# Plug-and-Play solutions for energy-efficiency deep renovation of European building stock

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

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4. **Research methodology**
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   Innovative aspects and scientific contribution

- **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**

  (source: European Parliament, 2016, Boosting Building Renovation: What potential and value for Europe?)

- 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?

- **Barriers for large-scale deep renovation in Europe**

  (source: European Parliament, 2016, Boosting Building Renovation: What potential and value for 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

- **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

- 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:

- **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
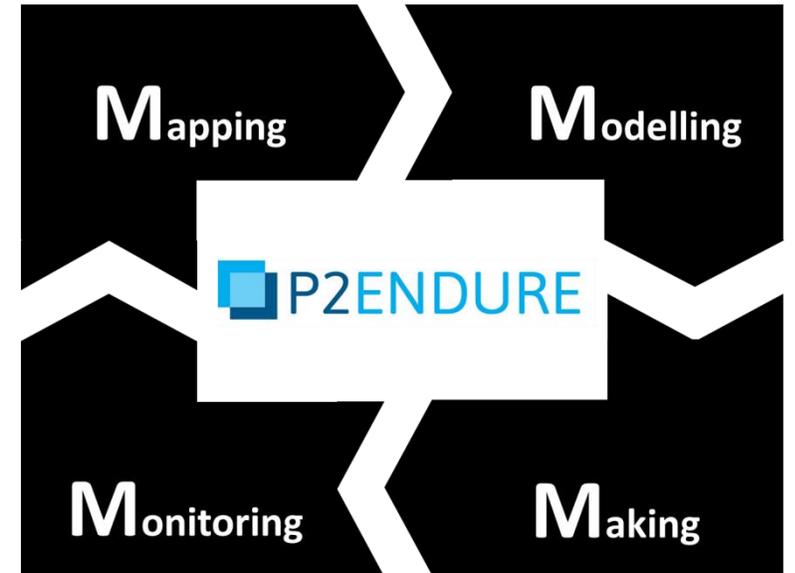
- **Scan-to-BIM**

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

- **BIM-to-BEM**

Experiments with 2 different methods and toolsets:

- Revit – IFC – CYPETHERM

- Revit – SketchUp with Legacy OpenStudio plugin – EnergyPlus [using open source tools]
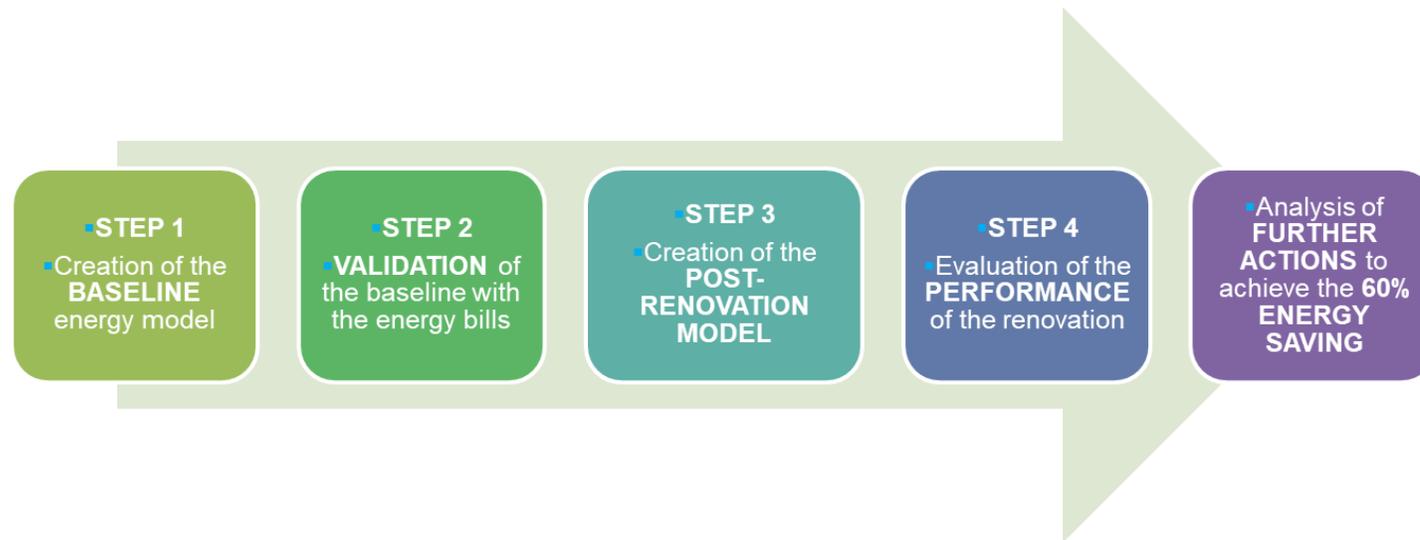
- **BIM-to-BEM**

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

- **(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
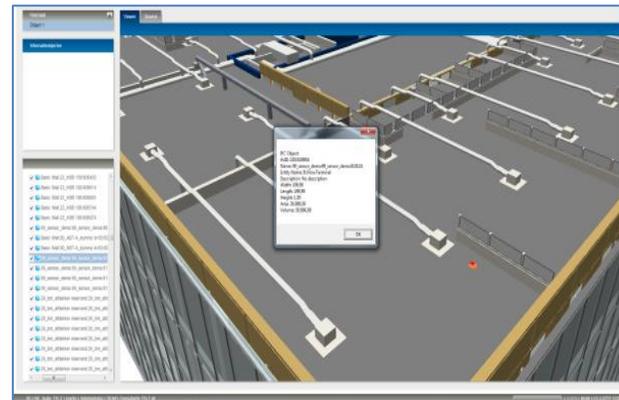
- **Plug-and-Play renovation solutions**
  - Multifunctional panel with possible integration of climate regulation system
  - Potential PnP integration of smart control systems in adaptive building envelope
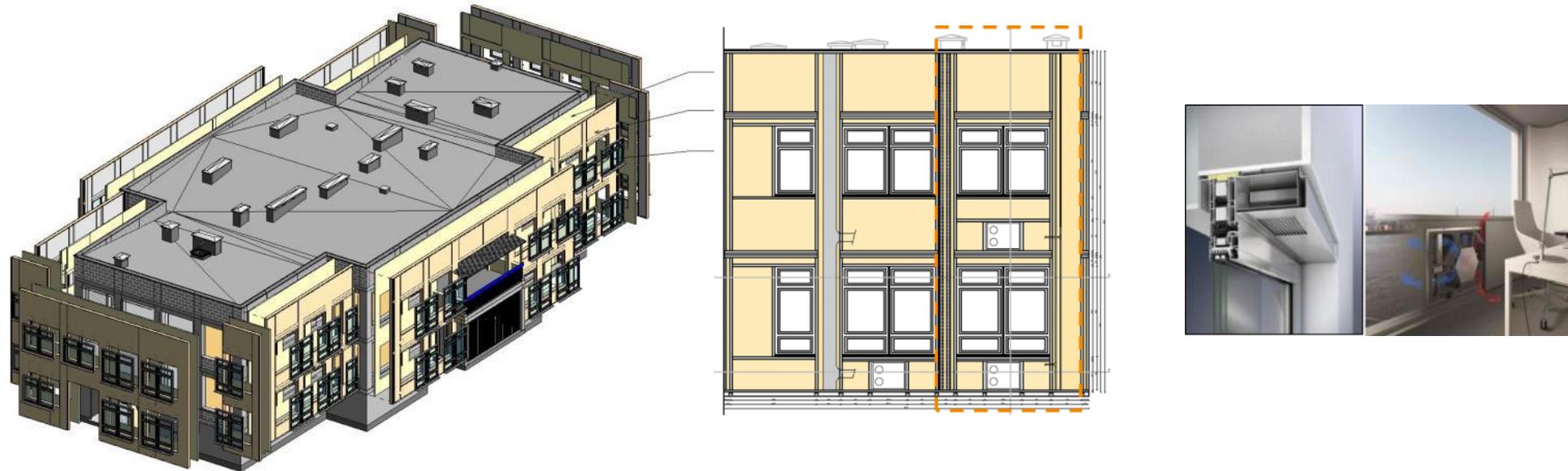
- **Plug-and-Play renovation solutions**
  - Reversible window with advanced climate and energy properties
  - Potential PnP integration of smart sensors and control systems for an active window
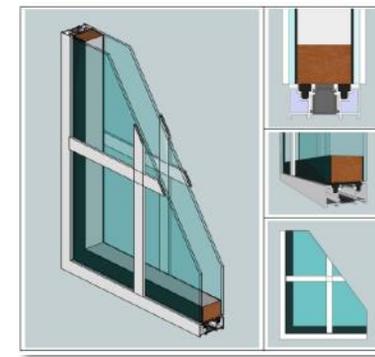
- **On-site 3D printing**
  - Collaborative robot for façade retrofitting by on-site 3D rendering and milling
  - Potential integration of advanced robotics and smart materials in on-site 3D printing

- **IEQ monitoring system**

  - Comfort Eye (patented): affordable monitoring system of indoor temperature, air quality ($CO_2$)

  - Potential integration of IoT smart sensing and actuators: IEQ monitoring system connected with BMS (Building Management System), real time data to BIM

- **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

**in** Dr. Rizal Sebastian (Project Coordinator)

**www.P2Endure-project.eu**