maltese energy auditor).
6. Optimise building energy concepts with the help of quantified feedback that serves as a decision-making “tool” in the design steps.	6.1 Practice stationary, simplified building energy calculations such as forms of energy and main energy fluxes for steady state energy balance (gains, loads, transmission, airflow, storage, mechanical ventilation, heating, cooling, daylight). 6.2 Compute energy and HVAC system concept optimisation with help of calculations.



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Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 - 6.2	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit.	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through the submission of internally assessed learner work, as well as external assessments through written and theoretical examinations. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit. This study unit provides new, specialised theoretical and practical knowledge for learners. Participants pass upon successful completion of: - An exercise assignment (weighted at 50%) in the form of calculating the steady state energy balances of building examples and optimising different case investigations. - A written examination by answering and solving questions, exercises, as well as theoretical problems (weighted at 50%). The exam contains tasks according to assessment criteria (1.1 - 6.2).	A short written review and feedback for learners about the exercise assignment. A grade (mark) on the basis of the exercise's content quality. A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.



Operational Programme II – European Structural and Investment Funds 2014-2020
"Investing in human capital to create more opportunities and promote the well-being of society"

Project part-financed by the European Social Fund
Co-financing rate: 80% European Union; 20% National Funds





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		An examination is a time-constrained assessment that will take place on a specified date and at a specified location. The overall study unit grade is computed from the weighted mean of its components. The pass mark for a study unit is 50%.	
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STUDY UNIT 4

Building Aerodynamics

MQF Level 7

6 ECTS

E-learning: No

Rationale

A high performance building needs to be sustainable, as well as resist different stresses without being structurally compromised. Besides rain and snow, wind is the most continuous natural force a building needs to withstand. In addition, also the movement of air inside of a building needs to be considered for optimised ventilation and thermal energy fluxes. Among thermal energy fluxes air flow phenomena are a deciding 'member' of heat distribution, heating and cooling effects due to thermal convection and wind induced fluid flow mechanisms. Aerodynamics is the umbrella term used to describe these effects and it's the topic of this study unit.

Herein, we discuss how different aspects of a building's design needs to be considered in regard to aerodynamics. Is it a high blunt body like most skyscrapers in Manhattan, or a low modern streamlined building? How does a building affect the air flow through a city and how do the surroundings create effects like vibrations and flutter? What influence does the pitch of a roof, a huge door in the hallway, or the number and arrangement of windows have on structural stability? Moreover, how can we use the wind energy actively or passively for ventilation, air conditioning and other aspects that result in the healthiness of buildings? All of these influencing factors will be discussed and eventually described by mathematic models like the Hubsch law and the Bernoulli equation. These models also bridge gaps between the wind channel tests and the design of the resulting building. Therefore, this

study unit will also present the basics to perform wind channel experiments and will show how the results can be applied in the real world. Without understanding and implementing knowledge about aerophysics in building design, it is not possible to create sustainable, low energy environments.

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Utilise and apply the learned building aero physical context and coherence system in the development of theoretical high performance building ventilation concepts;
2. Optimise building passive ventilation system with special regard to high thermal and air quality comfort, respectively low energy demand;
3. Solve steady-state, simplified comfort and energy calculations according to natural and mechanical ventilation in buildings;
4. Optimise energy and climate performance of HPB's ventilation systems with help of simplified stationary ventilation calculations.

Content – Detailed

1. Understanding the basics of building aerodynamics. In this study unit the emphasis is on building aerodynamics, meaning the air flow system characteristics and their effect on air quality, thermal comfort and energy demand in and around buildings, respectively, on the city level design and between buildings. Also includes: Building related fluid dynamics and aero physics fundamentals. Airflow system characteristics and their effect on air quality, thermal comfort and energy demand in buildings. Airflow structures in and around buildings, as well as between building blocks. Indoor and city (outdoor) building aerodynamics. Wind effects on buildings and ventilation. Effects of energy and climate (comfort). Dispersion of contaminants.

Aerodynamic optimisation of building design. Building related fluid dynamics and aero physics fundamentals, energy and mass conservation law, aerodynamic coefficients, flow patterns, atmospheric and building boundary layers, flow separation, wind characteristics, turbulence systems, vertical wind velocity profiles and blunt and streamlined bodies.

2. The aerodynamic character of structures and buildings. Permeability of surfaces. Energy and climate (comfort) effects of building aerodynamics. Wind effects on buildings and ventilation and wind loads. Wind current systems in and around, respectively, between buildings and close to the building envelope (wind flow on facades). Dispersion of contaminants in the vicinity of buildings. Aerodynamic optimisation of layout, section and building shape forming, as well as optimal arrangement and sizing of openings and windows in the building envelope. Aerodynamic effects of space organisation and building body form.
3. Planning of complex, active and passive building ventilation concepts: air flow conduction in buildings, integration of natural and mechanical ventilation systems in buildings, wind induction and thermal buoyancy (stack effect) exploitation, passive façade ventilation, utilisation of wind energy for passive ventilation. Air handling centrals. Indoor and outdoor pressure distribution. Wind effects in outdoor spaces, interrelation between environmental effects and comfort sensation, wind protection, wind comfort criteria and wind shelters.
4. Investigating how building orientation, site integration and placement, distance between building bodies, velocity and direction of wind affects air flow systems and the air change of buildings. Aerodynamic analysis of building case studies.
5. Acquiring building ventilation calculation methods. Steady-state comfort and energy calculation estimations as the basis for the first functionality check of ventilation concepts and decision-making support.
6. Identifying solutions in building ventilation calculation methods. Exercises: Learners are taught and practice stationary, simplified, estimative building ventilation

calculations; mechanical and natural ventilation. Ventilation system concept optimisation with the help of calculations.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to: 1. Utilise and apply the learned building aero physical context and coherence system in the development of theoretical high performance building ventilation concepts.	Upon completion of this study unit, the learner can: 1.1 Utilise a building aerodynamic modelling approach in theoretical, conceptual planning. 1.2 Manage knowledge including energy and mass conservation law, aerodynamic coefficients, flow patterns, atmospheric and building boundary layers, flow separation, wind characteristics, turbulence systems, vertical wind velocity profiles, blunt and streamlined bodies. 1.3 Differentiate between various wind current systems in and around and between buildings, close to the building envelop (wind flow on façades), as well as the dispersion of contaminants in the vicinity of buildings. 1.4 Introduce the aerodynamic effects of space organisation and building body form into HPB design. 1.5 Determine airflow systems and the air change of buildings by transferring knowledge about the effect mechanisms of building orientation, site integration and placement, distance between building bodies, velocity and the direction of wind. 1.6 Apply essential aero physical ventilation design processes: airflow conduction in buildings, integration of natural and mechanical ventilation systems in buildings, wind induction and thermal buoyancy (stack effect) exploitation, passive

	façade ventilation and the utilisation of wind energy for passive ventilation. 1.7 Deal with the effect of wind in outdoor spaces, city ventilation and wind comfort in settlement scaled design questions.
2. Optimise a building passive ventilation system with special regard to high thermal and air quality comfort and low energy demand.	2.1 Create comprehensive, engineering and natural science based aerodynamic analysis of given building case studies. 2.2 Deliver the aerodynamic optimisation of the layout, section and building shape forming, arrangement and sizing of openings and windows in the building envelope.
3. Solve steady state, simplified comfort and energy calculations according to the natural and mechanical ventilation in buildings.	3.1 Practice stationary, simplified estimative building ventilation calculations (rough approach) with mechanical and natural ventilation in a simple building and room level exercise. 3.2 Perform steady-state comfort and energy calculation estimations as the basis for the first functionality check of ventilation concepts and decision-making support in a given building/room case investigation.
4. Optimise energy and climate performance of HPB's ventilation systems with the help of simplified stationary ventilation calculations.	4.1 Demonstrate capability in elaborating the optimisation of ventilation system concepts with the help of calculations for a given building/room case investigation.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 - 4.1	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes.	A short written review and feedback for learners about the exercise assignment.



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	and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit,	The qualification assessment is completed through the submission of internally assessed learner work, as well as external assessments through written and theoretical examinations. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit. This study unit provides new, specialised theoretical and practical knowledge for learners. Participants pass upon successful completion of: - An exercise assignment (weighted at 50%) in the form of calculating stationary, simplified, estimative building ventilation calculations: the mechanical and natural ventilation of building examples and optimising different case investigations. - A written examination by answering and solving questions, exercises, as well as theoretical problems (weighted at 50%). The exam contains tasks according to assessment criteria (1.1 - 4.1). An examination is a time-constrained assessment that will take place on a specified date and at a specified location. The overall study unit grade is computed from the weighted mean of its components. The pass mark for a study unit is 50%.	A grade (mark) on the basis of the exercise's content quality. A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.
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STUDY UNIT 5

Energy and Climate Dynamic Building Simulations

MQF Level 7

6 ECTS

E-learning: Yes

Rationale

Planning reliability: *“Do not hope or fear from things, which could happen... .. rather let us know, what will definitely happen!”*

Energy, ecology and environment questions become increasing attention both in our general society, as well as in professional building industries. Closely related to this, comfort and energy performance questions are gaining more and more in importance, dealing with building climate behavioural and building physics characteristic.

Until the mid-1960s only ‘hand’ calculations methods could determine time averaged (typically monthly resolution) values for estimating energy use in buildings. Since computational resources were limited and expensive, in heating demand calculations e.g. the degree- day method was commonly used, neglecting and simplifying important elements, such as solar and internal gains, infiltration rates, non-steady operation of HVAC systems and transient thermal storage in structure’s mass, user behaviour, respectively. Different building geometries, MEP components and their components however require very complicated and time intensive algorithm handling.

Moreover, it is paradox that today’s practice uses hand-calculated methods to quantify the actual, highly complex dynamic processes in our buildings. As a logical result, monthly

resolution hand calculations usually don't agree with measured values. Their monthly resolution should be shortened so long, until dynamic simulations resolution is reached.

To sum it up, hand calculations are getting more and more complicated and time consuming solutions in contrast to dynamic simulations, which ensure hitherto unreached accuracy, high resolution and calculation velocity. While conventional hand calculations deliver approx. 50% of accuracy, triggering over dimensioning of HVAC systems and energy related structures (design uncertainty), dynamic calculations ensure approx. 95% accuracy, with exact dimensioned, cost-efficient technical system and structure dimensioning (certainty, design reliability).

Last but not at least, dynamic simulations make it possible receive a complete video film about the behaviour characteristic of a building I time dependency that gives the opportunity to design operation management and predict interdependency effects, which are – after a certain size and complexity of project - simply not possible to model with hand calculations anymore.

Building dynamic simulations means planning in four dimensions (4D), catapulting high performance building development into the next level. Due to this simulation supported design technique, project dependently 50-80% savings in investment and operation expenses can be achieved in comparison to conventional design. Also, simulations represent today's most developed and sophisticated methods to conduct research in building industries.

Implemented, case study reference building's experiences and insights about thermal building dynamic simulations supported design process.

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Implement theoretical learning content of thermal building physics in simulation supported building design;
2. Use thermal dynamic building simulation tool(s) to determine preliminary boundary conditions, 3D modelling of spaces and structures in creating HVAC systems and internal gains;
3. Evaluate and resolve problems in modelling and solver procedure;
4. Interpret heating and cooling load calculations, energy and custom, time dependent dynamic calculations applying thermal simulation software;
5. Evaluate and assess simulation results in terms of building physics background theory, thermal and visual comfort, energy demand and consumption;
6. Size building envelope structures and basic conceptual HVAC systems in terms of thermal efficiency;
7. Optimise HPB concepts and systems by working with simulations as design supportive feedback for machine and building development.

Content – Detailed

1. Understanding the function and background of stationary and dynamic thermal building simulation methods. Time dependent calculation of complex building physics. Building related simulations, building service system related simulations and system controlling related simulations. Indoor comfort and energy performance in results. Application possibilities and the importance of thermal building simulations in the development of HPB (high performance buildings). Stationary and dynamic calculation methods for entire buildings. Four-dimensional design where 'movies' are created instead of 'photos'. Instead of calculating continuously

- changing moments in time, time dependent results of indoor illuminance, daylight factors, artificial lighting, air temperature, relative humidity, air flow, air velocity and solar radiation will be calculated. Also, detailed, high-resolution pictures of the quality and quantity of the required energy for a building operation can be created. The calculations are carried out with dynamic building simulation supported modelling that enables precise feedback regarding the building's climate behaviour.
2. Principles of dynamic thermal building simulation with a focus on passive building strategies as well as active HVAC system solutions. Advantages and disadvantages, pro and contra in dynamic simulations. Application possibilities and the importance of thermal building simulations in the design and development of energy-efficient, environmental friendly and climate-responsive HPBs (high performance buildings).
 3. Simulation technology. Boundary conditions. Climate profiles. Multi-climate zone models. Internal gains. Room units. HVAC centrals. Passive ventilation. Controlling and regulation of openings, ventilation, shading and the complete technical system. Simulations in different design stages. Boundary conditions, level of detail, performance and potential of building thermal simulations in different design stages. 3D graphical and tabular feedback during modelling projects and monitoring results. 3D modelling of multi-climate-zone building models including structures, materials, occupants, equipment, as well as artificial lighting systems. CAD and IFC (BIM) import compatibility. Modelling of building services technical systems, heat generation centrals, heat transmitting room unit systems, as well as mechanical ventilation with air handling units. Passive ventilation. Complex controlling and regulation of openings, ventilation, shading and the complete HVAC system.
 4. Thermodynamic processes and a building's seasonal behaviour in daily, hourly, even second-based resolution (if needed) of a one-year energy and climate building simulation. Building physics and energy studies, façade optimisation, thermal comfort and visual comfort (daylighting), HVAC sizing, control optimisation and

system analysis for simulation supported thermal optimisation of HPBs and the development of innovative building concepts.

5. Understanding and interpreting the results of simulation calculations. Failure handling in modelling and calculations. Calculation settings. Result inspection. Thermal processes and buildings seasonal behaviour. Indoor thermal and visual comfort (daylighting). Energy demand and energy consumption.
6. Advanced level equation based mathematical models. Custom solutions. Thermal building simulations in research and development. A Modelica-like Neutral Model Format (NMF) advanced-level equation-based mathematical model that enables custom solutions, with its own extensions and R + D possibilities. No black box: equations are indicated (editable source code), calculated variables e.g. in one zone approx. 1000 temperatures, heat fluxes, CO₂-levels, control signals, comfort indices and energy values can be inspected by a critical user. Instead of hand-coded component subroutines, a variable time step solver enables the automatic adaption of calculation tolerance, eliminating numerical errors and speeding up calculation time.
7. Application of simulations. Load calculations. Energy and indoor climate calculations. Façade optimisation. HVAC sizing. System analysis. Optimisation of buildings, structures, services system controlling and operation.
8. Case study projects supported by thermal simulations. Awaited, estimated and calculated result comparison. Model predictive control and the operation of HPBs. Case study projects regarding thermal simulation supported planning and real implemented buildings. Analysis of dynamic simulation supported development questions, options, and cases with the evaluation of awaited, estimated and respectively calculated results. Model predictive control and the operation of HPBs. Thermal building simulations in research and development.
9. Identifying solutions in thermal building simulations and plan support. Exercises: Thermal dynamic simulation of a small scaled residential building using IDA ICE

simulation software. Understanding through detailed evaluation and analysis of the building physics processes and interdependencies in comfort, energy and architectural performance. Plan optimisation case investigations with simulation result feedback.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of this study unit, the learner can:
1. Implement theoretical learning content of thermal building physics in simulation supported building design.	1.1 Use thermal simulations to create detailed pictures about the quality and quantity of indoor comfort and the required energy for a building (energy demand) and its HVAC system operation (energy consumption). 1.2 Appropriately apply building thermal simulations in various resolutions, dependent on different design stages.
2. Use thermal dynamic building simulation tool(s) to determine preliminary boundary conditions, 3D modelling of spaces and structures in creating HVAC systems and internal gains.	2.1 Define the appropriate boundary conditions, level of detail, 3D multi-climate zone building models including structures, materials, occupants, equipment, as well as artificial lighting systems. 2.2 Model building service technical systems, heat generation centrals, heat transmitting room unit systems and mechanical ventilation with air handling units. 2.3 Integrate passive ventilation and shading systems in thermal building models. 2.4 Elaborate controlling and regulation macros for openings, ventilation, shading and the complete HVAC system. 2.5 Work with CAD and IFC (BIM) import.

3. Evaluate and resolve problems in modelling and solver procedure.	3.1 Perform the critical inspection of numerous temperatures, heat fluxes, CO₂-levels, control signals, comfort indices and energy balance values, etc. 3.2 Understand the “black box” i.e. indicated equations (editable source code) and calculate several variables. 3.3 Identify typical failure in geometry and structure modelling, as well as in technical system modelling. 3.4 Explore a decisive background and the reason for numerical errors in simulation results. 3.5 Evaluate the solutions for accelerating calculation time. 3.6 Consider the advantages and disadvantages, pro and contra, in dynamic simulations.
4. Interpret heating and cooling load calculations, energy and custom, time dependent dynamic calculations applying thermal simulation software.	4.1 Carry out thermal dynamic simulations of a small-scaled residential building, using IDA ICE simulation software. 4.2 Deliver reliable comfort and energy results.
5. Evaluate and assess simulation results in terms of building physics background theory, thermal and visual comfort, energy demand and consumption.	5.1 Analyse the results and modelling settings, regarding building physics processes and interdependencies in comfort, energy and architectural performance. 5.2 Interpret time dependent simulated results regarding indoor illuminance, the daylight factor, artificial lighting, air temperature, relative humidity, airflow, air velocity, solar radiation, etc. 5.3 Recognise the interactions between thermodynamic processes and a building’s seasonal behaviour in daily, hourly, even by-the-second resolution (if needed) of one-year thermal simulations. 5.4 Elaborate energy demand and consumption performance scenarios under similar climate-comfort boundary conditions, and/or different geometrical and structural settings.

6. Size building envelope structures and basic conceptual HVAC systems in terms of thermal efficiency.	6.1 Apply thermal simulations for the purpose of dimensioning: - building envelope (roofs, floors, walls and windows, openings) structures and internal structures (slabs, walls) according to national energy codes or international requirements. - heating, cooling and ventilation building services systems according to national or international legislations and/or concepts.
7. Optimise HPB concepts and systems by working with simulations as design supportive feedback for machine and building development.	7.1 Analyse dynamic simulation supported development questions, options and cases with the evaluation of awaited, estimated and calculated results. 7.2 Develop plan optimisation solutions during case investigations based on simulation result feedback: innovative agreements - with a focus on passive building strategies - with a focus on HVAC strategies. 7.3 Implement system analysis based control optimisation for HPBs. 7.4 Plan test versions for façade improvement and for a thermal and visual comfort (daylighting) upgrade.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 – 7.4	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes.	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through the submission of internally assessed learner work, as well as external	A short written review and feedback for learners about the exercise assignment. A grade (mark) on the basis of the exercise's content quality.



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	The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit.	assessments through written and theoretical examinations. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit. This study unit provides new, specialised theoretical and practical knowledge for learners. Participants pass upon successful completion of: - An exercise assignment (weighted at 50%) in the form of thermal dynamic building simulations using IDA ICE simulation software. The quantification of indoor climate and comfort performance of a given small-scaled case study building, including complete HVAC systems. Testing of different case settings in services systems and modifications geometry/structure for HPB model optimisation. - A written examination by answering and solving questions, exercises, as well as theoretical problems (weighted at 50%). The exam contains tasks according to assessment criteria (1.1 - 7.4). An examination is a time-constrained assessment that will take place on a specified date and at a specified location. The overall study unit grade is computed from the weighted mean of its components. The pass mark for a study unit is 50%.	A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.
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STUDY UNIT 6

Aerodynamic Building Simulations

MQF Level 7

6 ECTS

E-learning: No

Rationale

Detailed, high-resolution calculations in the field of building aerodynamics are only possible applying fluid dynamics model experiments and numerical simulations, ensuring high-level of precision. In contrast, simplified aerodynamic calculations for natural ventilation, night cooling potential or wind effects on buildings cannot deliver design accuracy and planning certainty, as well as reliability at the level and quality of computational fluid dynamic (CFD) simulations.

Since air flow currents are not visible, humans cannot develop a correct intuition for understanding flow processes. Due to visualisation of CFD simulations (and/or wind tunnel tests) currents 'become' visible, making easy analysis and thus visual development of correct intuition without understanding of very complex mathematical models. After basic understanding of simulation methods and proper viewing of results during this study unit, - as a next step - absolvents have the opportunity to further develop their CFD skills in post study programmes (e.g. Ph.D.).

This particular study unit delivers very deep and specific theoretical knowledge about high level building and aero physics, fluid dynamics and their practical application in simulations. Since the ability to use CFD simulation software is one of the highest levels of building modelling investigation and design skills, after successful completion of this study unit, participant can work with the following two competencies.

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Apply basic CFD simulations in small-scaled, simplified building example projects with special regard to air flow systems, natural ventilation solutions and passive cooling effect;
2. Further develop their building aerodynamic knowledge and CFD simulation skills in partly self-study, and partly post study programmes, such as Ph.D. doctoral research and education.

Content – Detailed

1. Acquiring the function and background of CFD building simulation methods.
Participants of this study unit will become familiar with the aerodynamic modelling of buildings and fluid dynamic simulations, as well as wind tunnel model experiment investigations. Basic understanding of simulation methods. Development of correct intuition for understanding flow processes, natural (and partly) mechanical ventilation, buoyancy and wind induced flows. Simplified steady state hand calculations in regard to natural (and partly) mechanical ventilation, buoyancy and wind induced flows. Relevant comfort factors of air. Zonal flow simulation coupled with thermal building simulation. Balances, conservation of mass and energy; simple principles that must be fulfilled by any model complexity. Boundary layer wind tunnel simulation technology, experiments and measurement techniques. Steady-state and transient computational fluid dynamics (CFD) simulations.
2. Simplified steady state hand calculations. Zonal flow simulation coupled with thermal building simulation. Boundary layer wind tunnel simulation technology, experiments and measurement techniques.
3. Steady state and transient computational fluid dynamics (CFD) simulations. Pre-processing methodology. Solver, settings and equations. Pre-processing:

- calculation space definition, geometry (CAD) generation, solid, 'air-tight' building and surrounding neighbourhood space 'negative' geometry generation, surface and 3D finite volume mesh generation, consisting of prismatic and hex core units. Mesh, e.g. boundary layer resolution determination. Building physics modelling, boundary conditions, discretisation, turbulence model definition, partial differential equations. Initialisation and start configuration. Solver: iterative numeric calculations of discretised conservation equations, monitoring, convergence and residuals.
4. Understanding and interpreting the results of CFD calculations. Post-processing, visualisation and the proper viewing of results. Developing easy analysis and thus the visual development of correct intuition without understanding very complex mathematical models. Optimisation with simulation feedback. Post-processing: analysis of results, visualisation, plausibility check, numeric evaluation and assessment of results (aerodynamic coefficient, pressure, velocity, direction, air flow and rate). Relevant conclusions, effect mechanisms, elaborated knowledge and optimisation with simulation feedback.
 5. Understanding calculation and simulation methods of different levels of complexity and interrelationships. Principally analogous, suitable and proper viewing of results in hand assessments, thermal-zonal flow simulations and in complex CFD simulations. Correct preliminary estimation of effects; correct definition of simulations and boundary conditions, as well as the correct verification of calculation results.
 6. Case studies of implemented buildings with several aero-physical simulation supported design examples. Implementation of a case study reference building's simplified estimation calculations; wind tunnel and CFD simulations, as well as monitoring measurement technology. Comparison of measurements in a wind tunnel, in real buildings and in CFD simulations. Pro and contra regarding on-site measurements and CFD simulations.

7. **Optional exercise:** Identify the solutions in CFD building simulations and plan support. Learners will build a simple one-zone simulation model as part of group work using Ansys Work Package software (Ansys Space Claim and Mesh). The natural ventilation system of the room is to be simulated via CFD solver (Ansys Fluent) and the results are to be visualised. Optimisation should be carried out by modified model cases and their simulations.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of this study unit, the learner can:
1. Apply basic CFD simulations in small-scaled, simplified building example projects with special regard to air flow systems, natural ventilation solutions and a passive cooling effect.	1.1 Prepare simulation including calculation space definition, geometry (CAD) generation, solid, 'air-tight' building and surrounding neighbourhood space 'negative' geometry modelling, surface and 3D finite volume mesh generation and resolution definition, and discretisation, initialisation. 1.2 Operate solver calculations comprising start configurations, numeric calculation iterations, monitoring, convergence and residual check. 1.3 Visualise and analyse results, including plausibility check, numeric evaluation and assessment of results (aerodynamic coefficient, pressure, velocity, direction, air flow rate). 1.4 Conclude insights about effect mechanisms in flow processes. 1.5 Properly view results in hand assessment, thermal-zonal flow simulations and in complex CFD simulations.

	1.6 Execute assessment criteria 1.1 – 1.5 in a simple one-zone CFD model and simulation exercise assignment. Can optimise the investigated room due to the modification of CFD model simulations.
2. Further develop their building aerodynamic knowledge and CFD simulation skills partly in self-study, and partly in post study programmes, such as Ph.D. doctoral research and education.	2.1 Continue working and make progress in CFD-related study and/or research.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 – 2.1	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through the submission of internally assessed learner work, as well as external assessments through written and theoretical examinations. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit. This study unit delivers very deep and specific theoretical knowledge about high-level building and aero physics, fluid dynamics and their practical application in one of the	A short written review and feedback for learners about the optional exercise assignment. A grade (mark) on the basis of the optional exercise's content quality. A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.



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	learning outcomes to the standards set by the assessment criteria for that study unit.	highest levels of building simulations. Participants pass upon successful completion of: - An optional exercise assignment (weighted at 50%) in the form of CFD building simulations using Ansys simulation software. The natural ventilation system of the room is to be simulated and the results are to be visualised. Optimisation should be carried out by modified model cases and their simulations. - A written examination answering and solving questions, exercises, as well as theoretical problems (weighted at 50%). The exam contains tasks according to assessment criteria (1.1 – 2.1). An examination is a time-constrained assessment that will take place on a specified date and at a specified location. The overall study unit grade is computed from the weighted mean of its components. The pass mark for a study unit is 50%.	
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STUDY UNIT 7

High-Performance High-Rise Buildings (HPhRB)

MQF Level 7

6 ECTS

E-learning: No

Rationale

The number of high-rise buildings (HRB) has increased for more efficient use of urban floor space areas without considering environmental and energy consequences. In addition, HRBs possess significantly more floors and floor space compared to regular building sizes. As a result in consequence, the material and energy consumption of a m² specific net floor space high-rise building is significantly higher in inefficiency than in regular building substance. On the other hand, nowadays population growth becoming exponential numbers: the PNUD (Program of the United Nations for the Development) estimates that 5 billion people will live in cities until 2030, whereas in 1950 30% of our population lived in urban areas, and in 2000 the proportion of settlement dwellers climbed to 47% and till 2030, it is projected to rise over 60%. Regarding the increase of land costs as well, it is inevitable for cities to go for vertical development. HRBs enable to save cultivable land, to reduce traffic infrastructure need and according pollution emissions, as well to reduce energy consumption and carbon emissions due to less horizontal energy infrastructure losses. A next logical step seems to be the further elaboration of HRB design into, green systems with high sustainable performance: the 'birth' of high-performance high-rise buildings (HPhRB).

This study unit delivers special theoretical knowledge about designing of one particular building type that plays a key role in future high performance and green urban development. The learning content is completely based on previous units and represents a unique topic

with less but so much the more special and inevitable learning outcomes.

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Understand and implement important and efficient theoretical issues related to high-performance high-rise buildings in design;
2. Distinguish between HPHRB solutions under different climate conditions in respect to building envelope (façade techniques) and space organisation;
3. Evaluate and assess climate and energy concepts for HPHRBs in different seasonal operation periods;
4. Develop hypothetic ideas for research and development in the area of tall buildings.

Content – Detailed

1. Deepening knowledge in the special design field of high-performance high-rise buildings (HPHRB). Extending design skill capacities in the field of HPHRB. High-rise building (HRB) architecture and engineering history. Settlement scaled functional mixture, density and space arrangement. After acquiring sustainable, green, environmental conscious, comfort- and energy-efficient theoretical knowledge and practical skills in general building design (residential and public buildings, offices, etc.), the focus of this study unit extends this previous topic with planning competencies in the field of high-performance high-rise buildings (HPHRB).
2. Design characteristics of HPHRBs. Design strategies and principles for achieving sustainable high performance in tall buildings under different climates. Usage of the given, prevalent properties of high buildings. Gravity as a solution for distribution and ventilation (thermal buoyancy – stack effect). The architectural and building physics properties of skyscrapers. Design strategies. HPHRBs in different climate

- conditions. Profiting from the special properties of tall buildings; gravity and thermal phenomena as efficiency potential. Historical development and architecture theory of HRBs, fundamental characteristics of building in verticality, urban density context, settlement space management, room and floor organisation. Special architecture and a building's physics-related properties connected to 'skyscraper' geometry, forming an internal spatial structure, traditional-cultural influences, aerodynamic parameters, wind effects (loads and passive ventilation and cooling capacities), optimal utilisation of land and the transport network, and the building envelope.
3. Design components of HPHRBs. Climate responsive building skin technology such as climate facades with more opacity, passive ventilation, daylight and shading systems, as well as absorber-power generation surfaces (collector and PV-systems, biomass and algae farms). Vertical gardening and farming in urban neighbourhoods for energy and alimentation production, as well for green public parks and recreational space creation. Specific HVAC and energy supply systems, waste water treatment, structures and materials.
 4. Climate skins and façades. Daylight and shading systems. Natural and mechanical ventilation systems. Building skin as energy generation surfaces. Vertical gardening, farming. Related building services systems. Specific structures and materials in HRHPBs.
 5. Analysis of HRHPB studies, building concepts, implemented and constructed projects. Good and bad examples in term of HPB's efficiency, environmental and comfort and health qualities. Diagnosis of innovative implemented buildings, as well as theoretical projects (plans) including data published about the performance.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of this study unit, the learner can:
1. Understand and implement important and efficient theoretical issues related to high-performance high-rise buildings in design.	1.1 Identify the fundamental characteristics of building in verticality in contemporary and historical perspectives, including traditional-cultural influences. 1.2 Demonstrate specialised theoretical knowledge considering the urban density context and efficient settlement space management. 1.3 Manage the solutions of 'skyscraper'-related special planning measures: room and floor organisation, geometry, forming and internal spatial structure. 1.4 Integrate the optimal utilisation of the land and transport network into HRHPB planning procedures. 1.5 Systemise the building physics characteristics of HRHPBs with special regard to: - building thermal qualities (comfort and energy) - building aerodynamic parameters, wind effects (loads, passive ventilation and cooling capacities) - verticality and gravity as the prevalent properties for the distribution of energies and for advanced natural ventilation.
2. Distinguish between HPHRB solutions under different climate conditions in respect of the building envelope (façade techniques) and space organisation.	2.1 Take various climate region conditions, such as climate factors and climate element processes into account, and to utilise their design-affecting aspects in the distinctive design of: - building structure components: climate skin façades with advanced opacity-transparency ratio

	- building space arrangements and as an effect on building shape forming. 2.2 Analyse HRHPB's different sustainability qualities.
3. Evaluate and assess climate and energy concepts for HPHRBs in different seasonal operation periods.	3.1 Plan climate responsive concepts in various meteorological situations and time intervals including the: - space organisation concept - building body shaping concept - structures concept - passive ventilation systems concept - mechanical ventilation systems concept - heating and cooling systems concept - operation management concept.
4. Develop hypothetical ideas for research and development in the area of tall buildings.	4.1 Create and advise on ideas and concepts for the improvement and development of HRHPB design, based on acquired insights about state-of-the-art HRBs.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 – 4.1	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through external assessments through written and theoretical examinations. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the	A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.



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	assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit.	assessment criteria for that study unit. This study unit represents a unique topic, delivering special theoretical knowledge about one particular HPB type that improves green urban development significantly. Participants pass upon successful completion of: - A written examination answering and solving questions, exercises, as well as theoretical problems (weighted at 100%). The exam contains tasks according to the assessment criteria (1.1 - 4.1). An examination is a time-constrained assessment that will take place on a specified date and at a specified location. The pass mark for a study unit is 50%.	
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Operational Programme II – European Structural and Investment Funds 2014-2020
"Investing in human capital to create more opportunities and promote the well-being of society"
 Project part-financed by the European Social Fund
 Co-financing rate: 80% European Union; 20% National Funds



STUDY UNIT 8

High Performance Settlements (HPS)

MQF Level 7

6 ECTS

E-learning: Yes

Rationale

The holistic character of HPB design requires extending the focus from a single building in a larger context, to the connection of several buildings across districts to the level of complete cities. Based on extreme growing population tendencies in settlements and urban neighbourhoods, handling of urban planning aspects is critical in respect to energy and environment optimised retrofitting of historical city cores, refurbishing and extending existing settlement residential, public, office and industry building district substances. Also development of new sustainable settlements is of prime importance, since the implementation of one green, high comfort and energy performance building contributes only 'one water droplet' amount of improvement in our society's' sustainability evolution, while creation of complete districts and cities represents the represents 'ocean'-sized advancements in our World's green development. Another reason occurs for devoting special attention to high performance settlement (HPS) design, namely the holistic character of high performance building design approach that requires extending the focus from single building on the larger context, on the connection of several buildings across districts to the level of urban context.

Thus, a lot of single threads of previous units will converge in this study unit and will be expanded to a new meta level. Beforehand, presented concepts like indoor comfort will be applied to outdoor comfort models of whole cities by discussing the influence of green

areas, suburb structures, street exploitation, orientation of buildings as well as lessons from history. Moreover, the influence of airflow in cities on heat losses, air pollutants and greenhouse effect in settlements will be shown through positive, as well as negative examples. While high performance buildings describes the architectural challenges of designing sustainable housing, high performance settlements take everything one step further and formulates the ultimate goal: designing the carbon neutral settlement.

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Identify strategic components and topics in sustainable development and/or refurbishment of district or settlement level projects;
2. Estimate energy demand status using statistical methods;
3. Develop settlement scaled energy supply and management concepts, based on energy situation and infrastructure analysis;
4. Distinguish between different future scenarios in city energy refurbishment or new development;
5. Develop city climate concepts for high comfort quality in outdoor urban public spaces;
6. Observe and take part in local settlement development procedures and recommend modifications or improvements as a planner, evaluator or consulting design expert.

Content – Detailed

1. Expanding knowledge in the special design field of high-performance settlements (HPS). Based on previous experience and the already learned special holistic knowledge of high performance building design, the curriculum must be expanded to the larger context of settlements. Thereby completing the scope of design factors with all the remaining relevant interrelationship of building design implementation.

The theory of high performance settlements (HPS), sustainable urban planning, urban climate, urban energy systems and sources, as well as urban ecology systems will all be covered.

2. Vernacular, environmentally friendly, efficient settlement history. Sustainable urban planning theory. Urban climate basics. Urban comfort basics. General urban energy and ecology systems. Traffic, transportation and infrastructure in sustainable quarters.
3. Energy, material and climate flow in urban districts. Smart city grid systems.
4. Characteristics and design components of HPS in refurbishing settlements. Vernacular, environmentally friendly and efficient settlement history. Energy and environmentally optimised retrofitting of historical city cores. Refurbishment of diverse existing settlement districts. Climate and energy analysis of positive and negative existing settlement design settings, case studies.
5. Characteristics and design components of HPS in newly developed settlements. City energetics and city climatology, city comfort factors, urban comfort (of external, public spaces), effects of topography, orientation, A/V-ratio and building typology. Solar and aerodynamic aspects in city planning. Shading, daylight, wind protection, shelters, city ventilation. Density and economic space usage. Horizontal and vertical green spaces and biodiversity. Climate and energy analysis of positive and negative new settlement design settings and case studies. Simulation supported settlement design examples.
6. Settlement energy regulation plans. Status analysis and energy assessment statistical tools. Settlement scaled concept plans, urban energy development and management strategies. Energy, material and climate flows. Future scenarios. Situation and status analysis of the building substance, energy infrastructure and regenerative energy potentials using statistical tools. Settlement scaled energy utilisation and supply conception planning. District heating, central and decentralised energy supply solutions, energy centrals and distribution. Energy

coordination and energy system refurbishment. Energy conservation in buildings, the user behaviour of the occupants and the efficiency of the energy supply. Sustainable future scenarios of settlement models. The energy regulation plan in historical city cores, city centres and in neighbourhoods under heritage protection. Thermal and **optional** CFD simulations in city design task examples.

7. **Optional** energy and climate efficient settlement excursions. Visiting contemporary or historic high performance settlements.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of this study unit, the learner can:
1. Identify strategic components and topics in the sustainable development and/or refurbishment of districts or settlement level projects.	1.1 Extend the focus from a single building to a larger urban context, due to a holistic design approach. 1.2 Provide fundamental theoretical solutions in: - refurbishing and extending existing settlement residential, public, office and industry building district substances - the development of new sustainable settlements. 1.3 Demonstrate specialised, multi-disciplinary knowledge of settlement climatology, comfort and energetics including the solar and aerodynamic aspects, topography, building density, horizontal and vertical green spaces.
2. Estimate energy demand status using statistical methods.	2.1 Deliver energy calculations about existing settlements using statistical methods.
3. Develop settlement scaled energy supply and management concepts, based on the energy situation and infrastructure analysis.	3.1 Assess an existing settlement's energy infrastructure with different energy sources and the potential analysis of renewable energy usage.

	3.2 Prepare decision-making support for a settlement energy regulation masterplan.
4. Distinguish between different future scenarios in a city energy refurbishment or a new development.	4.1 Deliver energy calculations in regard to retrofitting or new developments in settlements, using statistical methods. 4.2 Design settlement energy concepts.
5. Develop city climate concepts for high comfort quality in outdoor urban public spaces.	5.1 Apply building and block arrangement, shading, daylight, wind protection, shelter and city ventilation system solutions for the design of external, public spaces.
6. Observe and take part in local settlement development procedures and recommend modifications or improvements as a planner, evaluator or consulting design expert.	6.1 Complete the climate and energy analysis of settlement-scaled districts. 6.2 Contribute to projects dealing with smart city grid systems.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 – 6.2	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through external assessments through written and theoretical examinations. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit.	A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.



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assessments through written examinations.

For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit.

This study unit rounds up the holistic building design methodology, delivering specific theoretical knowledge about HPS planning, the greater context and scale for sustainable development in the built environment. Participants pass upon successful completion of:

- A written examination by answering and solving questions, exercises, as well as theoretical problems (weighted at 100%). The exam contains tasks according to assessment criteria (1.1 - 6.2).

An examination is a time-constrained assessment that will take place on a specified date and at a specified location.

The pass mark for a study unit is 50%.



STUDY UNIT 9

Project 1 – Building Design Project (HPB)

MQF Level 7

6 ECTS

E-learning: No

Rationale

To master the acquired methodical and instrumental competencies, the learners finish their master course with two practical study units. The current study unit instructs learners to summarise the acquired theoretical knowledge and practical competencies from previous study unit topics, and apply them in a building project design task.

Participants are already able to demonstrate HPB philosophy, planning methods and contents, as well as impact factors of complex building physics. Dependencies and synergies between site, neighbourhood, orientation, building function, geometry, structures and aesthetics, as well as building climate, comfort, energy, environmental questions and building services systems will be merged into a meaningful relationship. In addition, participants can apply design-supporting techniques, such as climate, comfort, energy and aerodynamics simulations.

The topic of this exercise is the design of winery. Depending on the chosen location for the premises, the demands of the design challenge will be different. Therefore, basic information about viticulture and climate zones are provided and put into context of high performance buildings.

The planning development will be carried out by teams, in order to practice interdisciplinary-like working environment, as well as to enable part time study participants to absolve a high performance building (HPB) project design in more deepened and detailed resolution, thus enhancing and mastering their building design skills.

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Design innovative HPBs, considering architecture, building climate, comfort, energy, aerodynamics and the environment;
2. Implement holistic design philosophy and the theoretical methods and issues of complex building physics into HPB design;
3. Create a type of scientific planning work, applying dynamic simulations tools and models in the field of thermodynamics, lightning and fluid mechanics, whereby decisions will be quantified and – in this way – justified;
4. Discuss design concepts in a team, justifying selected concepts and reaching agreements through negotiations;
5. Present and debate design project ideas.

Content – Detailed

Mastering methodical and instrumental competencies in HPB design. Application of acquired special theoretical knowledge and practical skills from study units 1 - 8.

Assessment and integration of interdependencies between the HPB design approach, planning methods and related building physics mechanisms.

Learners will work actively in design teams, elaborating a self-sufficient, zero CO₂-, or energy-positive building in different climate regions. Each design team will choose a different climate zone where the project is to be elaborated upon. Participants will work in an

interdisciplinary manner integrating several architectural, engineering and scientific topics from the previous study units. The task is to develop an energy and climate concept for new or refurbishment active house project, using architectural planning methods, as well as stationary and dynamic calculations.

The project work includes climate analysis of the site, indoor and outdoor boundary conditions assessment, elaboration of different potential building concept variations, elaboration of space organisation, building form finding and structural concept or the refurbishment concept (if applicable). It will also include development of the façade and building envelope concept, as well as the climate concept, including operation management (heating, cooling, ventilation and lighting) and HVAC systems. Based on previous project concepts (building concept and climate concept) the energy concept is to be elaborated upon. Furthermore, renewable energy utilisation potentials must be taken into consideration.

The different systems and components, as well as structural solutions must be devised from concept to detail.

Supporting HPB design procedure with estimated, rough building physics calculations in regard to energy balances. Solving steady state “hand” calculations of energy fluxes, losses and loads, storage, heating and cooling, ventilation and daylight. An energy-positive total energy balance is the overall target.

Supporting HPB design procedure with building physics simulations for energy optimisation feedback. Application of thermal, daylighting and **optional** (not obligatory) fluid dynamic simulations. Exact, dynamic quantification (dynamic simulations) of the thermal comfort parameters, air quality, daylight properties and energy demand and consumption, respectively. Energy fluxes of heating, cooling, internal and external loads, losses, storage and ventilation. Influence of the user behaviour and seasonal building operation management.

And **optional** choice is plan optimisation supported by lighting simulations and CFD airflow simulations.

Cost-efficiency evaluations in construction and operation will be taken into consideration on the basis of hand calculations (investment costs) and dynamic thermal simulation results (operation expenses), including CO₂-emission analysis.

An **optional** choice is plan development and optimisation using an LCA tool.

Providing complete HPB design solutions and plan documentation, visualisation and presentations. Exercises (study unit project assignment): Plan a development as part of active teamwork. The design task comprises elaborating on a particular self-sufficient, zero CO₂-, or energy-positive building in a different climate region, per design team. Learners will report and document the building and climate, as well as the energy concept. Sketch and approval plans with crucial details must be submitted. After presentation of the project by the learner team, a written review and feedback for learners will be provided.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of this study unit, the learner can:
1. Design innovative HPBs, considering architecture, building climate, comfort, energy, aerodynamics and the environment.	1.1 Elaborate on the architecture, energy and climate concept for a particular new or refurbished active house project with architect's plans, including acquired knowledge and skills, e.g. boundary condition and potential analysis, space and form management, façade, climate and energy design component integration.
2. Implement holistic design philosophy and the theoretical methods and issues of complex building physics into HPB design.	2.1 Explore the dependencies and synergies between the site, neighbourhood, orientation, building function, geometry, structures and aesthetics, as well as building climate, comfort, energy, environmental questions and building service system factors.

	2.2 Develop a HPB design using architectural planning methods, as well as stationary energy calculations.
3. Create a type of scientific planning work, applying dynamic simulation tools and models in the fields of thermodynamics, lightning and fluid mechanics, whereby decisions will be quantified and – in this way – justified.	3.1 Carry out dynamic thermal simulations for HPB design support in the following fields: - climate zoning-based space organisation - building climatic orientation - building body forming and geometry - building envelope design - thermal mass and opaque structures - glazing ratios - façade development - roof structure - shading - internal heat gains (illumination, equipment) - metabolic heat release and activity level of users - solar radiation gains - seasonal operation concepts - thermal and air quality comfort evaluations (for main functional spaces and rooms) - visual comfort, natural/artificial lighting concept, daylight factor and natural illuminance - comparative analysis of building services systems (energy sources, heat generating systems, heat transferring systems, efficiency test), energy demand - Seasonal HVAC systems operation and passive operation, heating load of the building, energy consumption of the building services systems, in the following systems: - heating - cooling - mechanical ventilation - natural ventilation - operation cost evaluation, payback period estimation - operation CO2-emissions evaluation. 3.2 Carry out optional CFD simulations in summer operation mode: determination of natural ventilation and cooling potential in the form of airflow characteristic modelling.

4. Discuss design concepts in a team, justifying selected concepts and reaching agreements through negotiations.	4.1 Practice in an interdisciplinary working environment, the collection experience with adequate communication of the project and plan development.
5. Present and debate design project ideas.	5.1 Document, visualise and present the project assignment solution to an appropriate and reasonable quality level.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 – 5.1	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit.	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through the submission of internally assessed learner work. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit. This study unit requires the application of all acquired theoretical knowledge and practical competencies from the previous study units. Participants pass upon the successful completion of: - A project assignment (weighted at 70%) in the form of a complete HPB design elaboration. Learners	A short written review and feedback for learners about the project assignment. A grade (mark) on the basis of the project's content quality. A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.



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		support their planning work using building physics calculations to develop and/or optimise the desired design solution. Design solution assessment according to assessment criteria (1.1 - 5.1). - An oral presentation (a defence of the project) presenting concepts, calculation results and plans, as well as answering questions and responding to remarks from the study unit docent (weighted at 30%). The oral project presentation is a time-constrained assessment that will take place on a specified date and at a specified location. The overall study unit grade is computed from the weighted mean of its components. The pass mark for a study unit is 50%.	
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STUDY UNIT 10

Project 2 – Settlement Design Project (HPS)

MQF Level 7

6 ECTS

E-learning: No

Rationale

To master the acquired methodical and instrumental competencies, the learners finish their master course with two practical study units. Based on the nature of holistic, iterative planning approach, particular – second – exercise study unit widens the design scope and addresses the development task of a high performance settlement (HPS). This task gives learners the opportunity to use the previously acquired theoretical knowledge and practical competencies in a project design task, with the main focus on study unit 8 -“High performance settlements (HPS)”.

Participants are already able to demonstrate HPB philosophy, planning methods and contents, as well as impact factors of complex building physics. Furthermore, participants can apply design-supporting techniques, such as climate, comfort, energy and aerodynamics simulations. Comprehension of gained knowledge handles the interdependencies and synergies between urban neighbourhood, building typology and aesthetics, as well as city climate, comfort, energy, environmental questions and settlement infrastructure and services systems will be considered into a meaningful relationship.

The exercise will be developed in group work in order to practice interdisciplinary-like work, as well as to enable part time study participants to absolve a larger scaled HPS project design, thus enhancing and mastering their urban design skills.

Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Design innovative HPSs, considering urban design, settlement climate, comfort, energy, aerodynamics and environment, as well as infrastructure and traffic;
2. Implement holistic design philosophy, theoretical methods and issues of complex building physics into HPS design;
3. Create a kind of scientific planning work, applying settlement related calculations, dynamic simulations tools and models in the field of thermodynamics, lightning and fluid mechanics, whereby decisions will be quantified and – in this way – justified;
4. Discuss design concepts with team, justifying selected concepts and reaching agreements through negotiations;
5. Present and debate design project ideas.

Content – Detailed

Mastering methodical and instrumental competencies in HPS design. Application of acquired special theoretical knowledge and practical skills from study units, especially from study unit 8. Assessment and integration of interdependencies between the HPS design approach, planning methods and related building physics mechanisms. Sustainable urban design skills.

Learners will work actively in design teams, elaborating upon a self-sufficient, zero CO₂-, or energy-positive settlement in an already existing city environment or a completely new urban construction setting. Design teams will work in an interdisciplinary manner, integrating several architectural and engineering, scientific topics from the previous study units. The task is to develop an energy and climate regulation master plan for historical or new settlements using urban and architectural planning methods, as well as statistical and simulation instruments.

The project work includes status and potential analysis in buildings, energy and infrastructure, settlement morphology and building typology analysis and consideration, as well as building energy typology elaboration. An essential part of the project task is the development of refurbishment categories and concepts, furthermore the elaboration of future development concepts and scenarios, including renewable energy utilisation potential detection and utilisation. Energy supply (energy source and energy generation) systems and corresponding HVAC building services systems must be planned in settlement scaled, low resolution with conceptual solutions in buildings, blocks and/or districts, city cores and settlements.

Different systems and components, as well as structure and traffic system solutions must be devised from concept to detail.

Supporting the HPS design procedure with the energy regulation plan method, using estimated, rough building energy calculations. Status and potential analysis in buildings, energy and infrastructure. Building energy typology elaboration. Solving heat and electricity demand calculations in a building and settlement scale, using statistical data. Future development concepts and scenarios. An energy-positive total energy balance is the overall target.

Supporting the HPS design procedure with building physics simulations for energy optimisation feedback. Application of thermal, daylighting and **optional** (not obligatory) fluid dynamic simulations. Exact, dynamic quantification of thermal comfort parameters, air quality, daylight properties and energy demand and consumption in specified building types and/or building blocks. Energy fluxes of heating, cooling, internal and external loads, losses, storage and ventilation.

Cost-efficiency evaluations in construction and operation will be taken into consideration on the basis of hand calculations (investment costs) and dynamic thermal simulation results (operation expenses), including CO₂-emission analysis.

As a result, an energy and climate regulation master plan, settlement energy and climate development plan must be delivered by the learners.

Providing complete HPS design solutions and plan documentation, visualisation and a presentation. Exercises (study unit project assignment): Plan the development as part of active teamwork. The design task comprises elaborating upon a particular self-sufficient, zero CO₂-, or energy-positive settlement in an already existing city environment or a completely new urban construction setting. The task is to develop an energy and climate regulation master plan. The design teams will choose tasks in different climate regions. A report about the buildings and climate, as well as the energy concept, is to be documented. Also a sketch and approval plans with crucial details must be submitted. After the presentation of the project by the learner team, written review and feedback will be provided to the learners.

Assessment Criteria

Learning Outcomes	Assessment Criteria
Upon completion of this study unit, the learner will be able to:	Upon completion of the study unit, the learner can:
1. Design innovative HPSs, considering urban design, settlement climate, comfort, energy, aerodynamics and environment, as well as infrastructure and traffic.	1.1 Elaborate upon the architecture, energy and climate concept for a particular new or refurbished settlement project with architect's urban plans, including acquired knowledge and skills, e.g. boundary condition and potential analysis, topography, urban indoor and outdoor space management, climate and energy design component integration.
2. Implement holistic design philosophy, theoretical methods and issues of complex building physics into HPS design.	2.1 Explore the interdependencies and synergies between an urban neighbourhood, building typology and aesthetics, as well as the city climate, comfort, energy, environmental questions and settlement infrastructure and services systems factors.

	2.2 Develop an HPS design using architectural planning methods, as well as stationary energy calculations.
3. Create a kind of scientific planning work, applying settlement related calculations, dynamic simulation tools and models in the field of thermodynamics, lightning and fluid mechanics, whereby decisions will be quantified and – in this way – justified.	3.1 Carry out dynamic thermal simulations for HPB design support in the following fields: - creating building types and blocks and their arrangement as space organisation on the conceptual urbanistic level - arrangement and design of external spaces and public spaces - conceptual, climate-based room-space organisation, building climatic orientation, building body forming and geometry - building envelope design: - thermal mass and opaque structures - glazing ratios - roof structure - shading - internal heat gains (illumination, equipment) - metabolic heat release and the activity level of users - solar radiation gains - seasonal operation concepts - optional task: thermal and air quality comfort evaluations (for the main functional spaces and rooms) - optional task: visual comfort, natural/artificial lighting concept, daylight factor and natural illuminance - energy demand for building operation management depending on a building's conceptual design, in the following systems: - heating - cooling - mechanical ventilation - natural ventilation - comparative analysis of building services systems (energy sources, heat generating systems, heat transferring systems, efficiency test), energy demand and consumption - operation cost evaluation and payback period estimation - operational CO₂-emissions evaluation 3.2 Carry out optional CFD simulations in summer operation mode: determination of natural

	ventilation and cooling potential in the form of airflow characteristic modelling in urban outdoor spaces.
4. Discuss design concepts with team, justifying selected concepts and reaching agreements through negotiations.	4.1 Practice in an interdisciplinary working environment, gaining experience in adequate communication of the project and plan development.
5. Present and debate design project ideas.	5.1 Document, visualise and present the project assignment solution at an appropriate and reasonable quality level.

Assessment Methodology

Assessment Criteria Covered	Assessment Scenario	Assessment Method	Grading Info (optional)
1.1 – 5.1	All assessments for the qualification are intended to ensure that participants in the study unit demonstrate they have acquired all the relevant information, knowledge and skills of the learning outcomes. The qualification of the assessment is fulfilled through the submission of internally assessed learner exercises, project work, as well as external assessments through written examinations. For the purpose of successfully passing a particular study unit's required criteria, a learner	All assessments for the qualification are intended to allow the learners to demonstrate they have met the relevant learning outcomes. The qualification assessment is completed through the submission of internally assessed learner work. To achieve a pass for a study unit, a learner must have successfully achieved all the learning outcomes at the standards set by the assessment criteria for that study unit. This study unit requires the application of all acquired theoretical knowledge and practical competencies from the previous study units, with the main	A short written review and feedback for learners about the project assignment. A grade (mark) on the basis of the project's content quality. A short written review and feedback for learners about the exam. A grade (mark) on the basis of the written exam's content quality.



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	must have adequately achieved all of the learning outcomes to the standards set by the assessment criteria for that study unit.	focus on study unit 8. Participants pass upon successful completion of: - A project assignment (weighted at 70%) in the form of a complete HPB design elaboration. Learners will support their planning work using building physics calculations to develop and/or optimise the desired design solution. Design solutions assessment according to assessment criteria (1.1 - 5.1). - An oral presentation (defence of the project) by presenting concepts, calculation results and plans, as well as answering questions and reacting to responses from the study unit docent (weighted at 30%). The oral project presentation is a time-constrained assessment that will take place on a specified date and at a specified location. The overall study unit grade is computed from the weighted mean of its components. The pass mark for a study unit is 50%.	
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Operational Programme II – European Structural and Investment Funds 2014-2020
“Investing in human capital to create more opportunities and promote the well-being of society”
Project part-financed by the European Social Fund
Co-financing rate: 80% European Union; 20% National Funds

