



Module 6 – Smart Buildings – Modern Technologies and Systems Integration

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1 Introduction

Smart Buildings module introduces the concept of smart buildings and their significance in modern urban development. It covers integrated technologies that enhance building performance and sustainability. Key topics include smart readiness indicators, energy management, new technologies, and the human factor.

2 Background and Motivation

The development of smart buildings is crucial in the context of modern urban development and sustainability. Integrated technologies enhance building performance, reduce energy consumption, and improve user comfort. This module explores the systems that make buildings intelligent and the broader implications of these technologies in the context of digital transformation. The goal is to provide a foundational understanding of smart buildings, their readiness indicators, energy management, new technologies, and the human factor, along with examples that illustrate these concepts. By the end, the students will understand the essential aspects of smart buildings and the importance of smart readiness indicators in the context of smart buildings.

3 Theoretical Framework

3.1 Key Concepts and Definitions

A smart building uses automated processes and advanced technology to efficiently manage and control its systems, such as heating, ventilation, air conditioning (HVAC), lighting, security, and other essential functions. These buildings integrate Internet of Things (IoT) devices, sensors, artificial intelligence (AI), and data analytics to optimize performance.

Challenges of Smart Buildings involve high initial costs, cybersecurity risks, complex integration, reliability of internet and power, and scalability challenges. Advantages, such as energy efficiency, cost reduction, occupant comfort and productivity, and enhanced safety and security, outweigh these challenges.

Future Trends in Smart Buildings include integration with smart cities, 5G connectivity, AI-driven adaptation, digital twins, and simulation. Sustainability is a core principle, with smart buildings integrating renewable energy sources like solar panels and wind turbines to reduce environmental impact. Comfort-driven systems that improve air quality and lighting are crucial for enhancing occupant well-being.

3.2 Smart Readiness, Energy Management and technologies

The Smart Readiness Indicator (SRI) is a standardized EU framework designed to evaluate a building's capability to effectively use smart technologies, such as building automation, energy management, and integration with the energy grid. The primary objectives of the SRI are to enhance energy efficiency, reduce carbon emissions, and

improve occupant comfort. There are two methods for calculating the SRI: Method A: A simplified approach suitable for smaller or less complex buildings, evaluating 27 smart functionalities. Method B: A more detailed assessment for larger or more complex buildings, evaluating 54 smart functionalities.

The SRI evaluation focuses on three key functionalities: optimizing energy efficiency and overall building performance, enhancing user comfort and convenience, increasing energy flexibility and interaction with the grid

Each smart functionality is assessed using seven impact criteria, including energy efficiency, fault detection and diagnostics, comfort, convenience, health and well-being, user information, and energy flexibility. Different building types have unique operational profiles and needs, influencing how smart technologies are applied. Climate is also a critical factor, with the European SRI framework dividing Europe into five climate zones, each assigning different importance to technical domains such as heating and cooling.

The SRI framework ensures a consistent and transparent assessment of a building's smart capabilities, supporting the EU's goals for energy efficiency and sustainability.

Energy management in buildings involves a structured approach to using energy efficiently across all systems and zones. The five pillars of energy management are monitoring, analysis, optimization, user engagement, and implementation. Main Goals of Energy Management include cost savings, reducing environmental impact, enhancing comfort, improving control and data visibility, and ensuring regulatory compliance. Legislation such as the Energy Performance of Buildings Directive (EPBD), ISO 50001, and the Smart Readiness Indicator (SRI) drives energy management practices.

Nearly Zero Energy Buildings (nZEB) are designed to use significantly less energy than traditional buildings, often integrating renewable energy sources and smart controls. Zero Emission Buildings (ZEB) aim for zero net emissions during operation, combining energy efficiency, on-site generation, and digital intelligence.

Building Management Systems (BMS) act as the digital brain of a building, monitoring and controlling systems like HVAC, lighting, and security. Future BMS will be AI-driven, cloud-based, and capable of real-time adaptation. While BMS offers centralized control and high-energy savings, challenges include high upfront costs, complexity, and the need for skilled personnel. Smart Meters enhance energy efficiency by providing detailed, real-time data on electricity, gas, water, and heat usage.

Measurement and Verification (M&V) of energy savings is tailored to different building types and behaviours, providing feedback for continuous improvement. M&V validates energy savings, supports compliance, and enhances transparency.

Future-ready buildings must address both operational and embedded carbon to meet 2050 climate targets. This requires faster renovation, increased digitalization, educated professionals, and supportive policies. Ultimately, energy management is

about designing buildings that respect environmental limits while enhancing quality of life.

3.3 Case Studies and Examples

Two real-life examples of smart buildings are shortly described below. More examples can be found in the Module 6 Booklet on smart buildings.

Luxembourg, NeoBuild Office

Technical Description: Integrates advanced energy management systems, utilizes solar panels, and is equipped with smart sensors for monitoring and optimizing energy usage.

Potential for Improvement: Enhance IoT integration for better data collection, implement advanced AI algorithms for energy management, and upgrade insulation and window technologies.

Luxembourg, The Elmen Social Housing Project

Technical Description: Features a comprehensive energy management system, incorporates solar panels and geothermal energy, and has smart lighting and HVAC systems that adjust based on occupancy and external conditions.

Potential for Improvement: Further integrate IoT devices for real-time monitoring, implement AI-driven analytics for optimization and maintenance prediction, and upgrade building materials for better thermal insulation.

4 Practical Applications

After completing module 6, students will have better understanding of implications related to smart building concept and significance, smart readiness indicators and methodologies that yet have to be adopted at the EU level and legal framework concerning smart buildings. They will be able to recognize relevant technical systems in buildings and their levels of smartness. They will also understand the importance of energy management, smart metering and data collection in smart buildings and will be able to select and apply an adequate methodology to verify the savings that are achieved through these technologies.

Generally speaking, the students will acquire basic knowledge on smart buildings, which will serve as a solid basis to build upon, depending on the future requirements, i.e. from their employers.

5 Summary and Take-home learning messages

Smart buildings use integrated technologies to enhance performance and sustainability. They feature automated systems for HVAC, lighting, security, and more, offering benefits like energy savings, cost reduction, comfort, and safety.

The Smart Readiness Indicator (SRI) is an EU framework that evaluates smart technologies in buildings, focusing on energy efficiency, comfort, and flexibility across nine domains.

Efficient energy management in smart buildings aims for cost savings, reduced environmental impact, and enhanced comfort, incorporating concepts like nZEB, ZEB, BMS, smart meters, and M&V.

Take-home Learning Messages: Smart buildings use IoT, AI, and data analytics to optimize performance and sustainability, significantly reducing energy consumption and operational costs. Automated systems enhance occupant comfort and productivity. Despite high initial costs and cybersecurity risks, the benefits outweigh the challenges. Future trends include deeper integration with smart cities, advanced connectivity, AI, and sustainable practices. Applying SRI methodologies improves smart readiness evaluation, requiring ongoing assessment and adaptation.

6 Further Reading and Resources

List of additional resources for students who wish to explore the topic further, Smart Buildings:

1. **Smart readiness indicator (SRI) Commission initiative**
https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/smart-readiness-indicator_en
2. **Training package for SRI assessors**
<https://ec.europa.eu/smart-readiness-indicator>
<https://ec.europa.eu/eusurvey/runner/SRI-assessment-package>
3. **SRI assessment tool**
<https://sri2market.eu/sri/>
4. **SRI2MARKET e-learning lessons on the SRI and its assessment methodology**
<https://learning.sri2market.eu/moodle/course/view.php?id=3>
5. **EVO organization (IPMVP)**
<https://www.evo-world.org/en/>
6. **Directive 2010/31/EU on the Energy Performance of Buildings (EPBD)**
<https://eur-lex.europa.eu/eli/dir/2010/31/oj>
7. **Directive (EU) 2018/844 (Amending the EPBD and EED)**
<https://eur-lex.europa.eu/eli/dir/2018/844/oj>
8. **Commission Delegated Regulation (EU) 2020/2155 (Smart Readiness Indicator – SRI definition & methodology)**
https://eur-lex.europa.eu/eli/reg_del/2020/2155/oj
9. **Commission Implementing Regulation (EU) 2020/2156 (SRI implementation procedures)**
https://eur-lex.europa.eu/eli/reg_impl/2020/2156/oj
10. **Directive 2012/27/EU on Energy Efficiency (EED)**
<https://eur-lex.europa.eu/eli/dir/2012/27/oj>
11. **Directive (EU) 2024/1275 on the Energy Performance of Buildings**
<https://eur-lex.europa.eu/eli/dir/2024/1275/oj>



12. General Union Environment Action Programme to 2030

<http://data.europa.eu/eli/dec/2022/591/oj>

13. 2023 revision of Energy Performance of Buildings Directive

[https://eur-lex.europa.eu/legal-](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive)

[content/EN/TXT/?uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive)

7 Assignments and Assessments Strategy

In this module students will be given 2 assignments.

First assignment will be communicated during online learning. It will prepare students for the group work in Hamburg. The assignment will be divided into two parts, to be completed by two separate groups:

Group 1 – students who live in Single-Family Homes

Task: Students will be asked to reflect on your home environment and daily interactions with systems like heating, lighting, or ventilation. Students will be asked to note any smart features and how your home responds to occupancy, time of day, or weather conditions and prepare notes for your group's discussion.

Group 2 – Students who live in Multi-Family Buildings

Task: Students will be asked to observe shared and private systems in your building. Identify smart features in central heating, hallways, or common. They will also be asked to reflect on their control over these systems (centrally managed or user-adjustable) and prepare notes for your group's discussion.

Connection to Final Assignment

The group structure continues into the final assignment in Hamburg, which will be communicated to students in person.

