ASHRAE Hellenic Chapter

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ENERGY IN BUILDINGS

EMEA 2024

Europe, the Middle East & Africa

FRIDAY - SATURDAY

NOVEMBER 22-23, 2024

@ 9:00-18:00

@ ATHENS GREECE

SESSIONS:

- SUSTAINABILITY
- HEALTH & SAFETY
- DECARBONIZATION
- TECHNICAL SOLUTIONS
- DIGITAL ENVIRONMENT
- POLICIES & LEGISLATION
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Session 2.2: SUSTAINABILITY – DIGITAL ENVIRONMENT

Chair: Triantafyllopoulos, Georgakakou, Tritou

Saturday November 23, 2024

Developing Smart Building Technology Modules to Enhance Workforce Preparedness: A Case for AI-Driven Academic and Professional Education

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), Building Technologies Office (BTO) Award Number DE-EE0009703.

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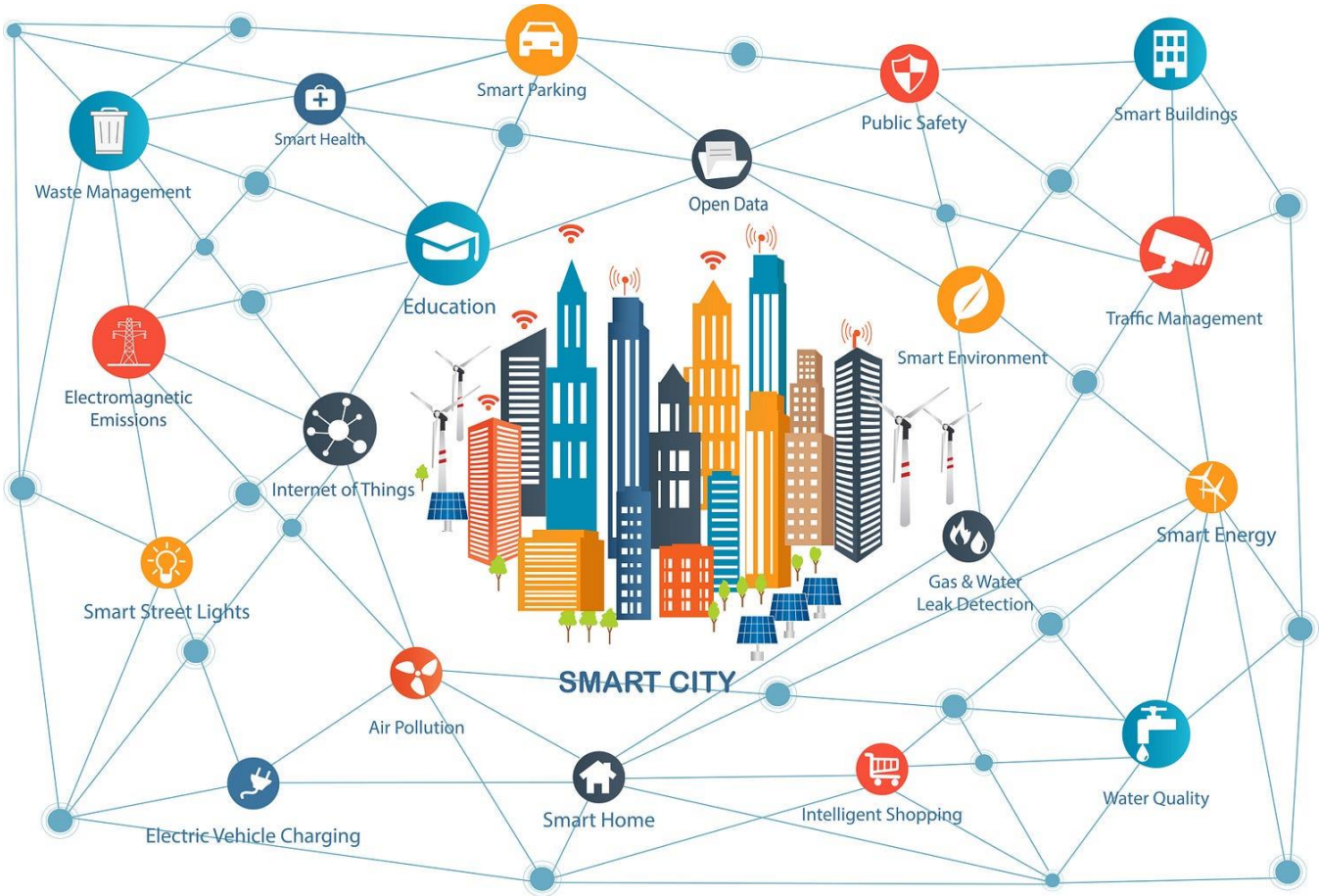
Ohio Northern University

OHIO NORTHERN
DICKE COLLEGE OF BUSINESS ADMINISTRATION

Outline

- *Introduction*
- *Recognized workforce need*
- *Expected project outcomes*
- *Primary drivers & team*
- *Objectives of the project*
- *Project outcomes*
- *Course Content*
- *Conclusions*
- *Sample examples*
- *Recognitions*
- *Resources*



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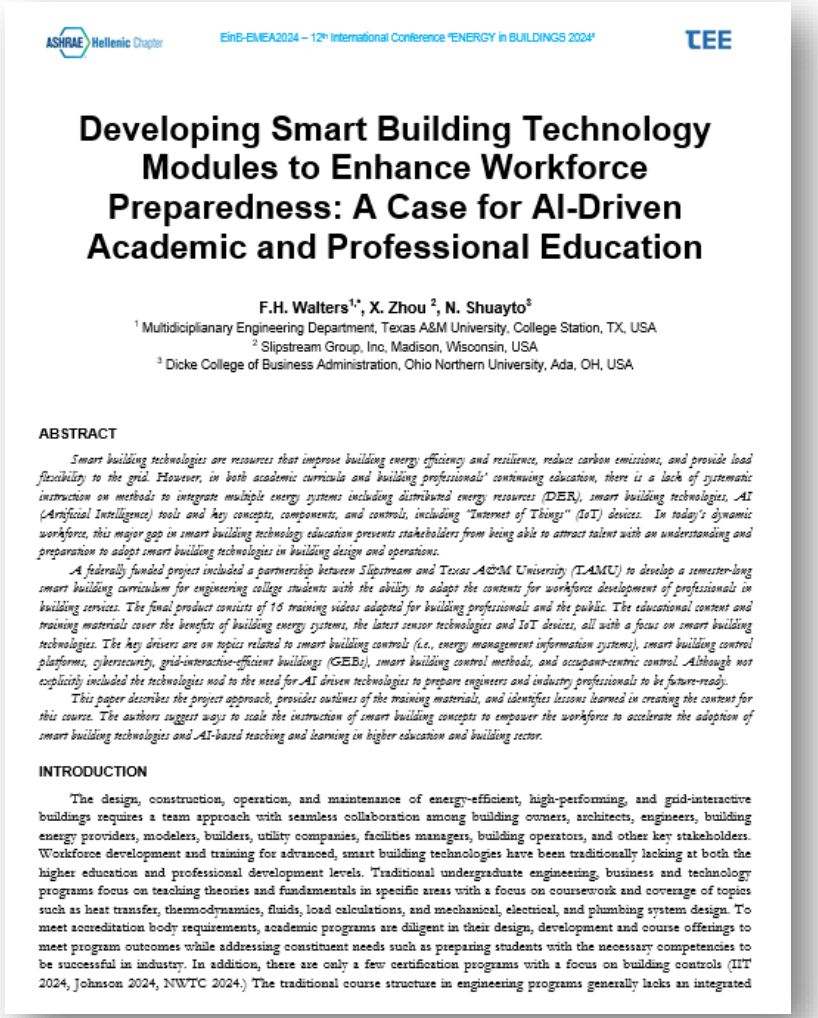
Introduction

- Smart building technologies ***improve energy efficiency, resilience, reduce carbon emissions***, and ***provide grid load flexibility***.
- There is a ***lack of systematic curricula*** on integrating energy systems, smart building technologies, AI (artificial intelligence) tools, and IoT (internet-of-things) devices in academia and for building professionals.
- This education gap ***hinders the ability to attract talent*** prepared for smart building adoption in design and operations - fundamental to decarb efforts.
- Through a federally funded grant project, a public-private partnership has ***developed smart building curriculum*** for ***engineering students*** and for use in ***workforce development*** for the building services industry professionals.

Recognized need for future-ready workforce

- The course materials ***fulfill the need for AI-driven, smart building technologies*** necessary to prepare engineering students and professionals for future needs.
- The paper ***outlines the project approach, course materials, lessons learned and suggests methods to scale smart building instruction*** to accelerate adoption of these technologies in the workforce and for academic curricula in higher education.



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Developing Smart Building Technology Modules to Enhance Workforce Preparedness: A Case for AI-Driven Academic and Professional Education

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ABSTRACT

Smart building technologies are resources that improve building energy efficiency and resilience, reduce carbon emissions, and provide load flexibility to the grid. However, in both academic curricula and building professionals' continuing education, there is a lack of systematic instruction on methods to integrate multiple energy systems including distributed energy resources (DER), smart building technologies, AI (Artificial Intelligence) tools and key concepts, components, and controls, including "Internet of Things" (IoT) devices. In today's dynamic workforce, this major gap in smart building technology education prevents stakeholders from being able to attract talent with an understanding and preparation to adopt smart building technologies in building design and operations.

A federally funded project included a partnership between Slipstream and Texas A&M University (TAMU) to develop a semester-long smart building curriculum for engineering college students with the ability to adapt the contents for workforce development of professionals in building services. The final product consists of 16 training videos adapted for building professionals and the public. The educational content and training materials cover the benefits of building energy systems, the latest sensor technologies and IoT devices, all with a focus on smart building technologies. The key drivers are on topics related to smart building controls (i.e., energy management information systems), smart building control platforms, cybersecurity, grid-interactive-efficient buildings (GEBs), smart building control methods, and occupant-centric control. Although not explicitly included the technologies nod to the need for AI driven technologies to prepare engineers and industry professionals to be future-ready.

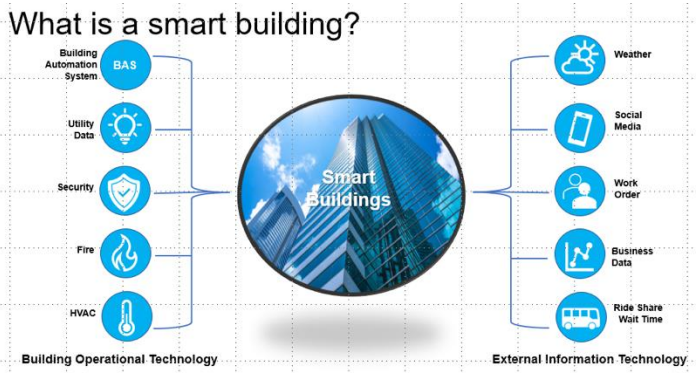
This paper describes the project approach, provides outlines of the training materials, and identifies lessons learned in creating the content for this course. The authors suggest ways to scale the instruction of smart building concepts to empower the workforce to accelerate the adoption of smart building technologies and AI-based teaching and learning in higher education and building sector.

INTRODUCTION

The design, construction, operation, and maintenance of energy-efficient, high-performing, and grid-interactive buildings requires a team approach with seamless collaboration among building owners, architects, engineers, building energy providers, modelers, builders, utility companies, facilities managers, building operators, and other key stakeholders. Workforce development and training for advanced, smart building technologies have been traditionally lacking at both the higher education and professional development levels. Traditional undergraduate engineering, business and technology programs focus on teaching theories and fundamentals in specific areas with a focus on coursework and coverage of topics such as heat transfer, thermodynamics, fluids, load calculations, and mechanical, electrical, and plumbing system design. To meet accreditation body requirements, academic programs are diligent in their design, development and course offerings to meet program outcomes while addressing constituent needs such as preparing students with the necessary competencies to be successful in industry. In addition, there are only a few certification programs with a focus on building controls (IIT 2024, Johnson 2024, NWTC 2024.) The traditional course structure in engineering programs generally lacks an integrated

Expected outcomes of project

- The project ***resulted in a semester-long***, academic ***course consisting of six modules*** for engineering undergraduate and graduate students, and ***16 training videos*** designed, building professionals and the public.
- Training ***content covers*** benefits of energy systems, sensor technologies, IoT devices, and smart building controls, including:
  - ***Energy management information systems (EMIS)***
  - ***Smart building control platforms***
  - ***Cybersecurity***
  - ***Grid-interactive-efficient buildings (GEBs)***
  - ***Occupant-centric control***



Primary drivers & collaborators

- Federal agency ***funded research project*** as awarded grant
- Aimed for ***broad dissemination*** and knowledge sharing
- ***Collaborative***, team effort, engaged multiple stakeholders
- Strategized, developed, ***and*** validated course content
- Provided ***innovative & iterative curriculum*** design
- Indented to fill ***smart building competency gaps***
- Designed for traditional ***engineering programs***
- Dissemination to include ***public*** with interest in buildings
- Provide ***lifelong learning for building professionals***

Image: https://shorturl.at/6LYSv

Objectives for course development

- Develop & validate a set of ***module-based***, course materials
- ***Market-ready*** for adoption by institutes of higher learning - globally
- ***Packaged, scalable***, smart building technologies for professors
- Develop ***online training videos*** suitable for building professionals
- ***Disseminate*** project information and resource to target audiences
- ***Build knowledge***, continuing education, lifelong learning opportunity
- Promote ***broader impact*** through partners & professional organizations

Summary of project outcomes

- Team's charge was to develop a semester-long course[1], ***new smart building course*** - suitable for any engineering college curricula
- Content to be packaged in ***adaptable*** & easy to follow modules
- Produce a series of 16 training ***videos[2]*** for customized & self-paced learning
- Final product is to be available ***free*** to universities, professionals and public
- Topics are to cover ***smart building technologies including AI***
- Content should provide ***industry trends and smart building benefits*** including building systems, sensors & IoT devices, advanced building monitoring & controls, smart building control platform, and case studies

[1]Modules for academic semester (15-week) course:

MODULE #	MODULE TITLE
0	Introduction of the Course
1	Fundamentals of Building Mechanical and Energy Systems, and Building System Integration
2	Smart Building Technologies Drivers and Trends
3	Fundamentals of Smart Building Technologies
4	Advanced – Building Energy Management and Controls
5	Applications of Engineering Tools and Standards—Building Operation
6	Smart Building Technologies Case Studies for Design and Operation

[2]Online sessions consisting of 16 training videos for building industry professionals:

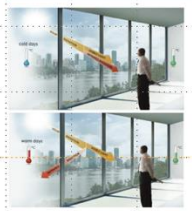
SESSION #	TOPIC CATEGORY	TOPIC
1	**Introduction**	Introduction to Smart Building Technologies
2	**Building Systems**	Building HVAC—Basic Systems
3		Building HVAC—Complex Systems
4		Networked Lighting Controls and HVAC Integration
5		Solar PV, BESS, and EV Charging
6		Smart Window, Automated Shades, Phase Change Materials, and Plug Loads
7	**Sensors and IOT Devices**	Sensors
8		IOT Devices
9	**Smart Building Controls**	Advanced Building Monitoring and Controls
10		Smart Building Control Platform
11		Smart Building Control Platform Cybersecurity
12		Smart Building Control Methods
13		Occupant-centric Control
14	**Smart Building Applications**	Grid-interactive Efficient Buildings and Connected Communities
15		Review of Whole-building Simulation Programs
16		Smart Building Application Examples

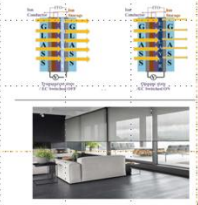
Conclusions and lessons learned for future work

- Smart building technologies are not adequately covered in ***higher education***
- The team utilized best practices in ***developing & testing*** curriculum for training
- Project's ***learning modules*** are systematically organized for scaffolded learning
- ***Lessons learned*** in course/content development:
    1) Involve project advisors early to review course outlines including topics covered
    2) Multiple rounds of internal and external technical expert reviews take time
    3) Collaborate with a learning management system provider
    4) Structure course content and delivery with focus on learning effectiveness & assessment
- Training materials will be available for ***free*** dissemination by the end of 2024

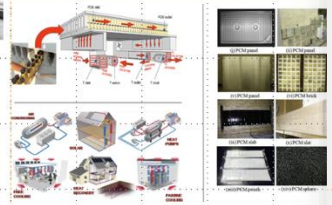
Example of PPT Slides for Academic Course

Summary: Introduction of Smart Envelope





- **Smart windows:** include thermochromic window, electrically activated switchable window, automatic shadin



- **PCMs in buildings:** include passive and active PCMs

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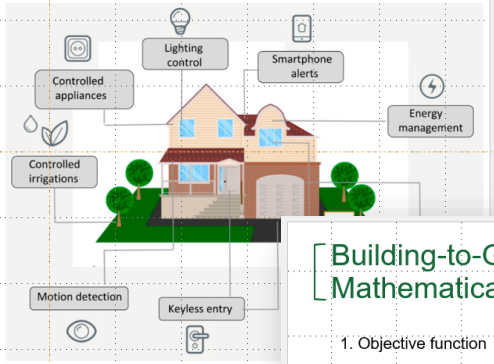
Internet of Things (IoT) Sensors

- Smart devices with advanced communication
- Provide implicit and non-direct occupancy presence and comfort detection
- Occupant feedback enabling energy saving and improved comfort



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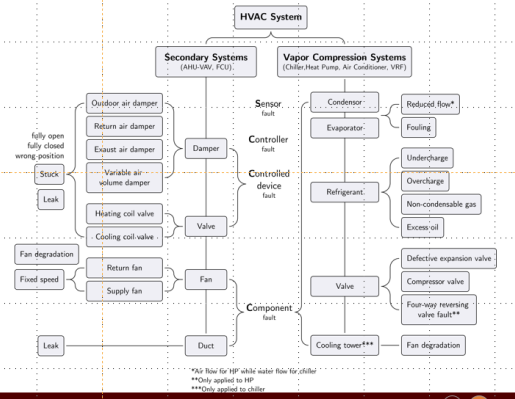
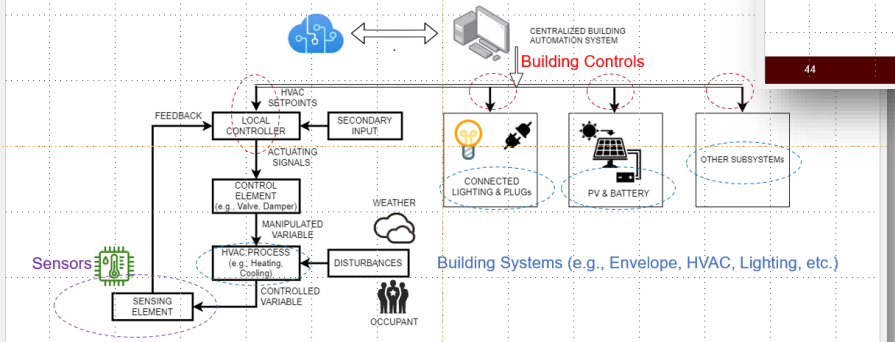
What is automatic fault detection and diagnostics

- Fault classification of HVAC systems [1].



Smart Building Elements



Adopted from Honeywell Engineering Manual of Automatic Control for Commercial Buildings

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Building-to-Grid Integration: Example 1 (3)
Mathematical Expression – Objective Function

1. Objective function

Objective function is to minimizing the operation cost in the coming 24 hours.

$$\min J = \min\left(\sum_{t=1}^{N} C_t^p\left(c_p^s(t), p^s(t), \tau\right) + c_p^d * \max\left(p^s(t)\right)\right)$$

Electricity consumption Demand charge

Where $c_p^s(t)$ — power price at time t;
$p^s(t)$ — power supply from grid at time t;
c_p^d — demand charge rate;

Constraints: Power balance, cooling balance, battery state of charge (SOC) dynamics, TES dynamics, etc.

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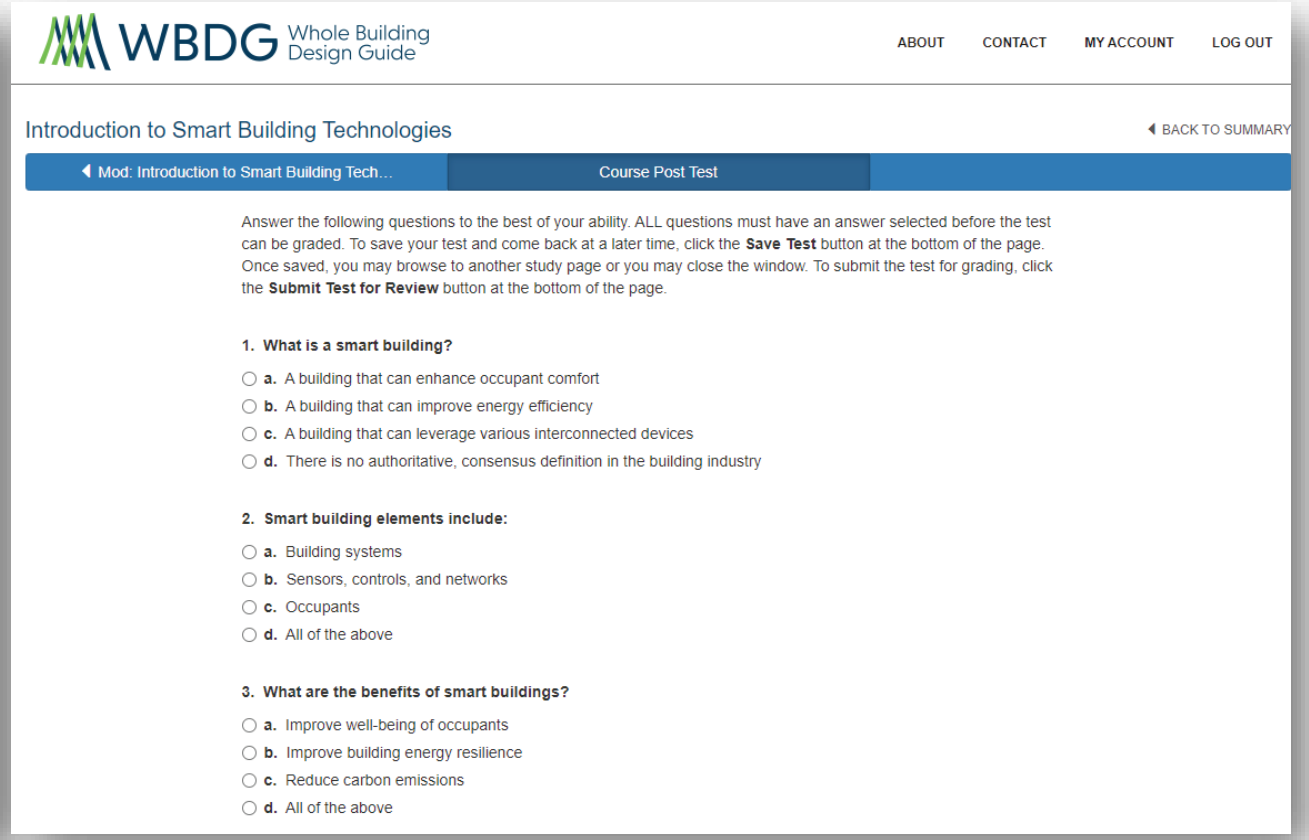
Example of Video Series & Assessment Tool



Acknowledgements

- Thank you, ***Hellenic Chapter*** for this opportunity to disseminate our work
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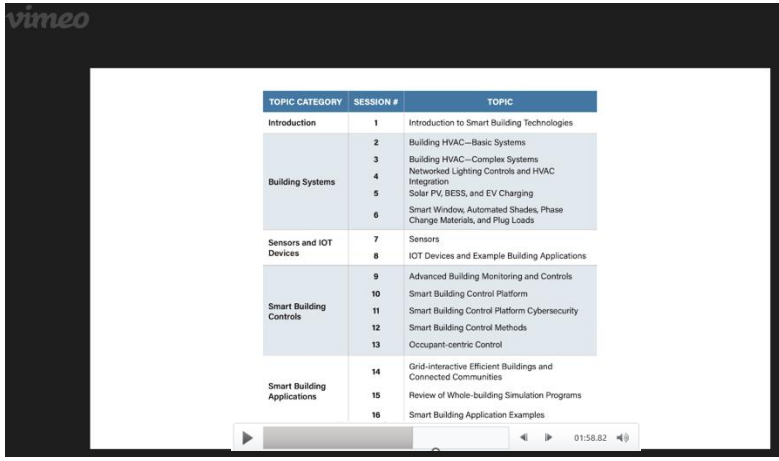
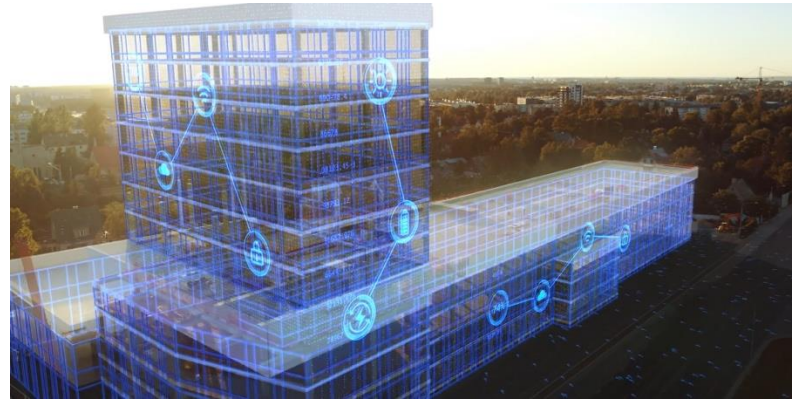
Resources

- To view a short ***promotional video*** for this opportunity, use the QR code
- Or paste this link into your URL ***https://shorturl.at/Ctkte***
- A complete list of additional ***resources***, are provided in the paper
- For more information ***access to the course content***, please contact the authors





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THANK YOU! Q & A

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