Building Sustainability and Design through Digital Tools

ATHENA

University goes Digital for a Global Sustainable Education

TEAM:

ISCTE - University Institute of Lisbon

POLIMI - Politecnico di Milano

COORDINATOR:

Prof. Ricardo Pontes Resende | ISCTE

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Main partners

Associated partners

GOALS

KNOW MORE...

About the Athena Project:

https://athenadigitaluniversity.eu/

About the Secclass Project:

https://secclass.pt/

GET TO KNOW...

The Athena E-Learning Platform:

https://athena.webwise.pt/

THE ATHENA PROJECT

The purpose of the ERASMUS+'s ATHENA "University Goes Digital" Project is to improve digital skills of university teachers, to reinforce their capacity to respond the challenges Higher Education faced during the COVID-19 pandemic or will face on future similar challenges. With active involvement of lecturers and students, ATHENA will create, test and implement innovative digital practices, using technologies to create new pedagogical approaches and achieve better learning and teaching experiences. The project seeks to foster cooperative learning environments, making them transformative and inclusive through the effective adoption of new technologies, such as e-learning, gaming platforms, virtual and augmented reality, systematically modelled to activate key competencies in digital learning. The project will create templates that lecturers can adopt and adapt to their classes, using different pedagogical approaches.

THE COURSE

The course´s main goal is to develop a broad understanding of the impacts of buildings in the environment, and to master BIM-based digital tools for the assessment of these impacts in building construction and operation. It aims to understand the theoretical framing of building sustainability, environmental costs in construction and operation ,and emerging BIM technology, and to explore the demands connected to the challenges of Circular Economy in architecture and construction, together with the available building sustainability evaluation schemes. To evaluate innovative solutions for sustainable architecture design considering embodied carbon and operational energy performance, and to become a transformation force for the digital transition of architecture and evidence-based design. This course was designed in collaboration with team elements of the EEA Grants' SECClasS Project, which develops optimized Classification Schemes to facilitate Circular Economy in construction.

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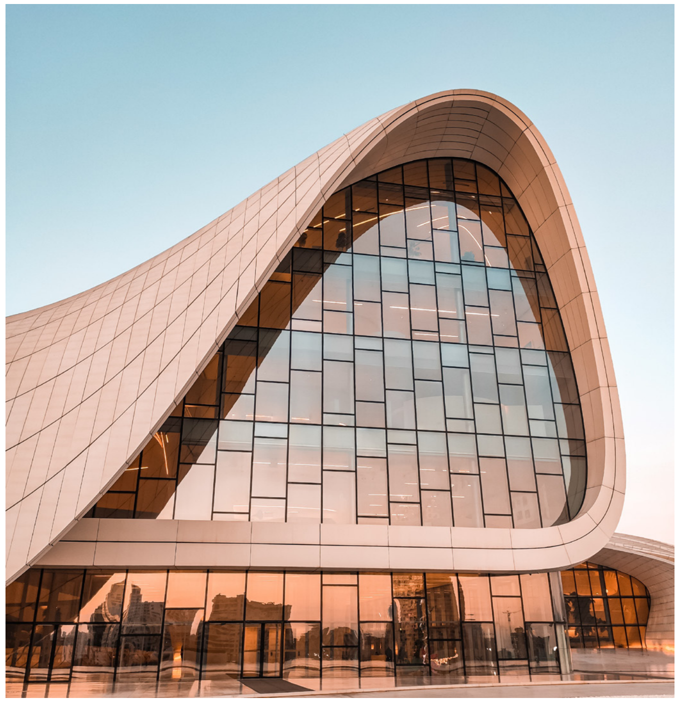
Course Structure

1



INTRODUCTION

Presentation of the course, goals, teachers, structure, classes and assessments.

2

FOUNDATIONS

Foundations of built environment sustainability and circular economy, building sustainability assessment tools, the european Level(s) framework, evidence-informed design and the digital transformation of construction.

3

PILOT BUILDING

Presentation of the pilot building case study, by the project team that designed it, used in the course assessment.

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Course Structure

4

GROUP ASSIGNMENT

Assessing the Pilot Building Case Study by considering either the embodied carbon on the building or the energy performance of the building. This will be done by considering different materials, insulations, or energy requirements.

4a

GROUP WORK

EMBODIED CARBON ASSESSMENT

The module starts with an introduction on Sustainable building design considering four aspects: land use, water use, embnodied carbon and energy waste (by Prof. Joana Mourão).

Then, the students are taught how to perform an alaysis on the BIM model of the Pilot Building, in order to assess the embodied cqrbon footprint and other outputs of the Level(s) European Framework. They will also analyse alternative scenarios (by Arch. Sara Parece).

4b

GROUP WORK

OPERATIONAL ENERGY ASSESSMENT

Starting module regarding operational energy performance with Rhinoceros 3D and Grasshopper, followed by a getting started module for software instalation, creating a geometry and defining materials, definition of zones, loads and schedules, and finally the EnergyPlus energy simulation.

Students will perform analysis considering the required energy for the building to be kept at comfortable temperatures, as well as the performance of the materials used. They will also analyse the possibility of different scenarios by experimenting with using different materials (by Arch. Leonor Domingos).

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SPEAKERS ISCTE - University Institute of Lisbon

RICARDO RESENDE

Civil Engineer, MSc, PhD

Civil Engineer and MSc (IST, 2000), and PhD (FEUP, 2010). Professor and sub-director of the Department of Architecture and Urbanism. Researcher and consultant in sustainable construction and digital construction.

LEONOR DOMINGOS

Architect, MSc, PhD

Architect (ULL, 2017) and PhD (ISCTE, 2022) researcher at ISTAR-Iscte, specializing in energy building performance, multi-criteria decision analysis, resilient and adaptative architecture, and visual programming with Grasshopper.

SARA PARECE

Architect, MSc

Architect (ISCTE, 2020), and PhD researcher candidate at ISTAR-Iscte, focused on Circular Economy, Sustainable Architecture, Decision Support Tools, Life Cycle Assessment, BIM and construction material efficiency.

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SPEAKERS ISCTE - University Institute of Lisbon

SUSANA REGO

Architect , MSc

Graduated in Architecture by ISCTE. Since 2018 works at ISCTE's architecture office for the Campus expansion as one of the lead architects designing and coordinating projects for the Lisbon and Sintra ISCTE Campus.

RÚBEN FERREIRA

Architect, MsC

Architect graduated from ISCTE. Since 2020 works at ISCTE's architecture office designing and co-coordinating projects. Responsible for the coordination and BIM implementation in the office.

BERNARDO MIRANDA

Architect , MSc, PhD

Architect (FAUL, 1987) and PhD (FAUP, 2014). Architecture Professor, Vice-Rector for the building heritage, member of the Lisbon Coucil Comission for the city Toponymic and observatory of Contemporary Religious Architecture.

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SPEAKERS

ISCTE

J O A N A   M O U R Ã O

Architect, MSc, PhD

Architect (UC), PhD (UP), and Postdoctoral in Urban and Building Regeneration by the Technical Institute of Lisbon (IST) and LNEC (Laboratory of Civil Engineering). Invited teacher at ISCTE (2022).

POLIMI - Politecnico di Milano

A N D R E A   B R A M B I L L A

Architect, MSc, PhD

PhD in Architecture Built Environment Construction Engineering with expertise on systematic evaluation of sustainability and health impacts of projects at urban and building scale.

E R I C A   M O S C A

Architect, MSc, PhD

Architect, PhD and postdoctoral researcher at the Department of Architecture, Built environment and Construction Engineering (ABC) of Politecnico di Milano. Collaborates with the “Design and Health LAB”.

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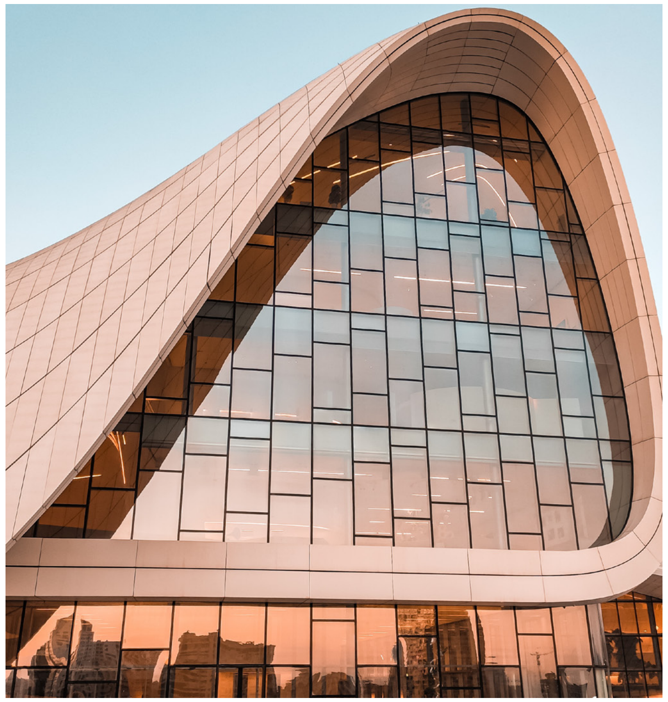

Module 1

MODULE GOAL

To understand the contents of the course and form work groups. Assign the building/case study/assignment the students will be working on. Learn how to use the learning platform.

MODULE CLASSES

1.1. Introduction

Module 2

MODULE GOAL

Frame the past, present and future global environmental situation. Understand the concepts of Sustainability and Circular Economy, as well as historical background. Know the built environment sustainability initiatives at European and global levels. Know the European framework: “Level(s)”. Understand the potential uses of technology for the industry, particularly BIM and energy assessment tools.

MODULE CLASSES

2.1. Foundations of Sustainability & Circular Economy

2.2. Building Sustainability Assessment Tools

2.3. European Level(s) Framework: the six macro-indicators

2.4. Evidence-Informed Assessment Tools

2.5. Digital Transformation of Construction

Final Written Assessment

Students must develop and present a strategy for the renovation and conversion of one of four suggested buildings, to one of the following uses: Student Residence, Hostel, Office Building and Housing. The strategy must address a series of specific defined points.

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FOUNDATIONS

2.1. Foundations of Sustainability and Circular Economy

Since the beginning of the industrial revolution, environmental disasters have ocurred in industrialized countries. The emergence of a social and political conscience began in the 60s, and the first United Nations Conference on the Human Environment was held in Stockholm, in 1972. Fifty years of environmental policies followed. In 2015, the UN created the Sustainable Development Goals, applicable universally to transform the world through 2015-2030. To achieve these goals, it is necessary to go from a linear economy to a circular economy, a new model that involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. The objective of the EU is to make Europe the first net-zero continent by 2050. To achieve this, in 2020 the EU embraced the European Green Deal, and set an Energy Roadmap for 2050 which aims to reduce carbon emissions by 80%, below 1990 levels. This strategy includes a range of sectors, starting from the central role of energy, including buildings, transport, industrial production, services provision, waste management, agricultural and land use, and the use of natural resources.

The built environment impacts many sectors of the economy, and accounts for about 50% of extracted material, and 40% of total EU energy use. The construction sector is responsible for over 33% of the EU's total waste generation, and 36% of total greenhouse gas emissions. In 2018, the EU launched Level(s), a strategy to assess the lifecycle of buildings, in line with the "Construction Product Regulation's Revision", promoting the adaptability and resilience of built assets.

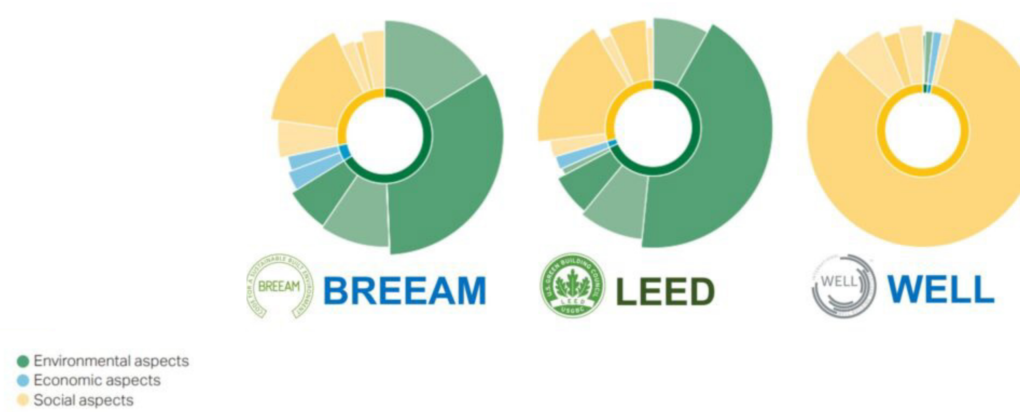
COVID-19 has hindered the progress towards achieving these, as it caused reduced life expectancy, increased poverty and unemployment rates. For the first time since the creation of the SDGs, the average index score did not increase in 2020. However, SDGs remain the only integrated framework for Economic, Social and Environmental development adopted by all UN member states. From 2021 to 2027, 35% of the EU's research funding will be dedicated to develop climate-friendly technologies.

THE EU & ASEAN. (2022, 07 18). *EU Green Deal*. Retrieved from EU-ASEAN Strategic Partnership 2022: https://euinasean.eu/eu-green-deal/

FOUNDATIONS

2.2. Building Sustainability Certification Schemes

Client and society's pressure requires designers and builders to prove environmental credentials in the industry. In that sense, various assessment methods were created throughout the years, and at least 20 of the 83 Green Building Councils around the world have developed certification schemes. The construction industry generates a lot of impacts, which have severe environmental consequences. How can such impacts be measured? LCA, or Life Cycle Assessment is one of the ways. LCA analyses the building's life cycle, starting with products and materials, construction process, use, end-of-life and reuse, recover or recycling of materials. This process is called "cradle-to-cradle". This is, however, an extremelly complex process as it requires great ammounts of information which is not always available. In order to make the process easier, to apply in real-world projects, other ways of assessing the environmental impact of buildings were devised. In 1990, the Building Research Establishment, in the UK, developed a system called "Building Research Establishment Environmental Assessment Method". In 1998, the U.S. Green Building Council created the "Leadership in Energy and Environmental Design". The WELL Building Institute created WELL in 2014, a roadmap to design and certify spaces to advance human health and well-being. Major differences on the importance of each aspect are noticeable in these three different tools. BREEAM is the one that gives greater importance to the economic aspects, LEED gives more weight to the environmental aspects, and WELL is essentially focused on personal well-being and social aspects. BREEAM uses quantitative standarts, while LEEDs thresholds are based on percentages. LEED is also considered to be simpler. While both BREEAM and LEED deal with the environmental sustainability of buildings, their biggest difference is how the rating is awarded. BREEAM uses licensed assessors who examine evidence against the credit criteria, while LEED examines the data the building design team sends to the Building Council.



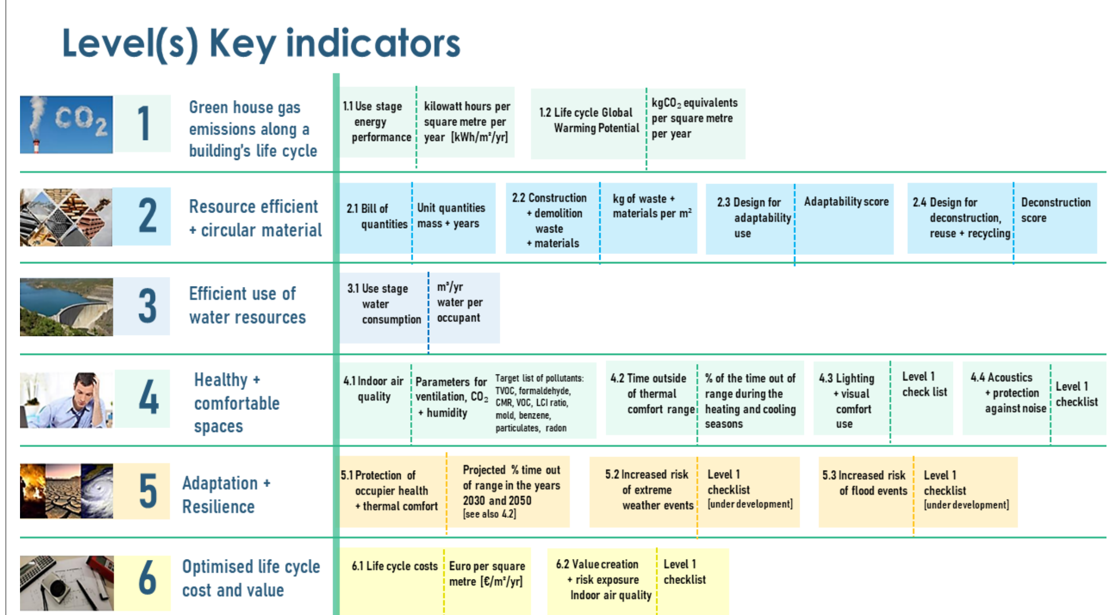
BUILD - AALBORG UNIVERSITET. (2018, 08 23). *Guide to sustainable building certifications*. Retrieved from BUILD: https://build.dk/Pages/Guide-to-sustainable-building-certifications.aspx

FOUNDATIONS

2.3. European Level(s) Framework: the six macro-indicators

On October 15th 2020, EU officially launched Level(s), an European framework for assessing buildign environment economically sustainable buildings. This framework was developed as a set of guiding principles to assess the sustainability of buildings, from the life cycle perspective, including transition toward circular economic models. It's goal is to provide a solid structure for building sustainability certification, in all EU countries, and to achieve 2050's EU decarbonization goals. Level(s) takes into consideration all the participants in the design/ building process of a building, from advisors and public authorities, architects, designers and engineers, clients and investors, as well as construction companies, contractors and occupants. The process is divided into three levels, which represent the usual sequential stages of a building project. Level 1, for concept development, Level 2, for design phase and Level 3, for the utilization phase. Level(s) is also organized into six macro objectives, which are: Green House Gas Emissions, Circular Material, Water Resources, Healthy Spaces, Adaptation and Resilience and Optimized Life Cycle Cost. These six macro objectives are then divided into 16 key indicators. The Level(s) common framework takes a whole life cycle approach to the sustainability of a building. To fully support this approach, the core indicators of macro objectives 1, 2 and 3 are complemented by a holistic assessment of a building's environmental impact - a full Life Cycle Assessment (LCA).

Whilst environmental impacts related to the use phase of buildings remain important, the move towards highly energy-efficient Nearly Zero Energy Buildings (NZEB) is now shifting the balance towars impacts associated with construction materials. These impacts cannot be addressed by a focus on one impact category or a single design aspect. Reporting is encouraged for all life cycle stages in order to obtain a full picture of the environmental impacts. Moreover, Level(s) is designed in a way that users can start by learning about the different steps that are necessary to conduct a life cycle GWP (Global Warming Potential) assessment and, if they choose to, extend the analysis to a full "cradle to grave" Life Cycle Assessment (LCA).

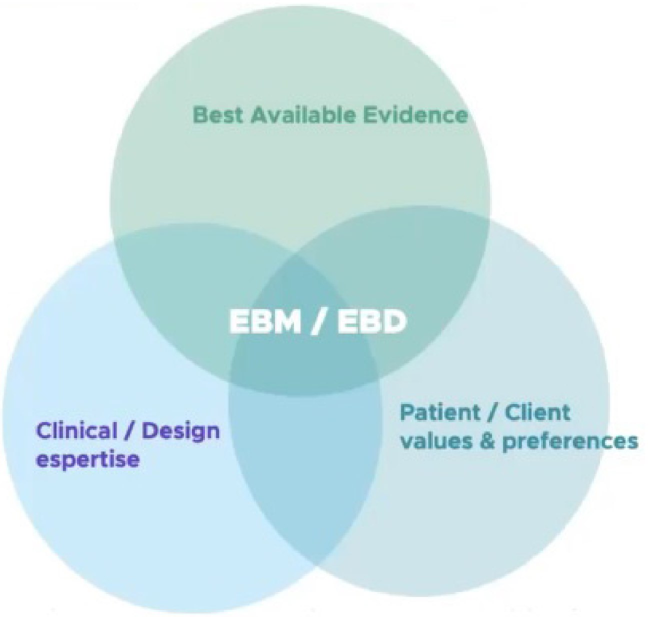


IGBC. (2022, 07 14). *Level(s) - EU Sustainable Buildings Framework*. Retrieved from IGBC - Irish Green Building Council: https://www.igbc.ie/certification/levels-eu-sustainable-buildings-framework/#what-level-jump

FOUNDATIONS

2.4. Evidence-Informed Assessment Tools

In the 80s and 90s researches revelead significant relationships between specific design solutions in healthcare spaces and health outcomes, defining the approach as Evidence-Based Design (EBD). Evidence-Based Design is an approach that mimics the evidence-based medicine approach. This approach takes the best-available evidence, the clinical expertise of the doctor, and the patient characteristics and preferences. The design space process emulates these aspects and translates them into the design methods, replacing doctor's expertise with the designer's and the patient characteristics and preferences with the clients, applying that with the best scientific evidence relative to design. If there is no such data, it is be collected during the design process, in order to make scientific informed decisions. The evidence based design (EBD) process considers five stages: Pre-design, where sources of relevant evidence are collected; Design, where the evidence is interpretated, innovative EBD concepts are created, a hypothesis is developed, and baseline performance measures are collected; Construction, to monitor the implementation of the design; Occupancy, to measure post-occupancy performance results and Organizational Readiness, to define evidence-based goals and objectives. This is a circular approach and method, as the final results will inform new research and as thus, be also part of the pre-design stage of another building or design product.



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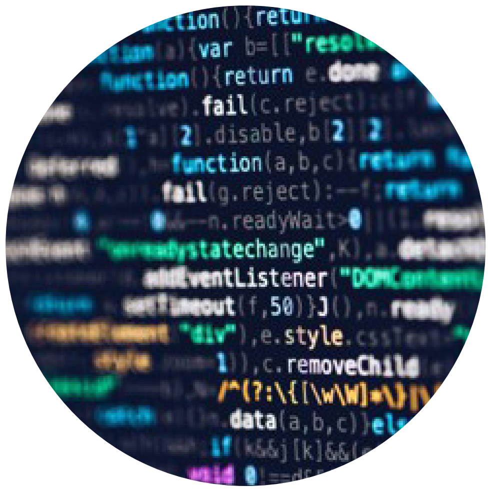

FOUNDATIONS

2.5. Digital Transformation of Construction

Construction is among the least digitalized industries. This is due to various factors such as the small size of companies, contracts not including incentives to lower risk and innovate; management is inadequate; a fragmented supply chain; I&D investment being much less than other industries, accounting for less than 1% of the companies budget (against 3,5% of the automobile sector, for instance).

We define Five trends shaping construction: first, higher-definition surveying and geolocation; second, next-generation 5-D building information modeling; third, digital collaboration and mobility; fourth, the Internet of Things and fifth, advanced analytics and Future-proof design and construction. Examples of survey and high definition geolocation can be laser scanning, photogrammetry, geolocated photography, exploration of satellite data and high precision GPS, as well as drones and other UAVs. Collaboration and digital mobility can be ensured by using digital means to achieve digital in real time collaboration between teams and companies.

IoT is also part of this process, ensuring possible sensors and data retrieved from everywhere: equipment, workers, materials (where, how much, when?) and new infrastructures and protocols. Also, the rise of new materials and technologies raise questions related to their carbon footprint, energy use and performance. Modular construction is also growing, through pre-fabrication of modules and providing flexibility in design, with on site assembly. BIM is at the center of this digital transformation, parametric modeling of objects in which alterations made on a digital model are automatically translated into all project views and a central place where data is stored and retrieved.

BIM is a collaborative process that englobes an ecosystem of softwares with different finalities which allow diverse analysis using the same model. BIM implementation, however, is not without difficulties. It requires investment (equipment, software and time), training, and a favorable contractual environment.

https://www.mckinsey.com/business-functions/operations/our-insights/imagining-constructions-digital-future

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Module 3

MODULE GOAL

Getting to know the pilot building case study for the course, and understand the provided study material: BIM model and CAD files. Analysing the material.

MODULE CLASSES

3.0. Introduction of the Pilot Building Case Study

- New Building Program
- ISCTE-University Institute of Lisbon Sustainability Goals
- Original Building
- Final Decision and WIP

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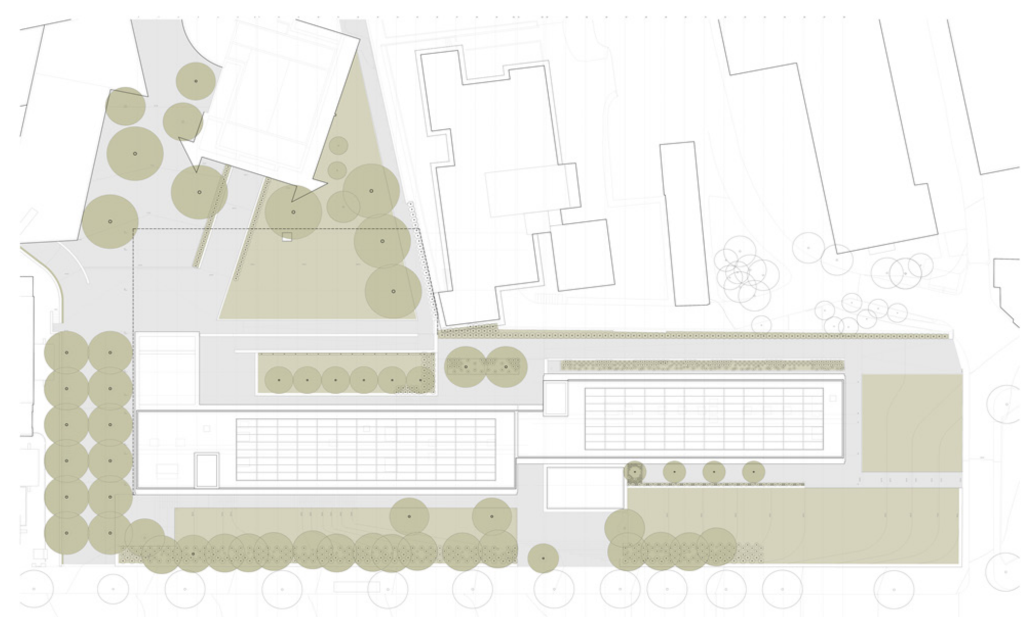
CASE STUDY

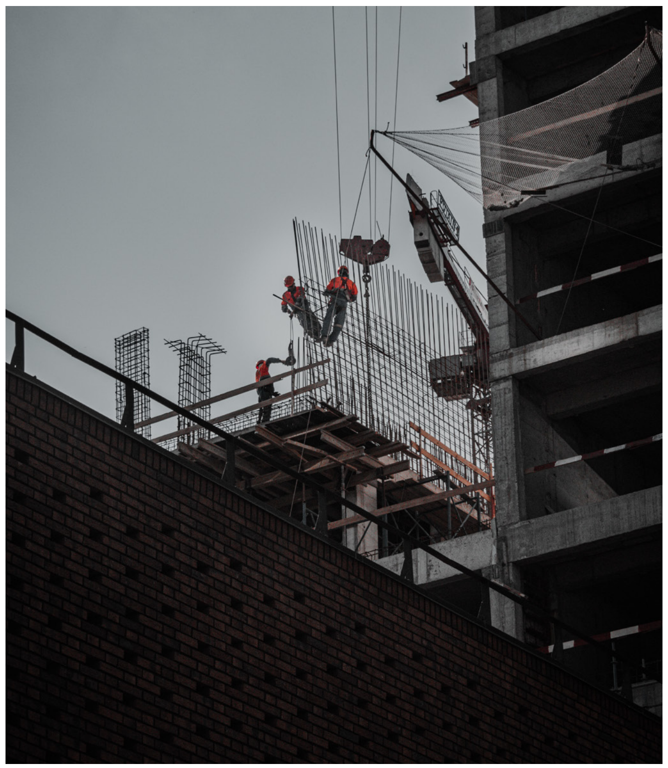
3.0. Introduction of the Pilot Building

The CVTT - Knowledge and Innovation is a new ISCTE building which will host the university Research Centers. One of the first aspects that preoccupied the design team was the understanding of the existing building, regarding its morphology, constructive philosophy, and state of preservation. To do so, the original architecture project of the existing building was consulted, and a diagnostic and structural inspection and a geological-geotechnical study were performed. The two buildings, with features similar to the concurrent school building types, follow the same constructive logic – framed reinforced concrete grid – but present differences in quality. The building from the 60s has worse quality, while the building from the 70s reveals more cared for construction process.

The notion of sustainability involves the whole complex dynamic tissue of society. This way, ISCTE has chosen, from the onset of this process to align its strategy to the main sustainability agendas and plans. At the time of the construction, the regulation for buildings resistance to earthquakes was practically nonexistent, so it was necessary to create a new system of columns and reinforcement beams connected, and parallel, to the facade.

The rehabilitation strategy implied: Understanding the efficacy and quality of the urban implantation of the existing building; Building and offering the city an urban park; Reinforcing the seismic resistance of the building; Pondering the hypothesis of total or partial demolition; Understanding the equation of the partitioning-type for the planned building program; and the Implementation of systems, integrated subsystems, and choice of materials as an opportunity to test interventional models at the Campus, striving to minimize their impact. The development of this project tried to approach sustainability in an integrated way and to respond to social, economic and environmental dimensions. In the scope of environmental sustainability, decisions were made to diminish the carbon footprint of the construction. In the moment of the final material choice, other features such as transport distance, experience and technical knowledge available in the Portuguese context were crucial. The approach of the implementation of these systems and subsystems culminated in an A+ classification in the building's energy certificate.





Module 4a

MODULE GOAL

Understand the stages of concept and pre-design carbon assessment policies and tools. Assess embodied carbon in a simple generic building, and a more complex one.

MODULE CLASSES

4.1. Principles of Sustainable Building Design

4.2. Environmental Product Declarations and Environmental Databases

4.3. How to use the SECClass "Carbon Calculator v.1.0"

Final Practical Assessment

In groups, students must use the provided "Carbon Calculator v.1.0", and insert on it the data from the Pilot Building's BIM model, so that they can measure the embodied carbon of part of the new ISCTE building.

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CARBON

4.1. Principles of Sustainable Building Design

Four main principles can be considered for Sustainable Building Design. These are Optimized Soil Management; Closed Water Cycle Management; Efficiency, Containment and Energy Autonomy and Careful Management of Waste and Materials. Regarding Soil: regenerate or return materials that are removed from the Biosphere back to the soil, allows to maintain its constant production capacity. From a soil conservation perspective, the rehabilitation of already built infrastructures is always more ecological. It is necessary to protect fertile soil, manage densities and allocate soil to open spaces. Regarding Water Management: urban metabolism becomes linear and contaminating when drinking water and organic waste mix, and energy is required for its recovery The process of urbanization expels organic matter and contaminates water reserves, making them improper for human consumption. It is necessary to protect local reserves, and to reuse water.

Regarding Energy: Buildings and cities consume energy while ensuring comfort, health and accessibility for its inhabitants, requiring energy, and usually, the source of this energy is either solar radiation or fossil fuels, that cause carbon emissions. It is necessary to reduce energy needs (to utilize bioclimatic strategies), to use integrated renewable sources and to use active (cost-efficient systems). Regarding Materials: Resources and waste can form part of the same closed circuit. In closed material dynamics, waste must be able to remain or return to the condition of material resource. Circularity will reduce embodied energy and embodied carbon. It is important to use ecologically selected materials (such as natural materials, low embodied energy materials and certified/circular materials), also to avoid or to reuse waste (for the conservation and rehabilitation of buildings, to separate and reuse construction waste, and articulate with urban rehabilitation), finally, to rationalise and extend material life cycles (through modulation, prefabrication, and a flexibility for evolution).

© https://theprepared.org/features-feed/ise-jingu-and-the-pyramid-of-enabling-technologies

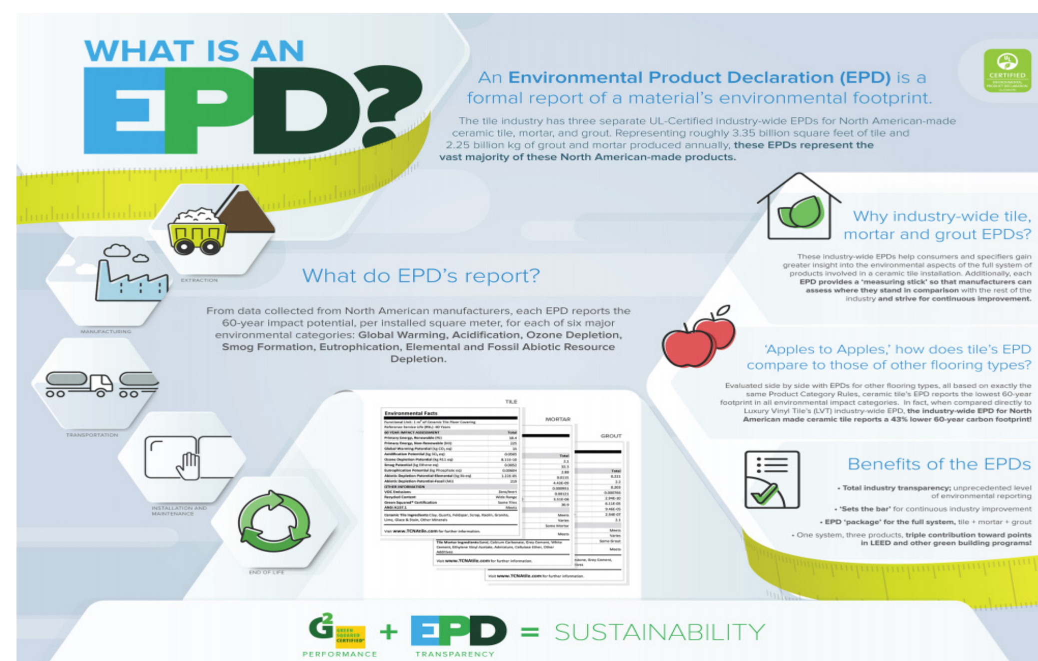
CARBON

4.2. Environmental Product Declarations and Databases

Embodied emissions are key in the timeline for effective climate change mitigation actions in the built environment, keeping in mind the Global Emissions and Temperature targets 2040 and 2055. The life cycle assessment (LCA) methodology, internationally standardized, quantifies the environmental impacts of products and processes throughout their entire life cycle. During LCA, inputs and outputs from the production processes are translated and converted in problem-oriented approaches, more precisely, into environmental impacts potentials. Global Warming Potential (GWP) is the the most widely recognized one. One of the main challenges of Building LCA is the quality and availability of data on the impacts of construction products. In recent years, LCA has been facilitated due to the increase of construction products manufacturers publishing LCA data for their products using Environmental Product Declarations or (EPD). An EPD is a document which communicates the environmental performance or impact of any product or material over its lifetime. It is an externally verified and standardized description of the profile of the product. EPDs are based on life-cycle assessment calculations according to the current standard. Within the construction industry, EPDs support carbon emission reduction by making it possible to compare different materials and products in order to select the most sustainable option.

An LCA database, on the other hand, is a database that contains generic data that can be used for life cycle assessment. This data consist of life cycle inventory data and/or already characterized life cycle impact assessment data. Life cycle inventory data is a list of all inputs and outputs from the production processes (material and energy flows), such as kg of methane emissions associated with each product. Life cycle impact assessment converts 'inventoried' flows into clearer indicators.

Data from an EPD is always life cycle impact assessment data, data that is already characterized. During the concept design phase, it is best to use generic data, rather than a specific single product EPD, to avoid making design decisions based on a single product that may not be representative of its category.



https://whytile.com/library/epd-sustainability-guide/

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CARBON

4.3. How to use the SECClass “Carbon Calculator v.1.0”

In this class students will learn how to use the “Carbon Calculator v.1.0”, initially developed by Project Secclass (https://secclass.pt/), which has been adapted in order to be used in Project Athena. Students will learn how to export data from a BIM model, (in this case, Autodesk Revit), import it into the calculator excel spreadsheet and perform carbon calculations.

Students will also be able to see the results in various schemes or graphics, in the Excel file, so that they can analyse them afterwards and take conclusions.

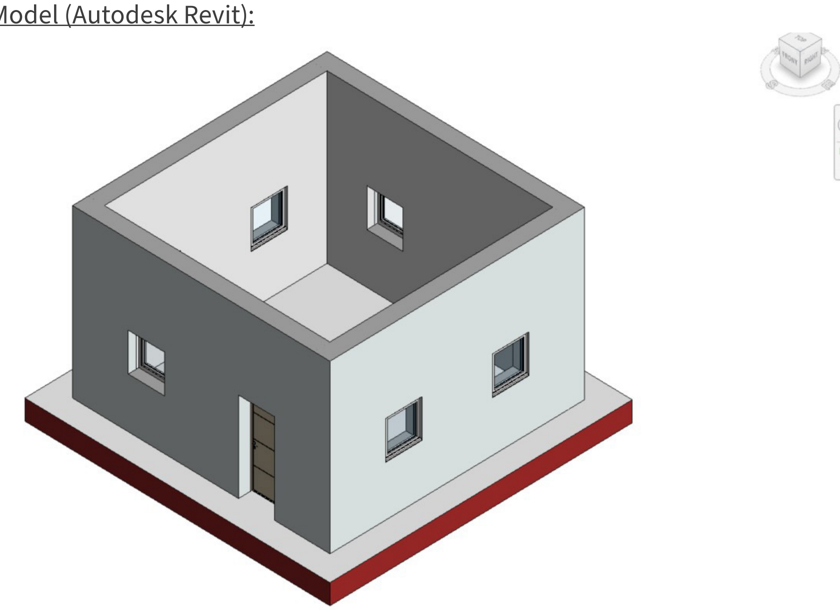
About the Secclass Project:

https://secclass.pt/

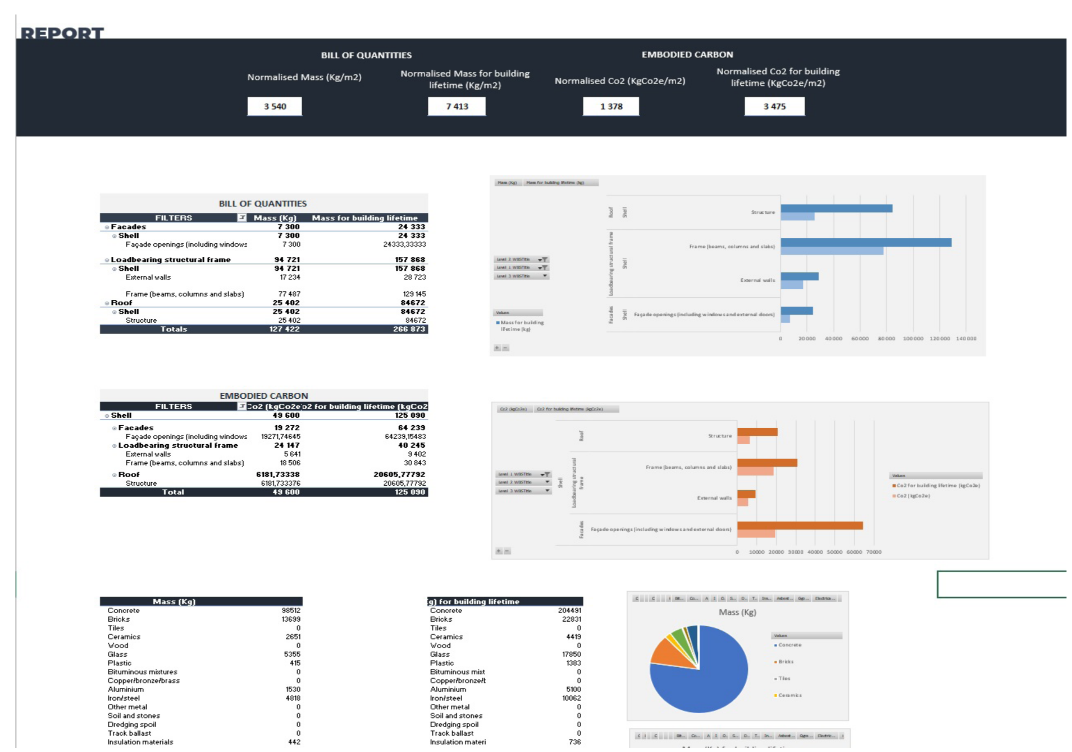
Video Tutorials:

https://www.youtube.com/channel/UC632_Bhl1GtIv_Jarva0p5A

Sample Building Model (Autodesk Revit):



Report Sheet from the SECClass “Carbon Calculator v.1.0”:



Module 4b

MODULE GOAL

Understanding all the stages of concept and pre-design energy assessment policies and tools.

Assessing the energy needs of a simple building in Rhinoceros, and using a Grasshopper script.

MODULE CLASSES

4.1. Operational Energy with Rhinoceros and Grasshopper

4.2. Getting Started - installing Software

4.3. Creating a geometry and defining materials

4.4. Defining zones, loads and schedules

4.5. EnergyPlus energy simulation

Final Practical Assessment

Students will create a simple 3D model of the pilot building in Rhinoceros 3D, import the geometry into Grasshopper and use the provided Grasshopper script to conduct simulations of cooling and heating energy, for Summer and Winter seasons. Data will then be be presented and analysed.

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E N E R G Y

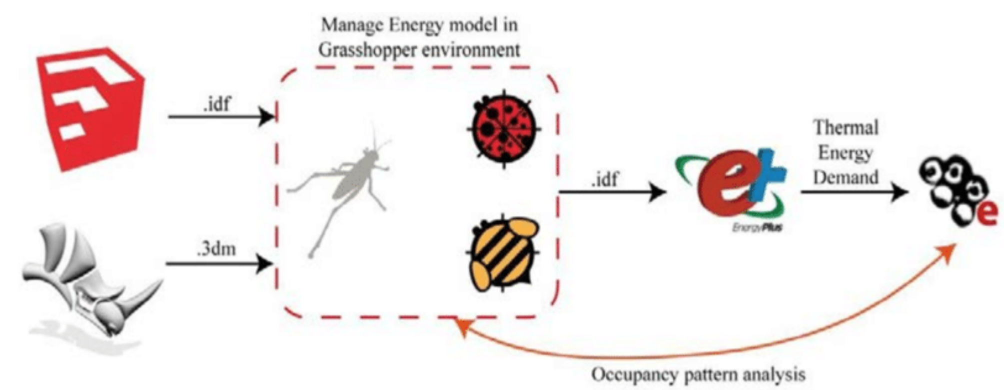
4.1. Operational Energy with Rhinoceros and Grasshopper

“The software can save companies millions of dollars in operational costs over the life of a building, compared to more traditional approaches. EnergyPlus is also being used to evaluate designs for future construction at the World Trade Center site.” (USA Department of Energy, 2001).

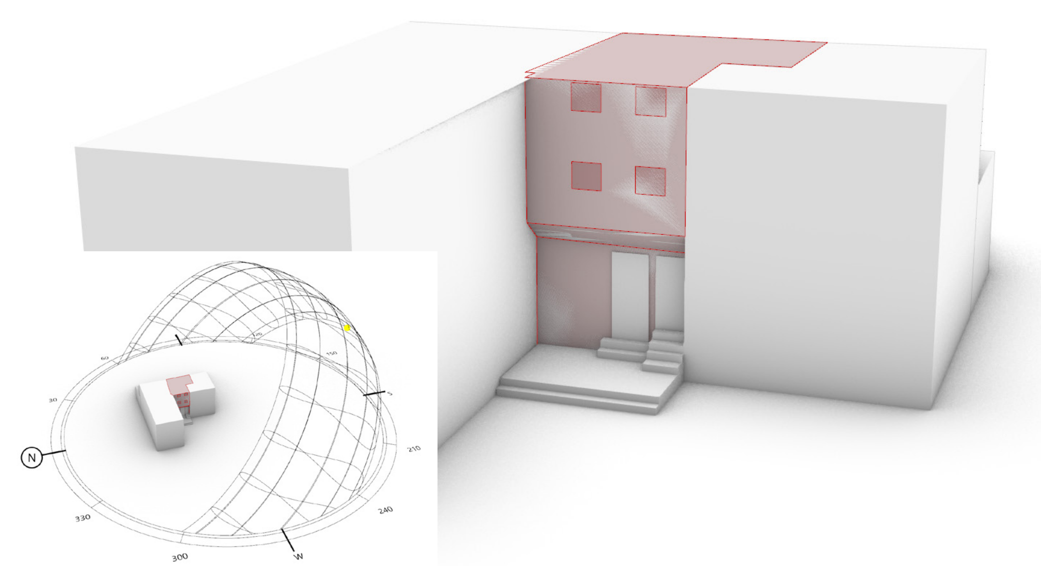
To do building performance simulations, both Rhinoceros 3D and the engine of EnergyPlus can be used.

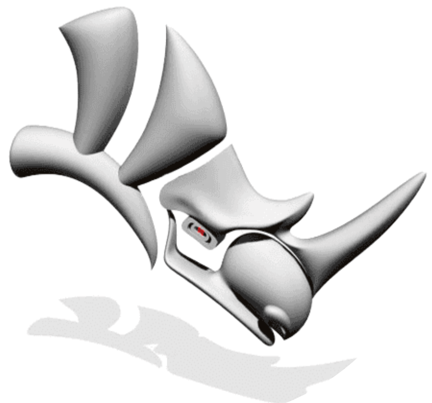
Rhino is a 3D modelling software which started to be developed in 1992, by Robert McNeel & Associates. EnergyPlus was launched in 2001, from a collaboration with the U.S. Army Engineering Research Laboratory, the Department of Energy’s Office of Building Technologies, the University of Illinois and the Lawrence Berkeley National Laboratory. It was designed as a stand-alone simulation program. LadyBug Tools ensures the connection between Rhinoceros through Grasshopper, a visual programming tool which functions within Rhino, and the simulation engine of EnergyPlus.

Ladybug Tools includes both plug-ins Ladybug and Honeybee. The first, is used for weather data visualization, and the second is used to connect Grasshopper to validated daylight and energy simulation engines, such as EnergyPlus. In order to conduct an energy simulation with Rhino and Grasshopper, the following questions/nodes must be considered: 3D geometry (Rhino model), Materials, Equipment Load, Outside Air Infiltration, Lightning Density, Number of People, Ventilation per Area, Ventilation per Person, Annual Schedule, Comfort Temperatures, Climate File (epw) and Analysis Period.



Example of a 3D building and a climate file visualization in Rhinoceros 3D:





ENERGY

4.2. Getting Started - Installing Software

In this class, students will learn how to instal the required softwares for energy performance simulations. These are the following: Rhinoceros 3D, Grasshopper (included with Rhinoceros 3D), LadyBug, Honeybee and Energy Plus. They can be found in the following links:

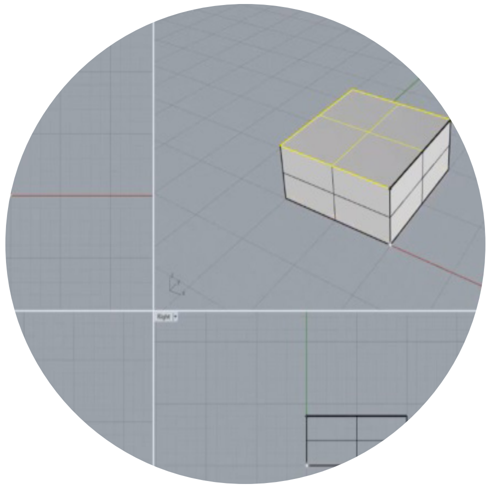
Rhinoceros 3D: https://www.rhino3d.com/download/

LadyBug and HoneyBee: https://www.food4rhino.com/en/app/ladybug-tools

EnergyPlus: https://energyplus.net/

Students will also learn how and where do download weather (climate) files, in order to conduct energy performance simulations in specific climates. These files can be downloaded in the following link:

Weather files (epw): https://energyplus.net/weather

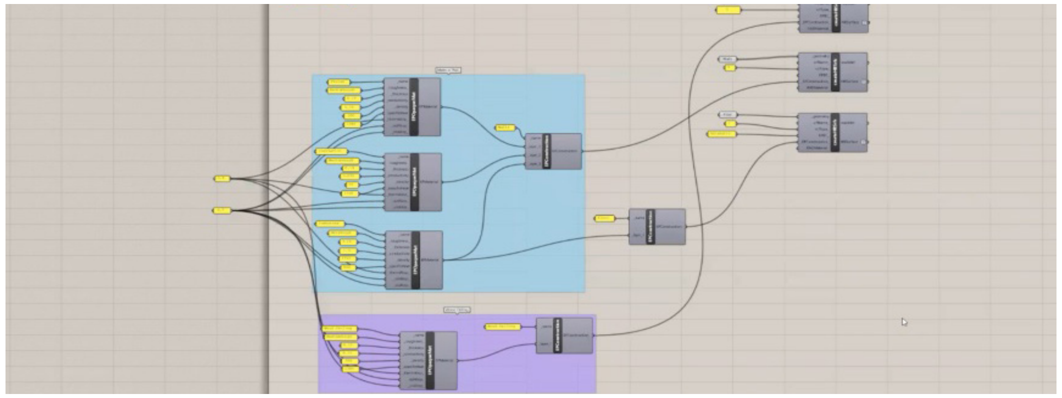


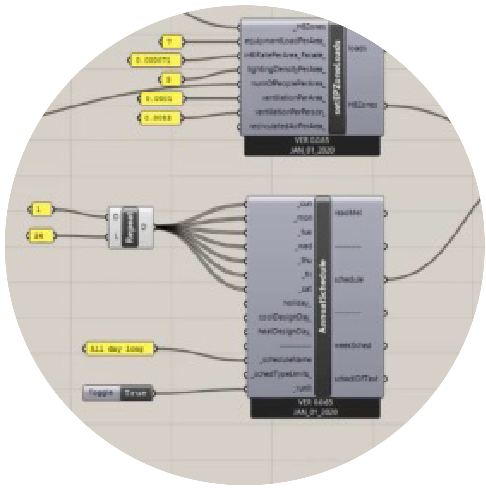
ENERGY

4.3. Creating a Geometry and Defining Materials

In this class, students will learn to create a basic 3D geometry in Rhinoceros 3D, import it into Grasshopper and use the provided Grashopper script to assign materials. These materials can be altered as the user needs to do various energy performance simulations. The following image shows a part of the Grasshopper script which includes the 3D surfaces and the materials nodes.

Part of the provided Grasshopper script:



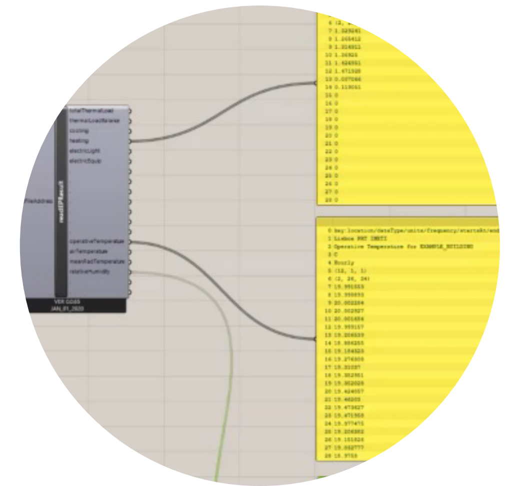


ENERGY

4.4. Defining zones, loads and schedules

In this class, students will learn how to use a Grasshopper script to define specific energy demands (loads), such as necessary lighting, occupation, comfort temperatures, ventilation, and more. They will also define an occupancy schedule for the building, by informing the sofware how many days per week and hours will the building be occupied. Next, students will define interior comfort temperatures for their building, for both Winter heating and Summer cooling seasons.

Finally, they will define an analysis period, which for this specific simulation will be the three months of Winter (December, January and February) and the three months of Summer (June, July and August).

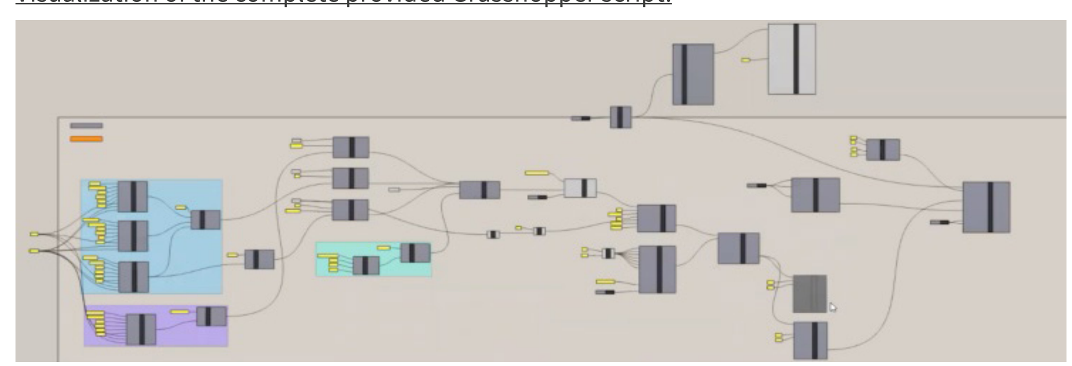


ENERGY

4.5. EnergyPlus Energy Simulation

In this class, students will use the EnergyPlus node to perform an energy simulation of their building. They will import their weather file, input optional energy simulation parameters, define a desired list of energy outputs (such as cooling and heating energy, and humidity), and run the simulation. After the simulation, students will learn how to read the simulation outputs data and export it into an Excel spreadsheet to be treated and analysed.

Visualization of the complete provided Grasshopper script:



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AKNOWLEDGMENTS

COLLABORATIONS

The Athena team of the “Building Sustainability Assessement and Design trough Digital Tools Course” would like to thank all the people that contributed to the realization of the content, as well as to all of the organization and research projects that contributed. Should you want to learn more about these projects, please visit the following links:

ISCTE - University Institute of Lisbon

https://www.iscte-iul.pt/

ISTAR - IUL

https://istar.iscte-iul.pt/

POLIMI - Politecnico di Milano

https://www.polimi.it/

POLIMI - ABC - Design and Health Lab

https://www.dabc.polimi.it/en/abclab/the-units/design-health-lab/

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