IEQ measurement and assessment tools for Plug-and-Play deep renovation in buildings

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Healthy, Intelligent and Resilient Buildings and Urban Environments

PRESENTATION OUTLINE

- Problem statement

- P2Endure for Plug-and-Play (PnP) renovation

- IEQ measurement and assessment protocol

- Comfort Eye

- Survey for nurseries

- Conclusion

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**

  (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)

PROBLEM STATEMENT

- **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, 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**

P2Endure for Plug-and-Play (PnP) renovation

- Call H2020-EE-10-2016: Accelerated and cost-effective deep renovation of buildings

- Project duration: 48 months (1 September 2016 – 31 August 2020)

- Coordinator: DEMO Consultants (NL)

- Consortium: 16 partners (8 SME, 5 large companies, 2 universities, 1 local government)

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# P2Endure for Plug-and-Play (PnP) renovation

Main aim

- 60% energy saving through deep renovation

- 15% cost saving compared to traditional renovation techniques

- 50% time saving and thereby reduction of disturbance during renovation

**4M Modular Processes**
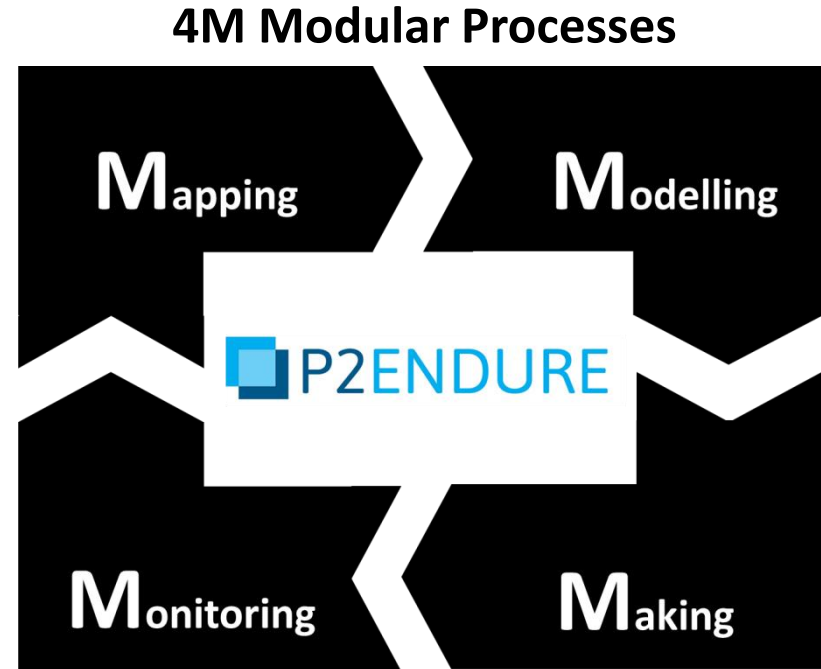
P2Endure for Plug-and-Play (PnP) renovation

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

  digital upgrade of building and energy information

- **Plug-and-Play renovation**

  upgrade of building components

- **On-site 3D printing**

  robotics for façade retrofitting

- **IEQ monitoring system**

  upgrade of Indoor Environment Quality
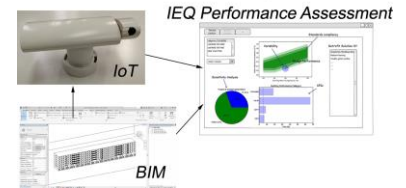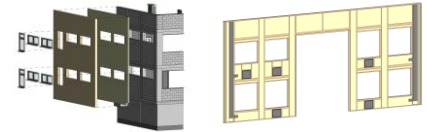
IEQ measurement and assessment protocol

A monitoring and assessment protocol for IEQ was developed according to current standards (EN15251, ISO7730, EN12354-3) with a framework based on innovative solutions and methodologies. The protocol provides information on:

- Parameters to be measured (what, how and when)

- Data collection based on sensors, surveys and questionnaires

- Data processing to calculate KPIs and investigate building performance
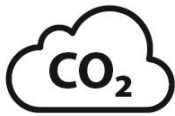
$$\Delta T = \frac{\sum_{i=1}^{n} POR_i * S_i}{\sum_{i=1}^{n} S_i} \ [\%]$$

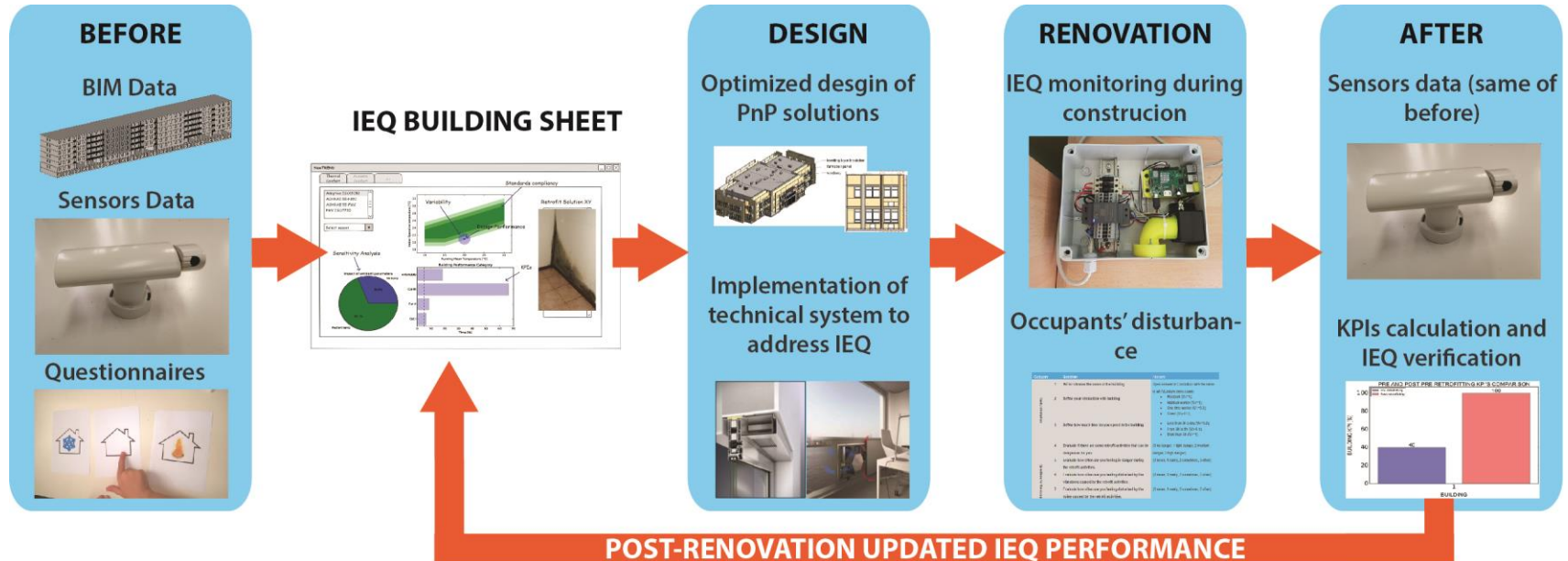$KPI = 0\% \text{ if } \Delta T \geq 5\%$

$KPI = 100\% \text{ if } \Delta T = 0\%$

IEQ measurement and assessment protocol

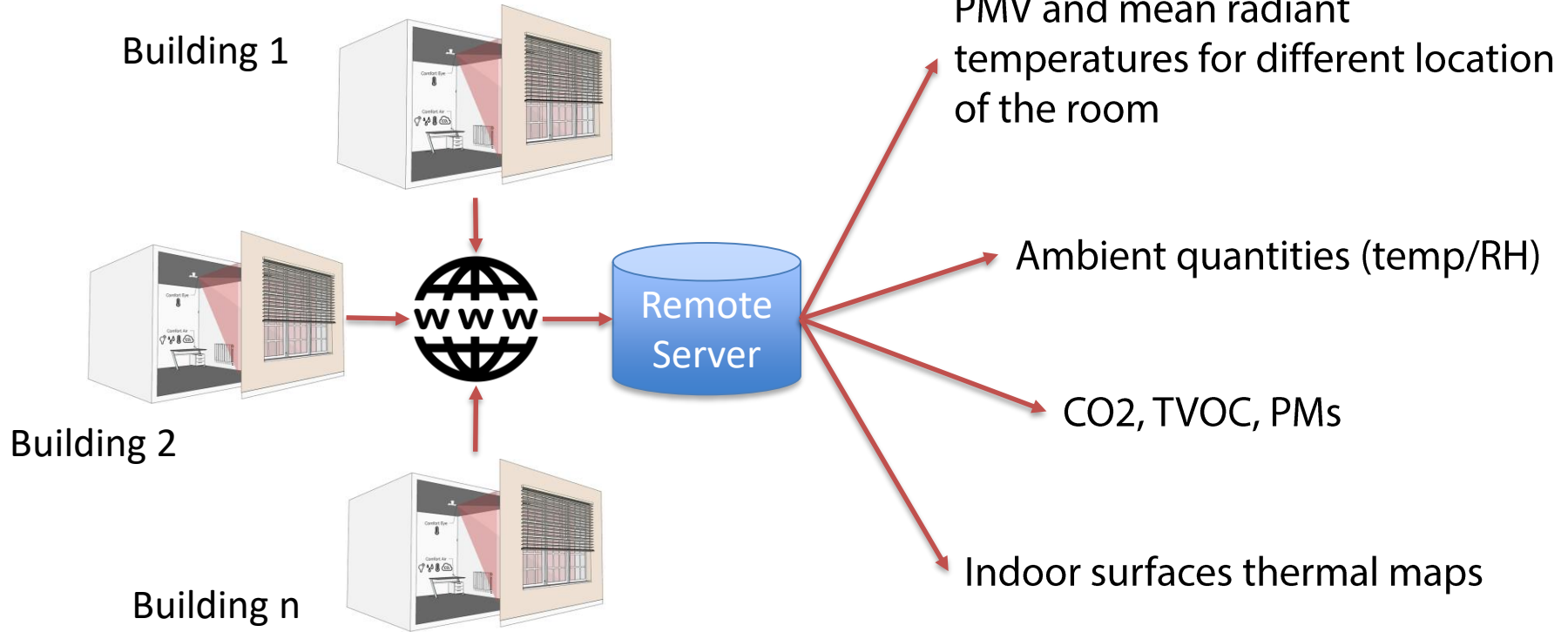## Application to the whole building renovation process

Comfort Eye

The Comfort Eye is an **innovative and non intrusive** solution for the IEQ assessment. It is a **IoT sensing** system composed of two nodes:

1. IR scanning sensor for multipoint mean radiant temperature measurement and envelope temperature monitoring

2. Desk sensing node for ambient parameters

Patented solution for indoor thermal scanning to calculate PMV for several positions of the room
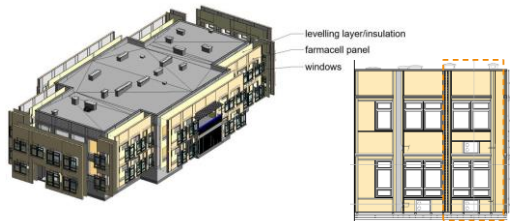
Comfort Eye

Building 1

Building 2

Building n

Remote Server

PMV and mean radiant temperatures for different location of the room

Ambient quantities (temp/RH)

CO_2, TVOC, PMs

Indoor surfaces thermal maps

Comfort Eye

One of the first application is the nursery demo case in Warsaw

Built in the 1983 with poor envelope performance and IAQ problems

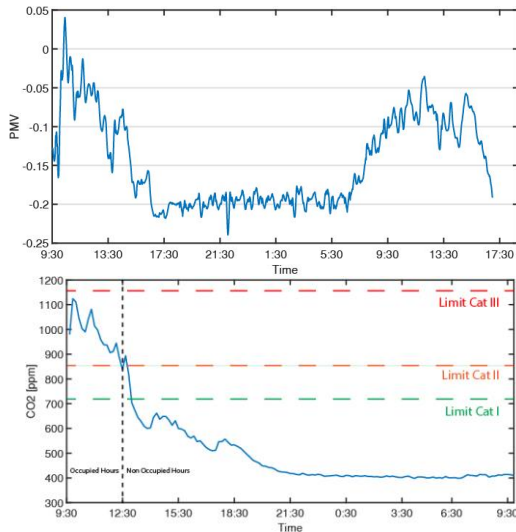levelling layer/insulation
farmacell panel
windows

PnP façade modules design with windows replacement and ventilation system

Comfort Eye

Winter data were collected for some days in February to test the Comfort Eye operation.

Average PMV of -0.15. The comfort is maintained within the acceptable range, providing a KPI of 100% with the fulfilment of Category II.

CO_2 measurement highlight poor level of IAQ during the occupied hours with CO_2 concentrations always within the Category III, leading to a KPI equal to 0%.

Comfort Eye

Winter data were collected for some days in February to test the Comfort Eye operation.

Wall
16°C

Window
10°C

$Tr = 17.8°C \ < Ta = 22.8°C$
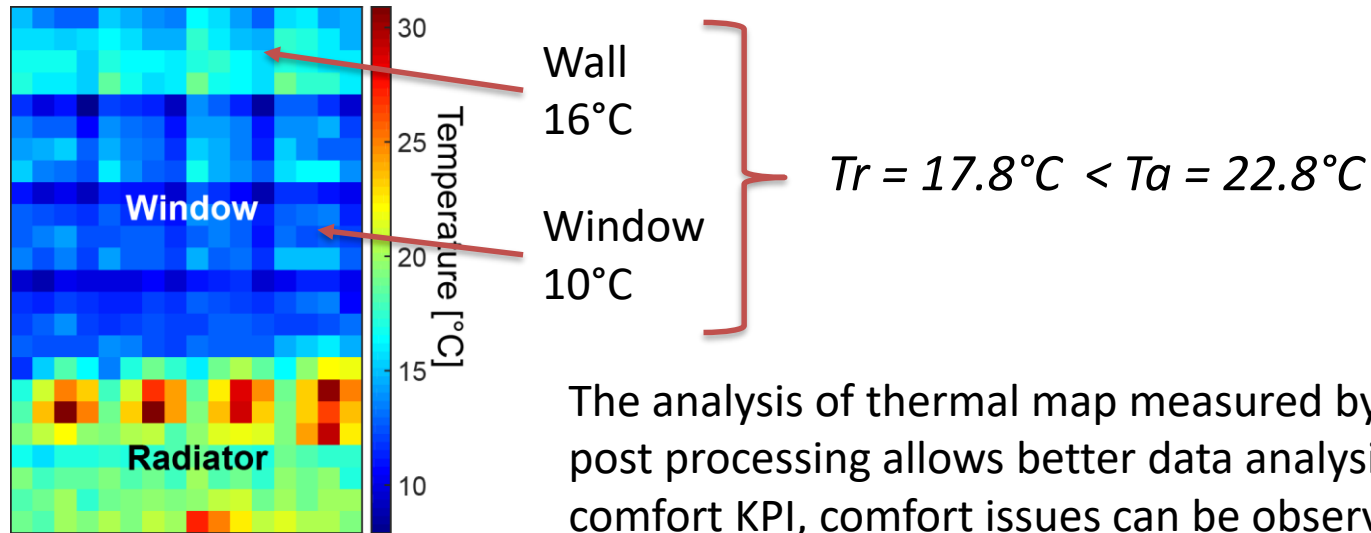
The analysis of thermal map measured by the Comfort Eye and post processing allows better data analysis: despite good comfort KPI, comfort issues can be observed.

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Survey for nurseries

3 nurseries within P2Endure demo cases: need of comfort assessment for children.

A nursery is located in Genova, built in 1930s with concrete structure and non-structural brick walls. The building is listed under the Italian Legislative Decree 42/2004, which poses cultural heritage constraints on its conservation.


IEQ assessment at "Nemo" school in Genova (IT) with measurement and survey

Survey for nurseries

The Deltaohm IAQ Datalogger HD21ABE for **CO2 metering** has been positioned on a shelf.

For comfort and the **PMV monitoring**, two different strategies have been identified:

- **Working days:** the **Deltaohm Microclima HD 32.3A** has been positioned on a piece of furniture.

- **Weekend:** the equipment has been placed in the center o the classroom, in order to properly evaluate the radiation temperature and the influence of the windows

N

16
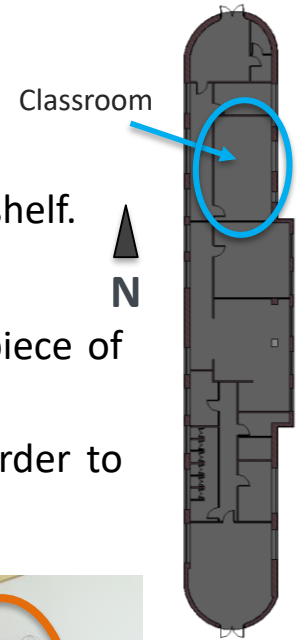
Survey for nurseries

The IEQ building sheet includes detailed analyses on comfort performance:

- Compliancy with EN 15251

- Variability analysis (deviation with respect to average operation)

- Calculation of performance according to % of hours within classification ranges
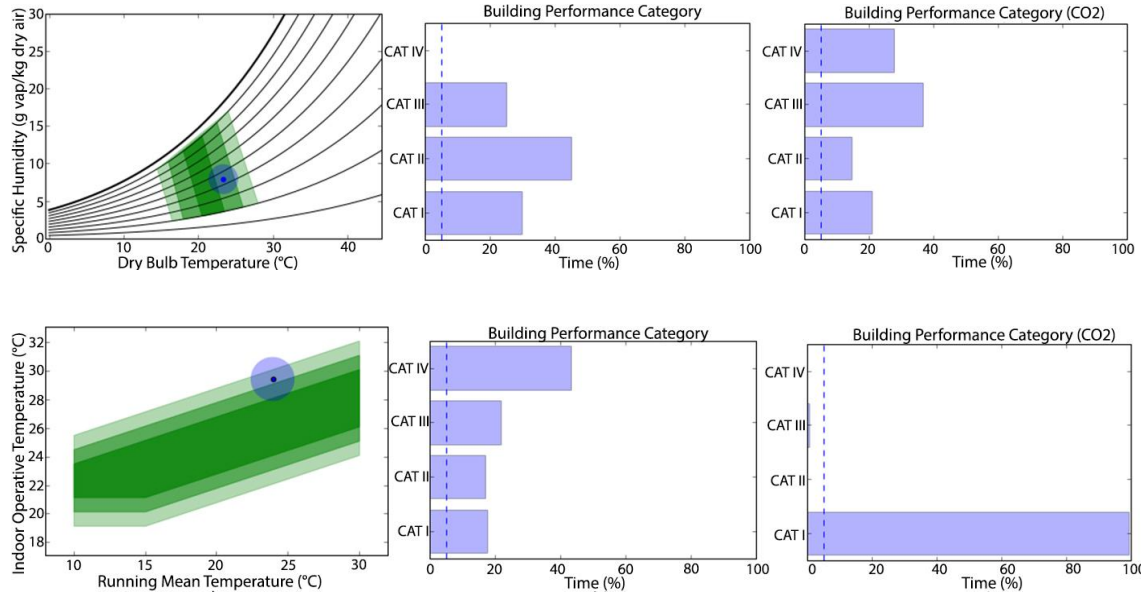
Survey for nurseries

Children Interviews

On the basis of these studies, the following questions have been distributed to the children, and different figures have been shown in order to help them to answer the question:

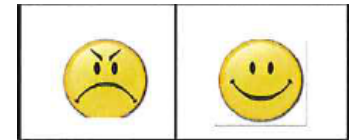What's the weather like?

Sunny   Partly cloudy   Cloudy

How is the temperature in the room?

Hot   Neither hot nor cold   Cold
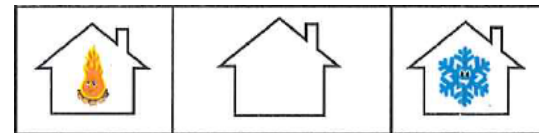
How you feel? (in this condition)

Sad   Happy

How you dress? (in this condition)

T Shirt   Long-Sleeved shirt   Sweater
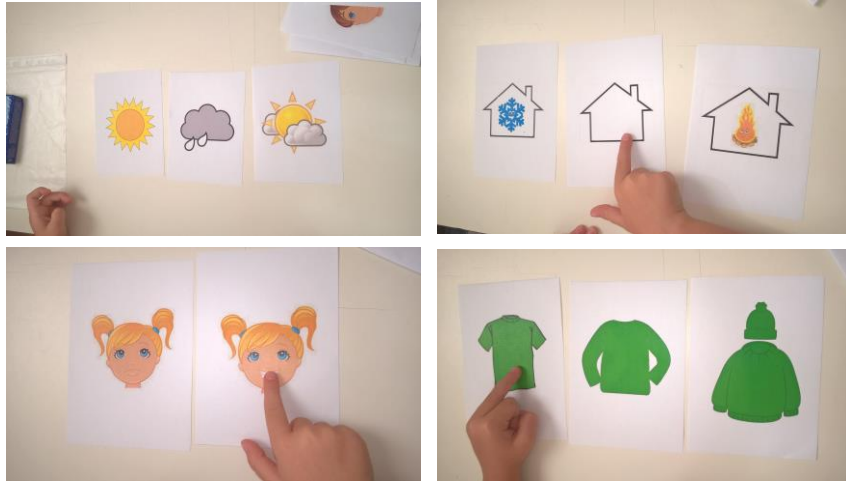
Would you prefer:

Warmer   like now   Cooler

Survey for nurseries

Children Interviews

The children answered the questions choosing among the cards. Answers were collected in indicating also age and sex. Results from surveys were compared with measurement

Q2:how do you think is the classroom today			Q3:When the classroom is (Q2 answ.) how do you feel?		At this moment, would you like to feel..		
hot	not hot neither cold	Cold	sad	happy	warmer	no change	cooler
87	38	3	57	70	20	50	58
69%	30%	2%	45%	55%	16%	39%	46%

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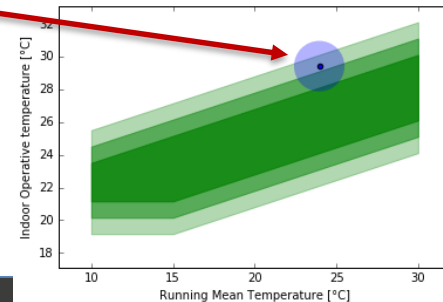
Conclusion

P2Endure developed an IEQ M&V methodology for buildings' renovation and will provide proof of evidence with application to 10 demonstration cases:

Transformation of university building to student housing in Enschede, NL
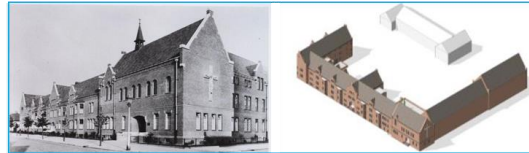
Deep renovation of public nursery building in Warsaw, PL

Deep renovation of residential building in Ancona, IT

Deep renovation of public nursery building in Gdynia, PL

Transformation of historical monastery to a hotel in Tilburg, NL

Deep renovation of historic residential building in Florence, IT

Residential district renovation in Odense, DK

Deep renovation of historical nursery building in Genova, IT

Transformation of school building to dwellings in Tilburg, NL

Transformation of public spa building to dwellings in Hürth, DE

Thanks for your kind attention

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www.p2endure-project.eu

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