Plug-and-Play solutions for energy-efficiency deep renovation of European building stock
1. **Problem statement**  
Main barriers for deep renovation at European scale

2. **Hypothesis**  
Plug-and-Play (PnP) renovation with simple, affordable and fast implementation

3. **Theoretical review**  
Adaptation and adoption of PnP concept from IT to construction

4. **Research methodology**  
Applied research in the P2ENDURE collaborative project

5. **R&D achievement**  
Prototype solutions and real pilot projects

6. **Conclusion and discussion**  
Innovative aspects and scientific contribution
1. Problem statement

• Almost 90% of the existing building stock in the EU is older than 30 years, but the rate of renovation is only 1-2% each year, and within this only 5% of the renovated buildings achieve >60% energy saving


• This fact is hard to accept since:
  – Advanced renovation solutions (products and services) are available
  – Sustainability policies and financial benefits encourage energy-efficient buildings
  – Research in deep renovation have achieved a high Technology Readiness Level (TRL)

• So, the research questions are:
  – What are the barriers for large-scale deep renovation in Europe?
  – How to break these barriers?
1. Problem statement

• Barriers for large-scale deep renovation in Europe

  – Financial barriers  : renovation cost, access to finance, [temporarily] low energy price
  – Technical barriers : lack of affordable technical solutions and knowhow of professionals
  – Process barriers  : fragmentation in supply-chain and high complexity for owners/occupants
  – Regulatory barriers : varying performance requirements and definition of (deep) renovation
  – Awareness barriers : insufficient insights in renovation benefits and increased user comfort
2. Hypothesis

• **Plug-and-Play (PnP) concept is key to large-scale deep renovation**
  
  – PnP deep renovation goes beyond ‘modular building units’
  
  – Plug-and-Play (PnP) solutions can break through the current renovation barriers
  
  – Scan-to-BIM-to-BEM is essential for PnP product and process integration
  
  – Upgrading building’s smartness through deep renovation can be facilitated PnP updates
3. Theoretical review

• The origin of PnP technologies from IT hardware and software domains, and the practical adoption and adaptation of the PnP concepts and principles for building deep renovation

  – PnP common understanding:
    Connecting an external device to a computer / electronic system without the need for manual installation of driver software or intervention

  – PnP building components:

  – PnP building automation:
4. Research methodology

• Scan-to-BIM-to-BEM
digital upgrade of building and energy information

• Plug-and-Play renovation
upgrade of building components, potential of smart control systems

• On-site 3D printing
robotics for façade retrofitting, potential of smart materials

• IEQ monitoring system
upgrade of Indoor Environment Quality, potential of IoT smart sensing
5. R&D achievement

- **Scan-to-BIM**

  Digital reconstruction of the existing building in As-Built BIM
  - Exterior and interior laser and thermal scans
  - No fully automated procedures / tools are yet available
5. R&D achievement

- **BIM-to-BEM**
  Experiments with 2 different methods and toolsets:
  - Revit – IFC – CYPETHERM
  - Revit – SketchUp with Legacy OpenStudio plugin – EnergyPlus [using open source tools]
5. R&D achievement

- **BIM-to-BEM**

  Existing technical bottlenecks:
  
  - Only relatively simple BIM models can be facilitated
  - Difficulties in making simulation of several design variants containing geometric changes
  - Needed extra time to redefine BIM properties besides geometry when these can not be imported by the current BEM tools
  - Issues with BEM system parameters depending on obtained data of the existing energy system, especially regarding old energy systems (e.g. old fashioned boilers)
  - Issues with BEM material parameters depending on the materials properties and stratigraphy data
  - Limited flexibility in choosing the simulation and output preferences in the current BEM tools
5. R&D achievement

- (Potential) use of BIM and BEM to upgrade the building’s smartness
  - As-Built BIM as input for P2Endure Parametric Modeller to configure renovation options
  - Location and properties of the sensors installed in renovated building can be included in BIM
  - Based on sensor data, performance levels of different rooms / storeys can be visualized in 3D
5. R&D achievement

- **Plug-and-Play renovation solutions**
  - Multifunctional panel with possible integration of climate regulation system
  - Potential PnP integration of smart control systems in adaptive building envelope
5. R&D achievement

- **Plug-and-Play renovation solutions**
  - Reversible window with advanced climate and energy properties
  - Potential PnP integration of smart sensors and control systems for an active window
5. R&D achievement

- **On-site 3D printing**
  - Collaborative robot for façade retrofitting by on-site 3D rendering and milling
  - Potential integration of advanced robotics and smart materials in on-site 3D printing
5. R&D achievement

- **IEQ monitoring system**
  - Comfort Eye (patented): affordable monitoring system of indoor temperature, air quality (CO2)
  - Potential integration of IoT smart sensing and actuators: IEQ monitoring system connected with BMS (Building Management System), real time data to BIM
6. Conclusion and discussion

• **Plug-and-Play is a way to upgrade building’s smartness through deep renovation**
  PnP technologies and principles derived from IT hardware and software domains have potential for adaptation and practical adoption to upscale building deep renovation

• **The biggest challenge for PnP deep renovation is the interoperability and integration**
  Integration is needed regarding both hardware (inter-connected renovation components, flexible joints) and software (BIM, modelling and simulation tools)

• **Just like in ICT domain, upgrading building’s smartness goes through gradual updates**
  Building deep renovation should be ‘future proof’ in terms of technology, economy and society. So, keep the PnP renovation systems open for continuous updates
Dr. Rizal Sebastian (Project Coordinator)

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