Sinergy

Capacity building in Smart and Innovative eNERGY management

WP3

Learning Material, Training Courses and Joint Proposal Preparation

D3.4 Training Courses and Learning Material on Energy Efficient Building Operation (v2)

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Executive Summary

The main objective of SINERGY work package 3 is to establish collaboration with strategic partners of the project (AIT and NUIG) and enable expertise and "know-how" exchange in the knowledge areas of smart grids, distributed energy resources, building optimization and building information modelling.

Task 3.2 focuses on the preparation of training courses on Energy efficient building operation, mainly provided by the partner NUIG National University of Ireland Galway. The report (Deliverable 3.4) summarizes the training courses under elaboration in the second reporting period, from April 2022 to June 2023.

A total of 10 modules were prepared during this period and delivered in a mix of online and face to face sessions.

SINERGY repository of lectures is accessible at this link https://project-sinergy.org/Lectures.

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Abbreviations and Acronyms

EEBO	Energy Efficient Building Operation

1. Introduction

The main scope of work package 3 (Learning Material, Training Courses and Joint Project Proposals Preparation) can be summarized as:

- Task 3.1: Preparation of training courses on Smart Grid Technologies.
- Task 3.2: Preparation of training courses on Energy Efficient Building Operation
- Task 3.3: Joint project proposals preparation and management skills upgrade.

This report points to the proposed lectures by NUIG during the second reporting period a screenshot from the SINERGY repository.

Table 1 gives a summary list of lectures prepared in the second reporting period, from January April 2022 until end of the project in Dec. 2023, while a screenshot from the SINERGY repository is presented in Figure 1.

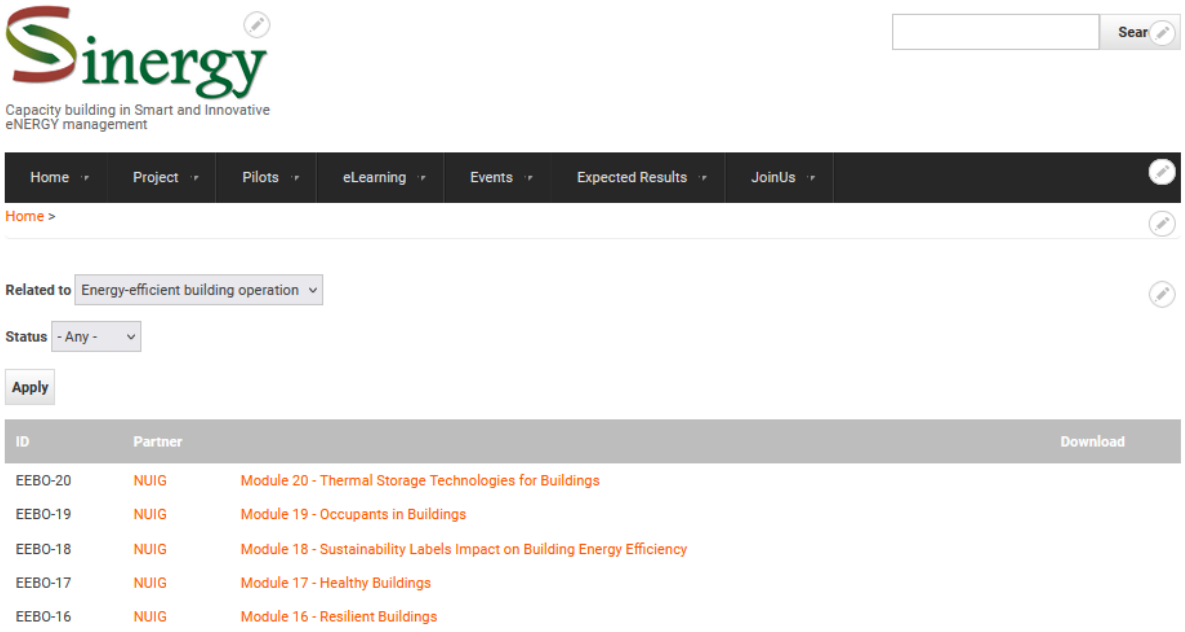
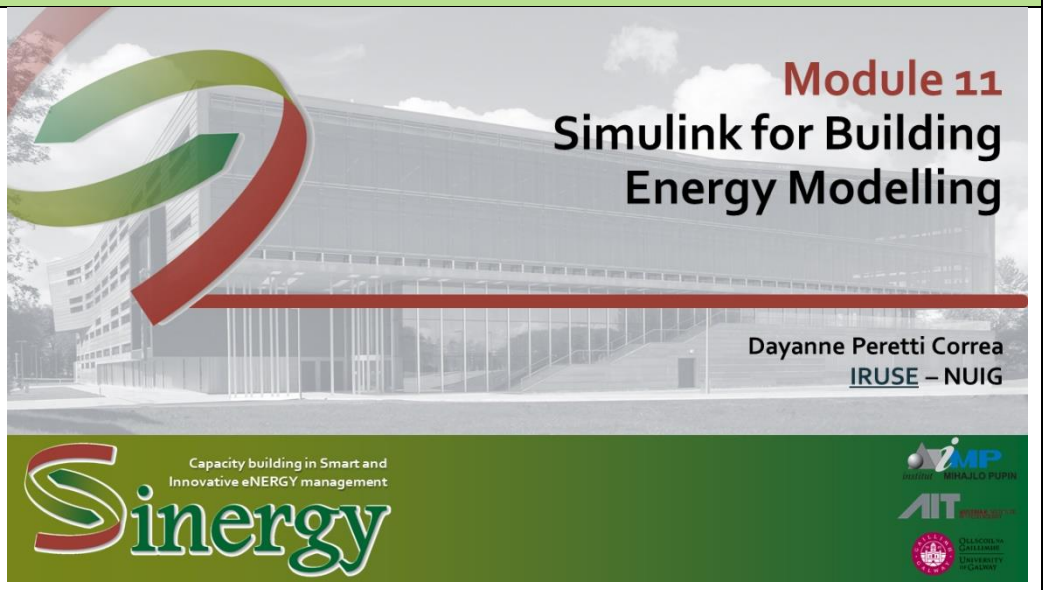


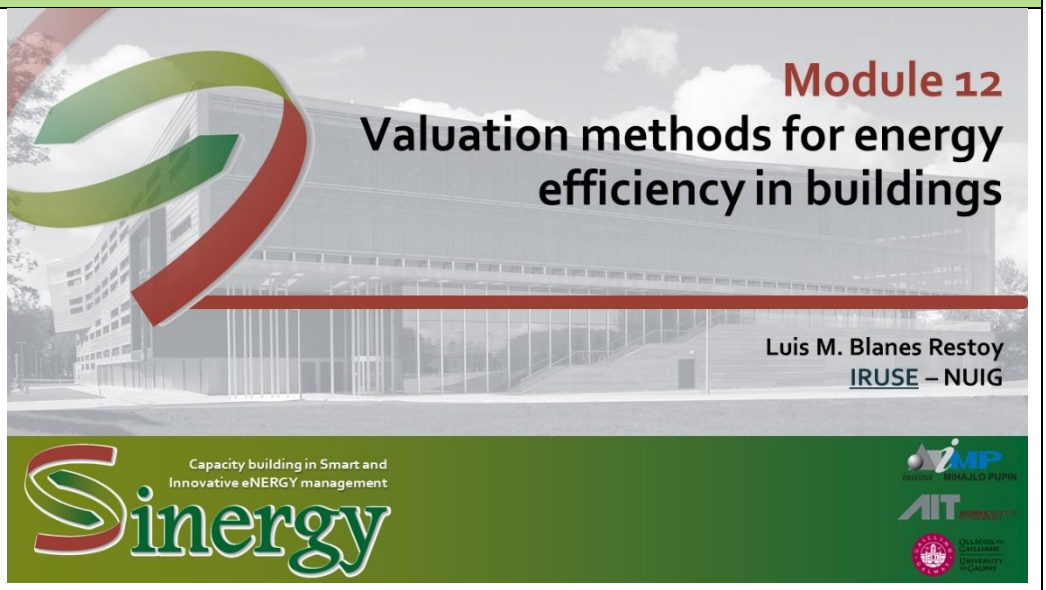
Figure 1. NUIG Lectures in SINERGY repository (example)

Table 1. Energy Efficient Building Operation (second reporting period)

	Energy Efficient Building Operation		
ID	Module Title (version 1)	Delivered by:	Status:
EEBO-11	Module 11 – Simulink for Building Energy Modelling	NUIG	done
EEBO-12	Module 12 – Valuation Methods for Energy Efficiency in Buildings	NUIG	done
EEBO-13	Module 13 – Ground Source Heat Pump GEOFIT pilot	NUIG	done
EEBO-14	Module 14 – Modelling of district heating and cooling systems	NUIG	done
EEBO-15	Module 15 – Model Predictive Control Applications for Building Energy Efficiency	NUIG	done
EEBO-16	Module 16 – Resilient Buildings	NUIG	
EEBO-17	Module 17 – Healthy Buildings	NUIG	
EEBO-18	Module 18 – Sustainability Labels Impact on Building Energy Efficiency	NUIG	
EEBO-19	Module 19 – Occupants in Buildings	NUIG	
EEBO-20	Module 20 – Thermal Storage Technologies for Buildings	NUIG	

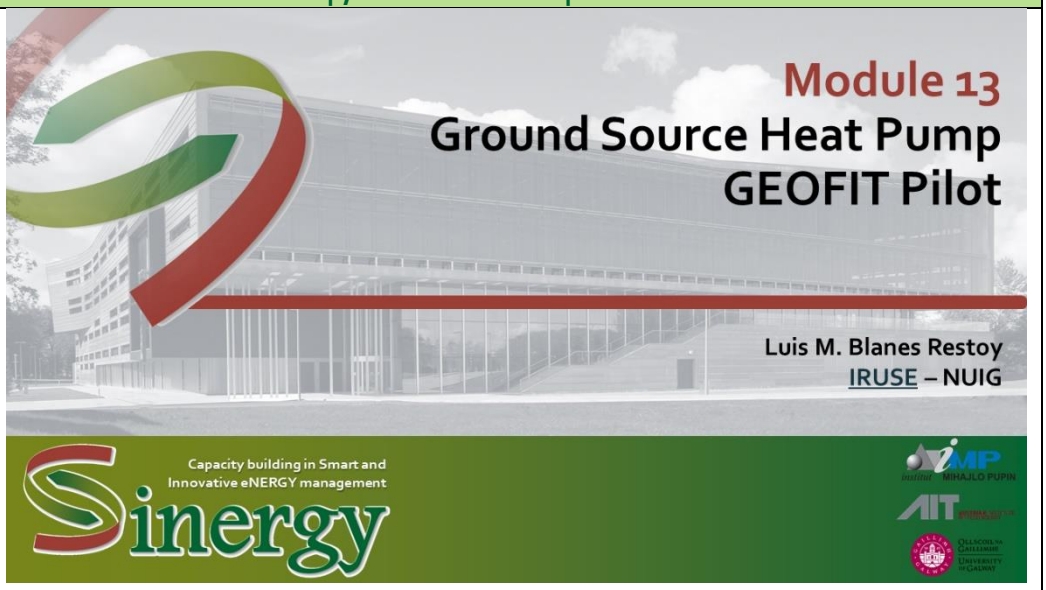
2. Summary of Lectures

Module 11 – Simulink for Building Energy Modelling (EEBO-11)	
Keywords	MATLAB, Simulink, Co-Simulation, Domestic Heating System, Smart Grid Simulation
Summary	 This module is a practical tutorial of the use of MATLAB and SIMULINK as simulation tools for energy efficient building operation. A complete walkthrough of the software and explanations of the different libraries and modules is provided in a hands-on session. This software is a state-of-the-art tool ecosystem with proven capabilities to flexibly accommodate most mathematical and numerical methods for energy modelling and multi-domain building operational problems. The modelling style of the software is equation based with a graphical block editor. The results can be integrated into other software for control and feedback loops to real systems e.g.: HVAC controls. The tutorial will be illustrated with two case studies: (1) a domestic scale heating system and (2) simulation of a smart grid project.
Reference Material	
https://uk.mathworks.com/downloads https://www.mathworks.com/solutions/electrification/building-energy-management.html https://publications.ibpsa.org/conference/paper/?id=bs2019_210641 https://repository.upenn.edu/cgi/viewcontent.cgi?article=1104&context=mlab_papers	

Module 12 - Valuation Methods for Energy Efficiency. (EEBO-12)	
Keywords	Hedonic Method, Green Premium, Brown Discount, Willingness to Pay, Valuation Methods
Summary	 When considering energy retrofit investment, a easy and quick method to assess financial feasibility is to consider capital investments (CAPEX) against energy savings. There is little consideration of the increase in value that the upgrades will bring to the building. This added value is difficult to assess, but it is an important effect that needs consideration and has deep financial implications. The EU has already highlighted the importance of a more comprehensive valuation and risk assessment method that reflects this value in order to unlock private investments. Organizations such as RICS and TEGOVA have created guidelines for professional practice of underwriting and finance assessment. We evaluate methods and examples of valuation of the energy retrofits in the building stock using existing reported examples in literature.

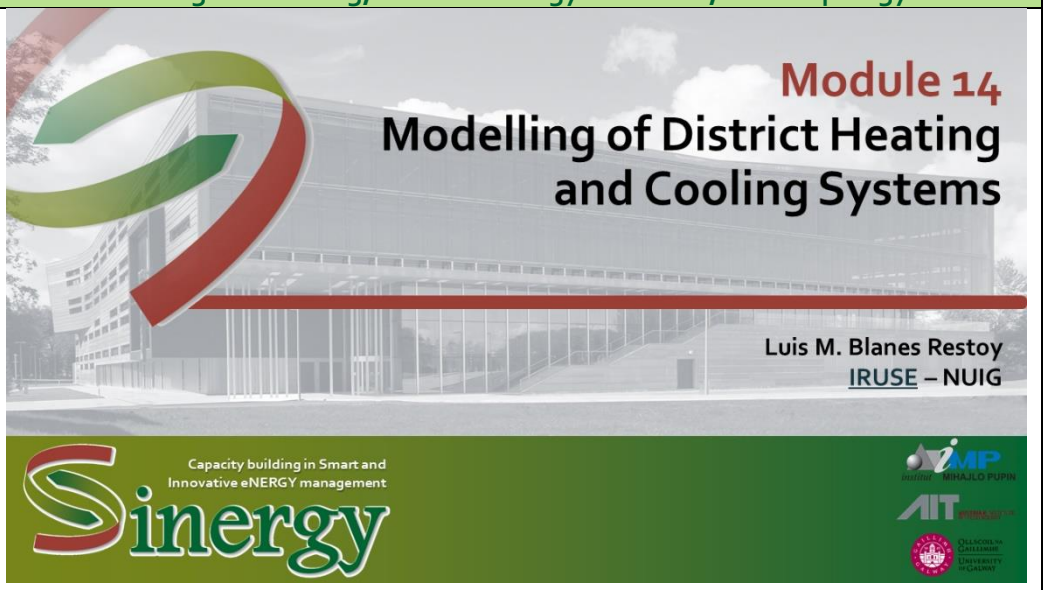
Reference Material

https://doi.org/10.3390/su142416967
http://hdl.handle.net/10419/234069
http://dx.doi.org/10.1016/j.eneco.2013.07.020
http://doi:10.2760/267367

Module 13 - Ground Source Heat Pump GEOFIT Pilot (EEBO-13)	
Keywords	Ground Source Heat Pump, Distributed Temperature Sensors
Summary	 University of Galway recently completed a ground source heat pump project as part of the EU-H2020 project GEOFIT. This module will explain the experiences and lessons learned of this pilot. From the design consideration using specialized software, the calculation of the load profiles, to the hydronic design options and analysis methods. The design exercise is put into contrast with the practicalities of budgeting, procuring, and executing the construction works. In this pilot, a novel method of monitoring and optimizing natural resources such as the heat stored in the ground is being installed that makes use of Distributed Temperature Sensing (DTS) fiber optic equipment.

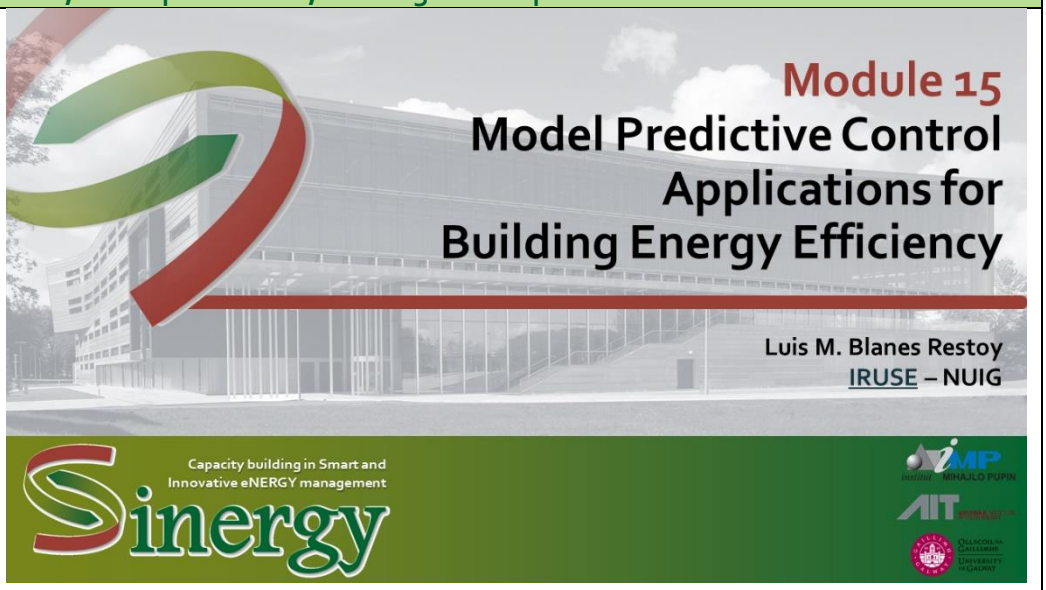
Reference Material

https://geofit-project.eu/
https://youtu.be/oKyiiKr7Tvw
https://buildingphysics.com/eed-2/

Module 14 - Modelling of District Heating and Cooling Systems (EEBO-14)	
Keywords	District Heating and Cooling, Thermal Energy Networks, DHC Topology
Summary	 In this lecture we will start with the classification of district energy systems from the from the 1st to the 4th generation and introduce the concept of 5th generation low exergy district heating and cooling network (5GDHC). Different network topologies will be analyzed and software tools that support the optimization of the network design and layout will be presented. The modelling of DHC networks is inherently difficult as it includes fluid dynamics in their underlying equations, with thermal storage and loads calculation and estimation playing an important role. A review of software tools that assist in the modelling, calibration and optimization problems of the networks is also provided, additional to the topology and layout tool mentioned above.

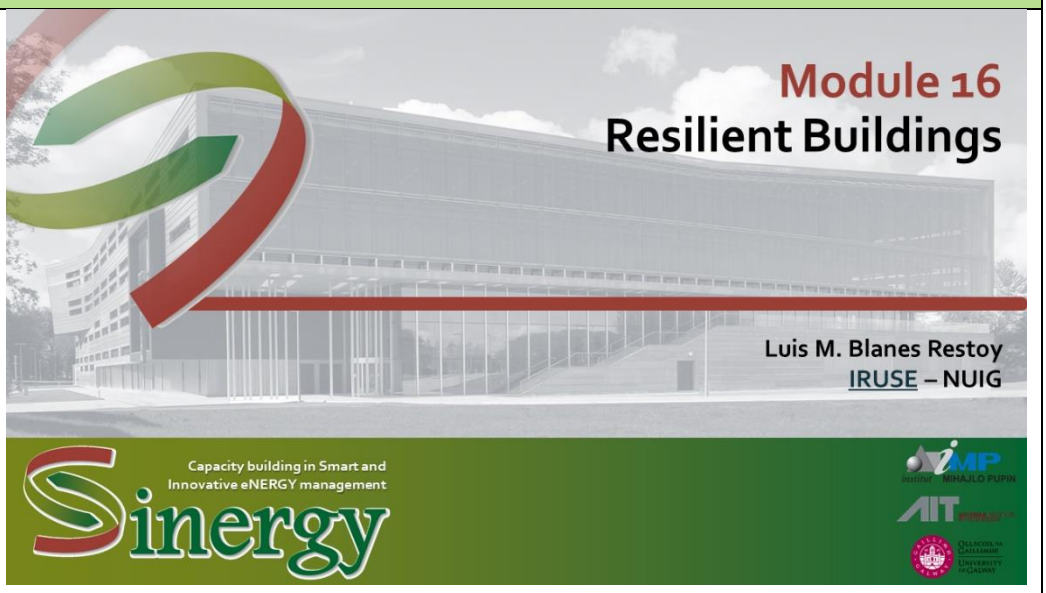
Reference Material

https://doi.org/10.1016/j.energy.2022.125060
https://doi.org/10.1016/j.rser.2017.06.109
https://doi.org/10.1016/j.egyr.2021.09.034
https://doi.org/10.1016/j.enconman.2019.05.066
https://doi.org/10.1016/j.energy.2022.124777
https://doi.org/10.1016/j.rser.2020.110577

Module 15 - Model Predictive Control Applications for Building Energy Efficiency (EEBO-15)	
Keywords	MPC, MPC optimization, Building HVAC optimization
Summary	 Model Predictive Control of building energy systems are very well developed and understood advanced techniques for control, optimization, and intelligent HVAC operation. The model of the building and the capacity to simulate future scenarios is the main strength of this approach. We review the existing landscape of software tools, techniques, and the practicalities of implementing such systems and interfacing with existing SCADA and BMS hardware and software in place. Data acquisition is a crucial part of the system as many existing buildings lack sufficient information and data to construct the needed models. Different key case studies will illustrate successful MPC implementations.

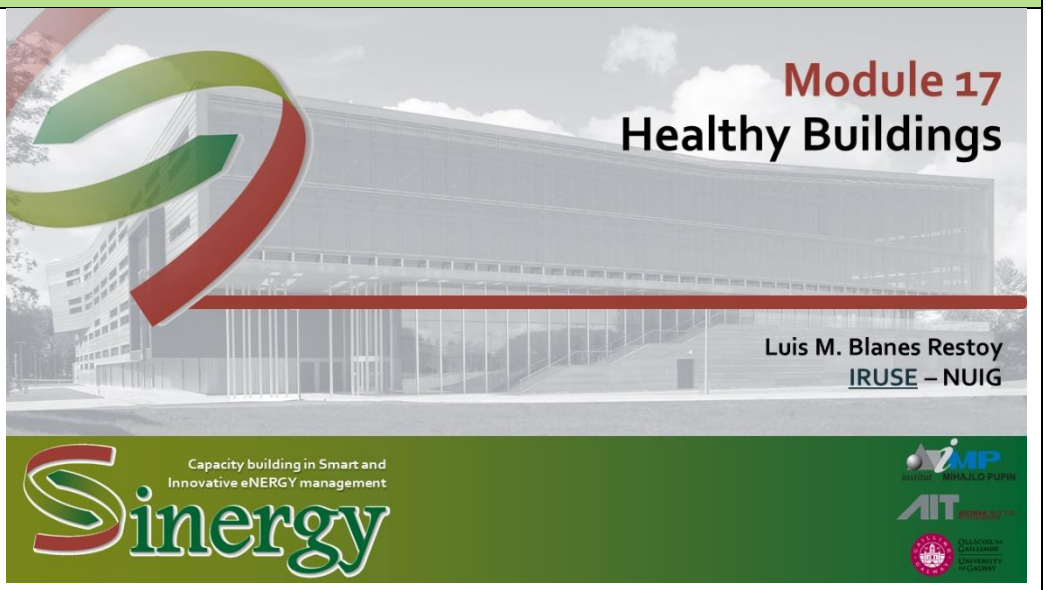
Reference Material

https://doi.org/10.1016/j.arcontrol.2020.09.001
https://doi.org/10.1016/j.rser.2021.110835
https://doi.org/10.1016/j.jobe.2020.101692
https://doi.org/10.1016/j.buildenv.2022.109053

Module 16 – Resilient Buildings (EEBO-16)	
Keywords	Climate Resilient Buildings, Overheating in Buildings, Ventilation Methods
Summary	 This module will analyse the concept of building resilience as the capacity to adapt, ameliorate and mitigate the impact of climate-related events and the future conditions of a changing climate and environment. There is a clear effect in internal thermal conditions of rising temperatures. Weather predictions and methods are to be considered in the design stage of new buildings and the refurbishment and adaptation actions of the existing and old ones. Different strategies to modelling of heating and cooling demands of buildings in futures scenarios are considered.

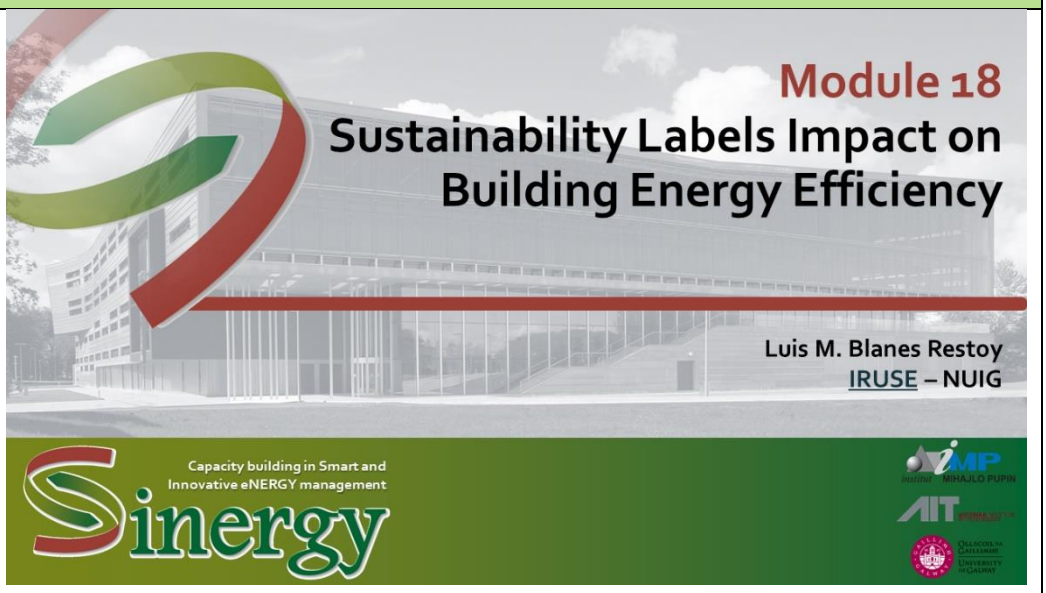
Reference Material

https://doi.org/10.1016/j.clet.2021.100286
https://doi.org/10.1016/j.enbuild.2015.12.020
https://doi.org/10.1016/j.buildenv.2023.110124
https://doi.org/10.1016/j.jobe.2022.105428
https://doi.org/10.1016/j.buildenv.2021.108022
https://doi.org/10.1016/B978-0-323-95336-8.00014-7

Module 17 - Healthy Buildings (EEBO-17)	
Keywords	Healthy Building, Thermal Comfort, Indoor Air Quality, Holistic Analysis, Acoustic, Visual Comfort
Summary	 The recent COVID-19 pandemic has brought to the attention of researchers, policymakers, and designers the need for a healthier environment, given the amount of time humans spend inside built structures and the importance of air ventilation and filtration. A comprehensive concept of health includes also thermal comfort, visual comfort, acoustic comfort, and mother psychological and social aspects that impact how buildings are designed and operated. Newly evaluation approaches of "wellness" are investigated, with a critical approach on the most impactful aspects of this new demands with regards to the building energy efficiency

Reference Material

https://doi.org/10.1016/j.jobe.2023.106703
https://www.wellcertified.com/
https://doi.org/10.1016/j.enbuild.2013.03.009

Module 18 - Sustainability Labels Impact on Building Energy Efficiency (EEBO-18)	
Keywords	LEED, BREEAM, DGNB, Passive House
Summary	 In this module, we will critically review sustainability assessment certification based on gathered evidence from last decades. Whereas LEED and BREEAM assessment methods are comprehensive, and energy is just one of multiple aspects of the certification, PASSIVE House is focused in energy and envelope optimization among other variables to consider in design. Other schemes for green building certification that are not widely adopted are also introduced. Building resilience against green design and sustainability is examined, as both approaches and orientations could conflict.

Reference Material

https://doi.org/10.1016/j.jobe.2023.105825
https://doi.org/10.1016/j.enbuild.2017.03.025
https://doi.org/10.1016/j.rser.2015.06.003
https://doi.org/10.1016/j.enbuild.2019.109683
https://doi.org/10.1016/j.enbuild.2017.04.009

Module 19 – Occupants in Buildings (EEBO-19)	
Keywords	Occupant Behavior, Behavioral Modelling, Occupant Centric Design
Summary	 There is a realization that technology-only solutions are not the most effective way of achieving best efficiency in building operation. Occupants and users' actions often diverge and develop in ways not always in consonance with the originally intended design of buildings. A way of sorting this discrepancy between "idealized" building occupant models and more realistic ones is to consider the role of occupants in the design and operation of buildings. Modelling the occupant's likely behavior, influencing it and extracting meaningful data from existing buildings are sides of the same problem that reveals the difficulties in considering human interactions with the built environment. Methods of modelling occupants are presented alongside tools and relevant case studies.

Reference Material

https://doi.org/10.1016/j.enbuild.2018.05.017
https://doi.org/10.1016/j.rser.2023.113396
https://doi.org/10.1016/j.enbuild.2020.110292
https://doi.org/10.1016/j.scs.2019.101685

Module 20 - Thermal Storage Technologies for Buildings (EEBO-20)	
Keywords	Thermal Energy Storage, Thermal Inertia, Cool Thermal Energy Storage, Exergy Analysis
	 This module focuses on storage technologies in buildings focusing on thermal storage for both heating and cooling applications that are at the building scale. Renewable energy sources that are discontinuous and the shift to a decentralized energy production, distribution and smart trading of energy makes thermal storage a key part of the new low-carbon energy system supporting resilience and flexibility of the grid. The module will start with a broad classification of TES systems using different criteria. Secondly it will deep into the different technologies with relevant case studies. Simulation of different TES will be illustrated, including software, libraries, and underlying physical models to be considered in model-based design and operations.

Reference Material

https://doi.org/10.1016/B978-0-12-417203-6.00006-5
https://doi.org/10.1016/j.enbuild.2023.112908
https://doi.org/10.1016/j.est.2021.102569
https://doi.org/10.1016/j.rser.2012.01.058

3. Summary of the training activities

The knowledge transfer between NUIG and IMP staff was mostly conducted online, see for example Figure 2, Figure 3 and Figure 4.

However, during the staff exchange (June 2022), IMP staff had an opportunity to visit the NUIG premises and to become familiar with the NUIG infrastructure, NUIG piloting activities and NUIG EU projects. Hence, in addition to technologies for Energy Efficient Building Operation, the NUIG training materials included case studies elaborated in other EU projects including REACT Renewable Energy for self-sustAinable island CommuniTies (GA No. 824395) and Geofit: Smart Geothermal Systems (GA No. 792210).

The case studies were discussed also in the face-to-face meetings during the staff exchanges of the NUIG team (July 2022 and November 2022) to IMP, see Figure 5.

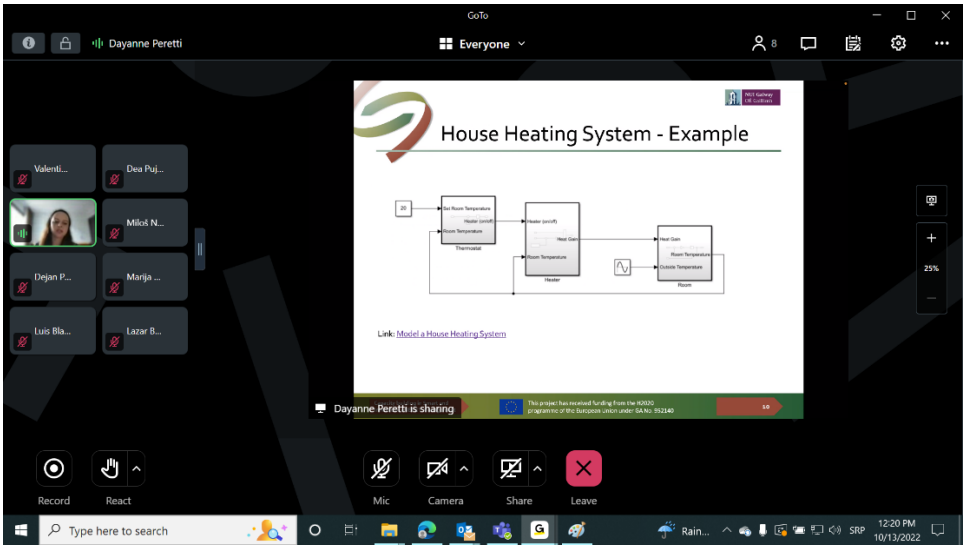


Figure 2. Module 11 delivery online

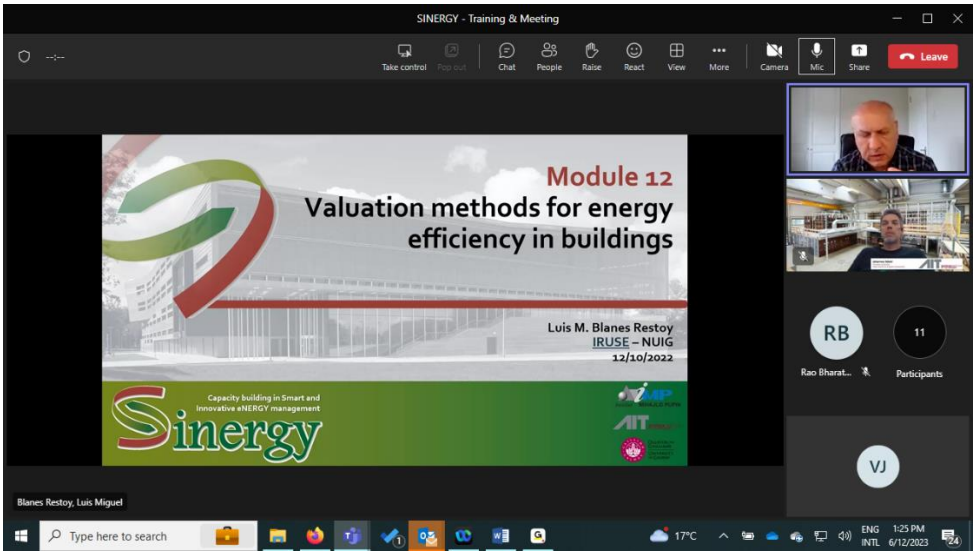


Figure 3. Module 12 delivery online

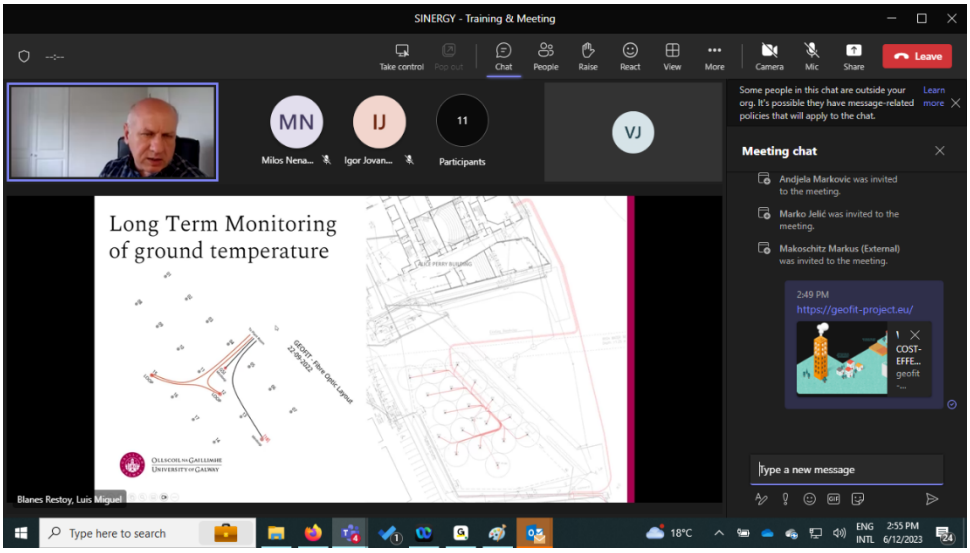


Figure 4. Module 13 delivery online

Figure 5. Case study discussion at IMP premises

4. Conclusion

Within the 30 months project duration, 10 trainings were organized by NUIG for IMP staff. The intention was to provide the audience of IMP young researchers with an overview of different disciplines applied to the specific building energy problems, and more specifically to the operational stage of the building life cycle (BLC), building performance simulation and building operation. Additionally, the NUIG training materials include case studies elaborated in other EU projects conducted by NUIG.

The knowledge transfer between NUIG and IMP staff was mostly conducted online. The case studies that are results of other EU projects (REACT, Geofit) were discussed at NUIG (June 2022) and IMP premises (July 2022, November 2022).