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Energy Performance Gap in New Existing Buildings

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Content

General overview on EPG

- What is EPG?
- Why EPG is important?
- Evidences of EPG’s
- What causes EPG?

PerfoGap project results

- Monitoring of the buildings
- Machine learning models for energy prediction

What is energy performance gap?

- Implementing provisions of the **EPBD all Member States requires to provide EPC** (Energy Performance Certificate) when buildings are constructed, sold or rented.

- The purpose of the certificate **is to compare** buildings‘ performance and inform the end-users. In addition, it is expected to reduce energy consumption and carbon emissions by providing market actors with information to make **better-informed decisions**.

- **However**, quite many mismatches and discrepancies could be found when comparing actual energy consumption with the once declared by the EPC. **This mismatch of energy demand is known as Energy Performance Gap (EPG).**

Why EPG is so important?

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- ✓ To meet the EU's climate objectives, the building sector will need to achieve **60%** greenhouse gas (GHG) emissions reductions by **2030** and **fully decarbonise by 2050**.

- ✓ Unfortunately Europe **is not on track**: buildings still account for 40% of the EU's total energy consumption and 36% of CO2 emissions.

- ✓ Today, roughly **75%** of the EU building stock is **energy inefficient**

- ✓ Special attention must be paid to the **residential buildings** as according to EU Buildings Datamapper, residential buildings in different countries **constitute 59-89 %** of the building stock and they are one the main energy consumers.

- ✓ **Higher** Energy Pperformance **Gaps** are found **in non-residential buildings.**

EVIDENCE OF EPG IN NON RESIDENTIAL BUILDINGS

Home | About Carbon Buzz | Evidence | Case studies | News

Case studies > Project details

450003: Crawley Library

Sector: Office
Benchmark category: General Office
Sector: Sport & Leisure
Benchmark category: Cultural activities

Design data	Actual data
59.0 kWh/m^2/yr	**140.2** kWh/m^2/yr

more project details

Building/project type: Existing

Building use: Mixed Use

Tenancy: Multi-Tenanted

The new Crawley library was built to provide a range of county council services including a central library, office and accommodation for administrative and social services. Facing a new public square, the four-storey building, which has a stone and glass facade, was designed to be a landmark for Crawley town centre and an example of low carbon best practice.

Project summary:

Aiming for sustainability and comfort, the building features high thermal mass, controlled day lighting, a sophisticated mixed mode ventilation system, a Building Management System (BMS) with sub-metered energy monitoring, solar water heating and a biomass boiler. The range of low carbon measures and principles embedded in the design has led to the achievement of several sustainability awards along with a BREEAM Very Good and an EPC A rating.

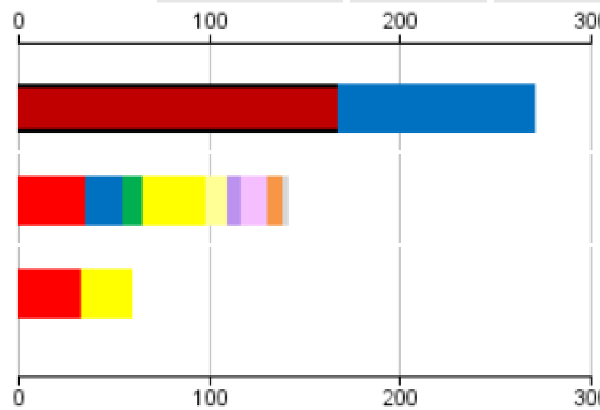
Project records

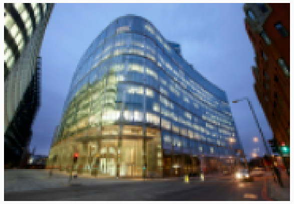
By end use | kWh | per m2 | update

CIBSE TM46 Composite Benchmark

Crawley Library - Main meter readings (12/12/2014)

Crawley Library - EPC as designed (31/5/2013)





201 Bishopsgate

Design data	Actual data
69.0 kWh/m^2/yr	**319.3** kWh/m^2/yr

more project details

Building/project type:	New build	**Building use:**	Mixed Use
Tenancy:	Multi-Tenanted		
Project summary:			

Project records

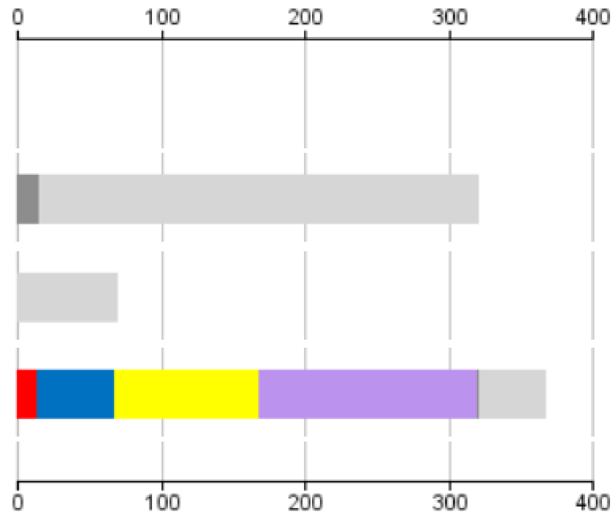
By end use | kWh | per m2 | update

CIBSE TM46 Composite Benchmark

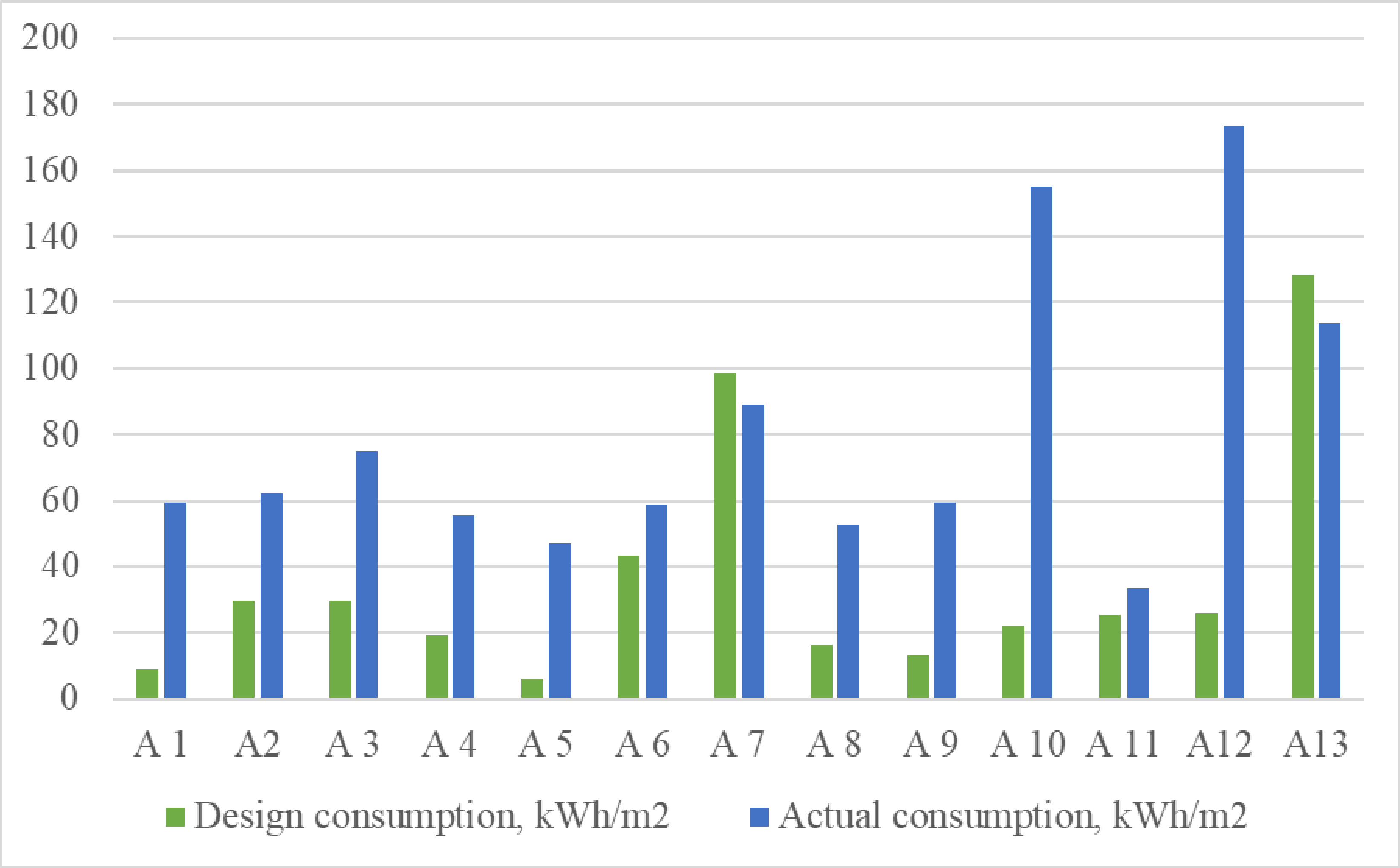
Whole building 2014/15 - Main meter readings (30/11/2015)

Planning target (6/12/2012)

Main meter readings (6/12/2012)

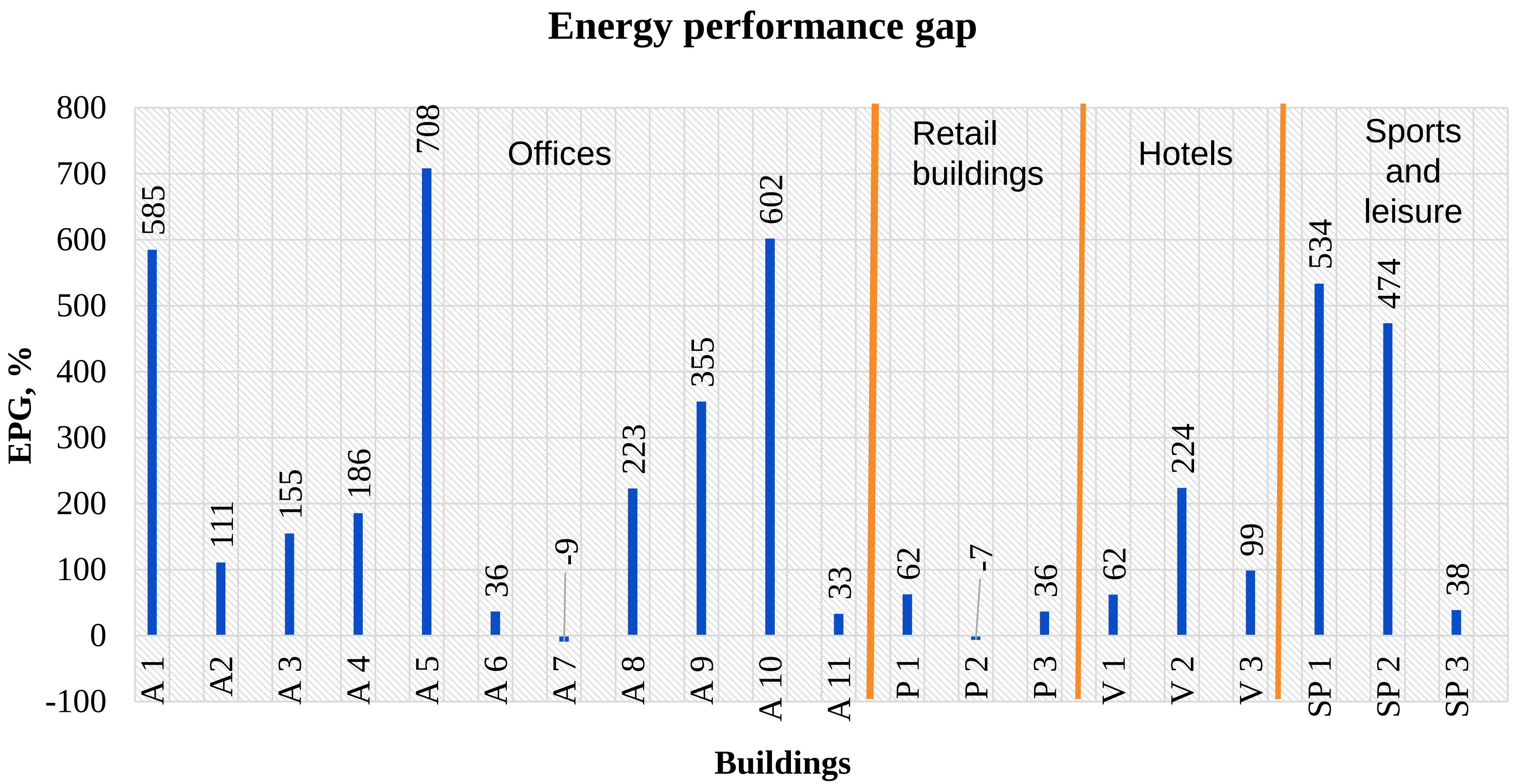


Energy consumption in new offices in Lithuania



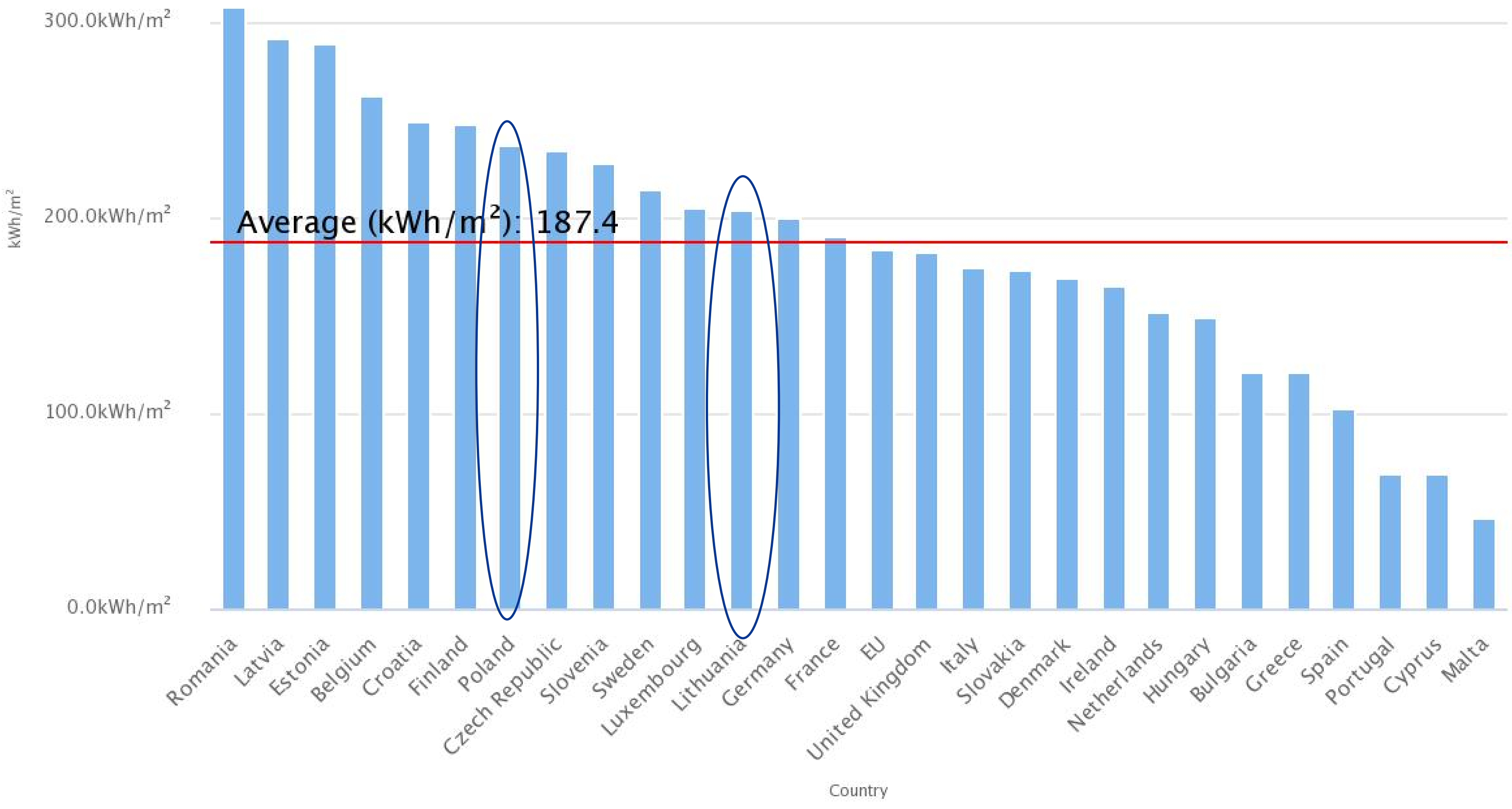
Note: Actual consumption is normalized at standard conditions

Lithuanian non-residential buildings



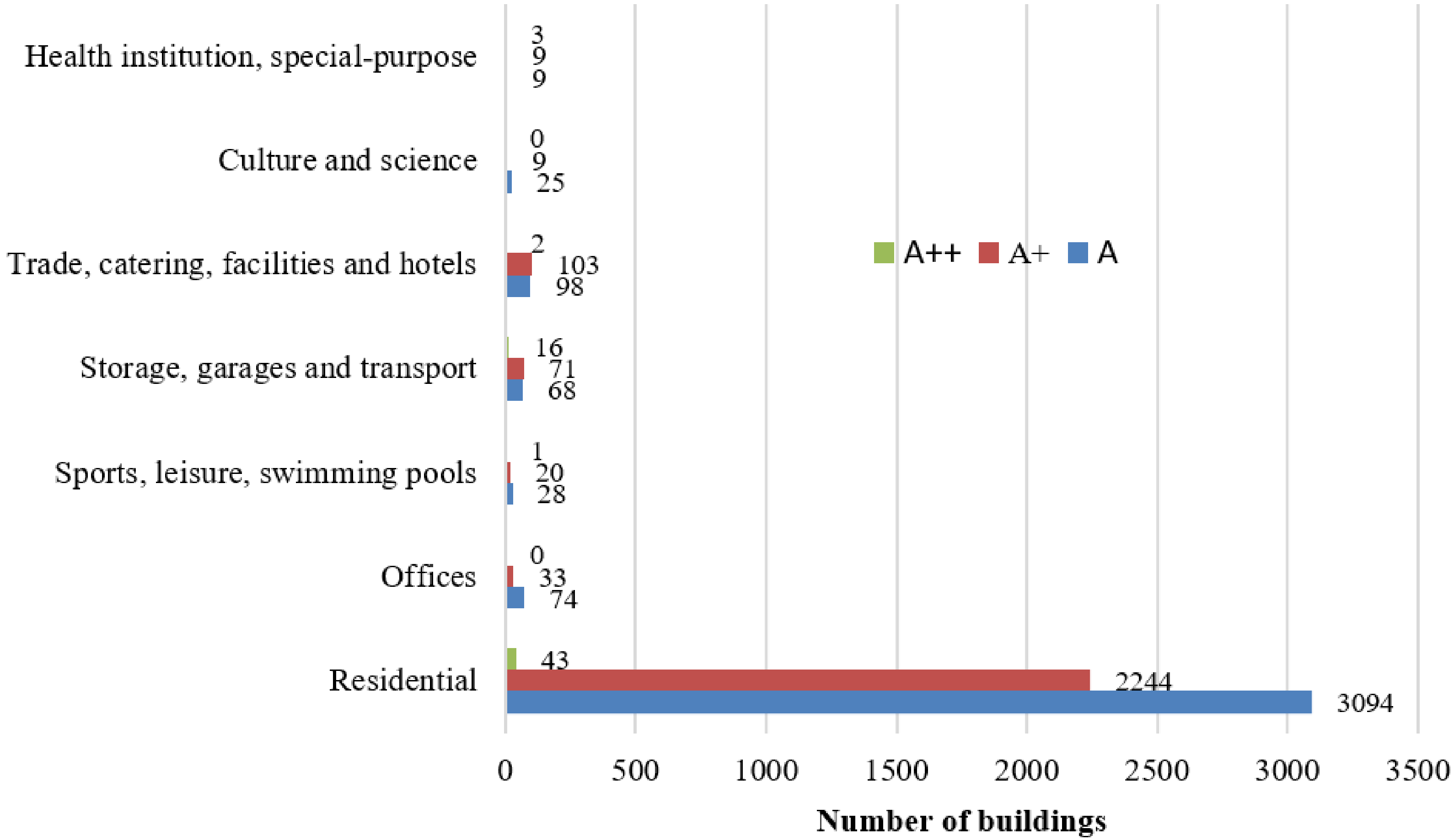
EVIDENCE OF EPG IN RESIDENTIAL BUILDINGS

Energy consumption in residential buildings (standard year)



Source: **EU Buildings Datamapper**

Overall situation in Lithuania in the end of 2020



Source: Motuziene et al. 2021

Annual predicted heating energy demand of different type of Class A buildings (Sample data – 3381)

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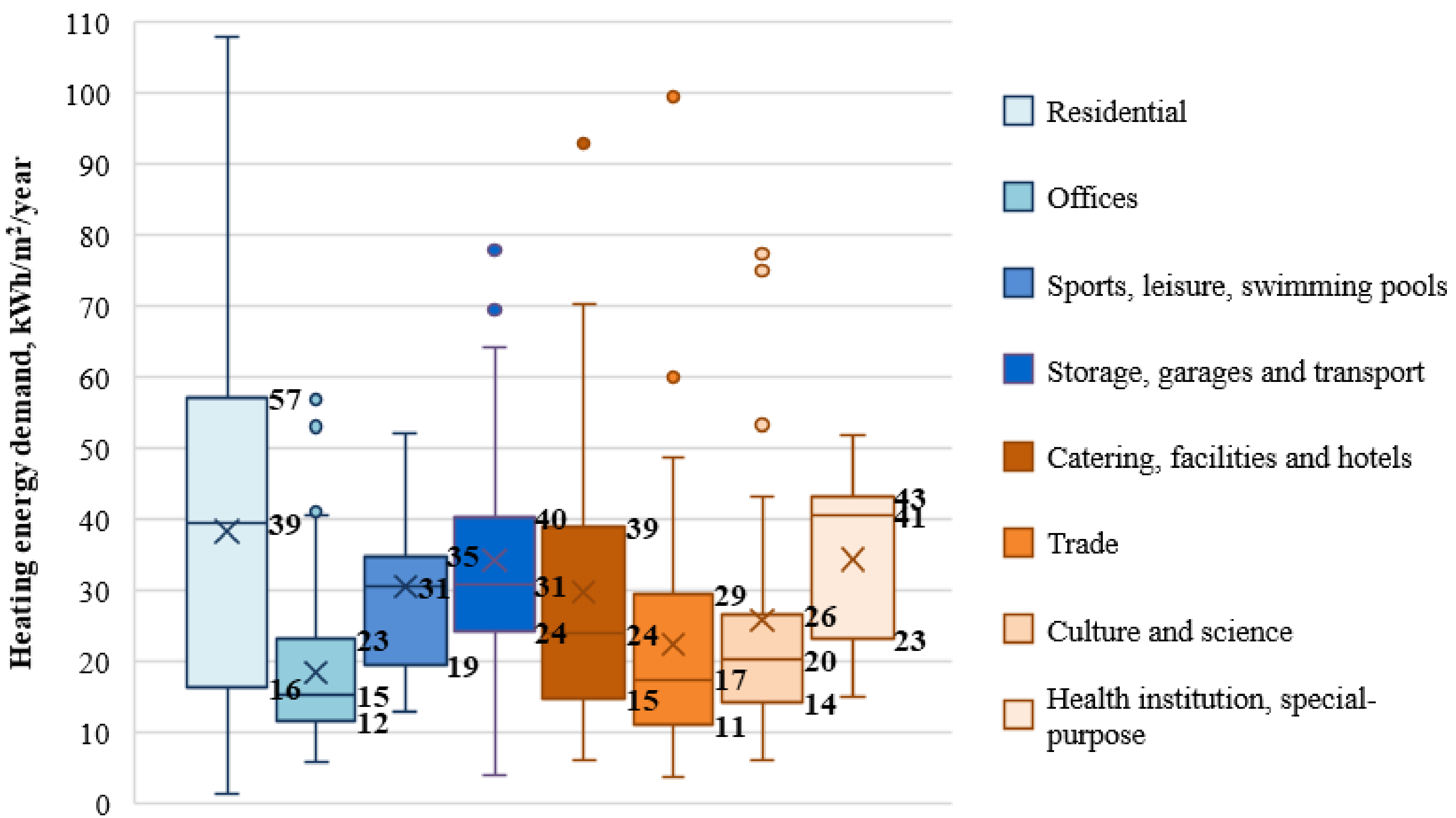
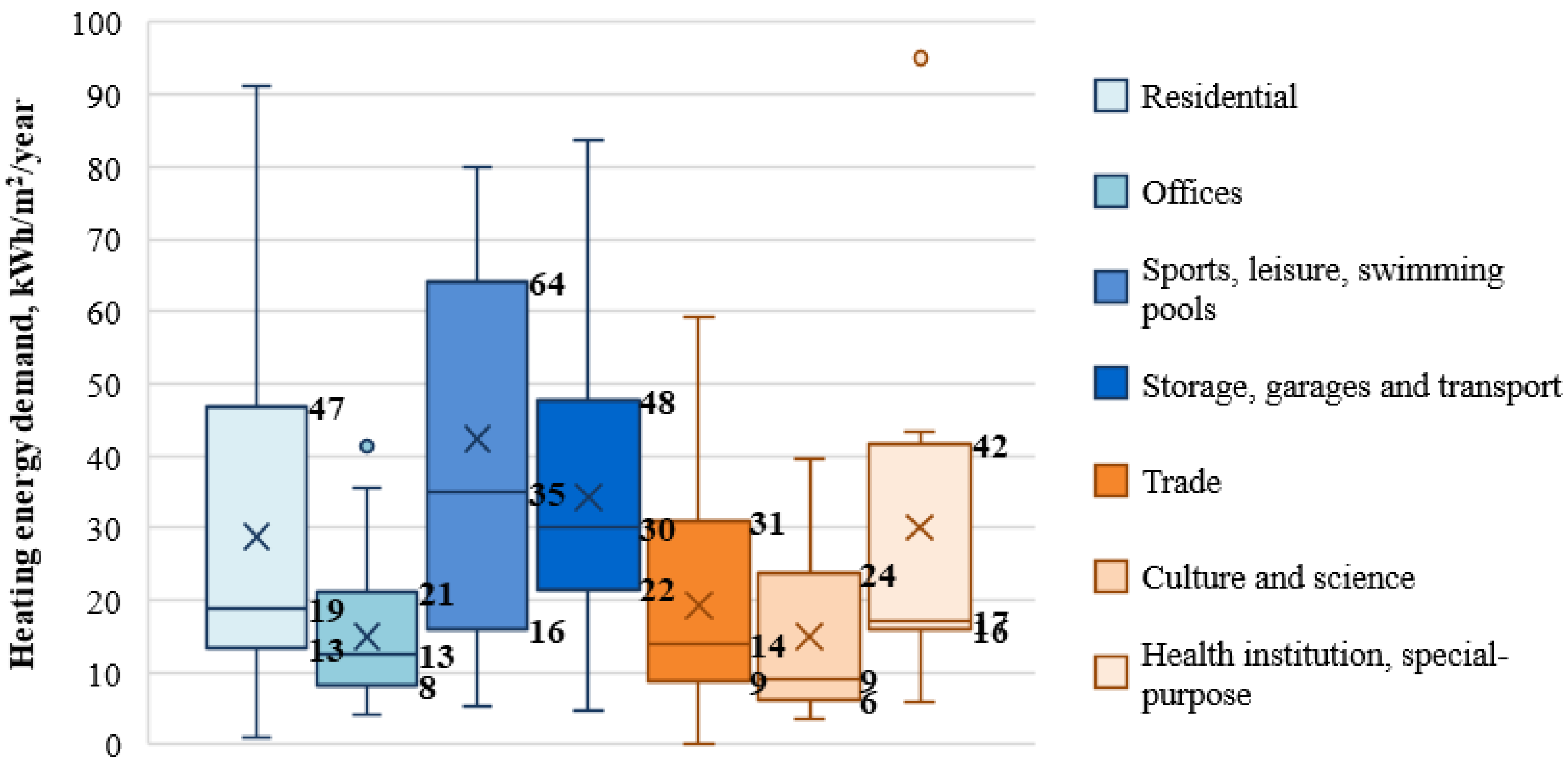


For residential buildings variation of the predicted energy demand is abnormal and variates from 1 to 108 kWh/m², with a median of 39 kWh/m².

Source: Motuziene et al. 2021

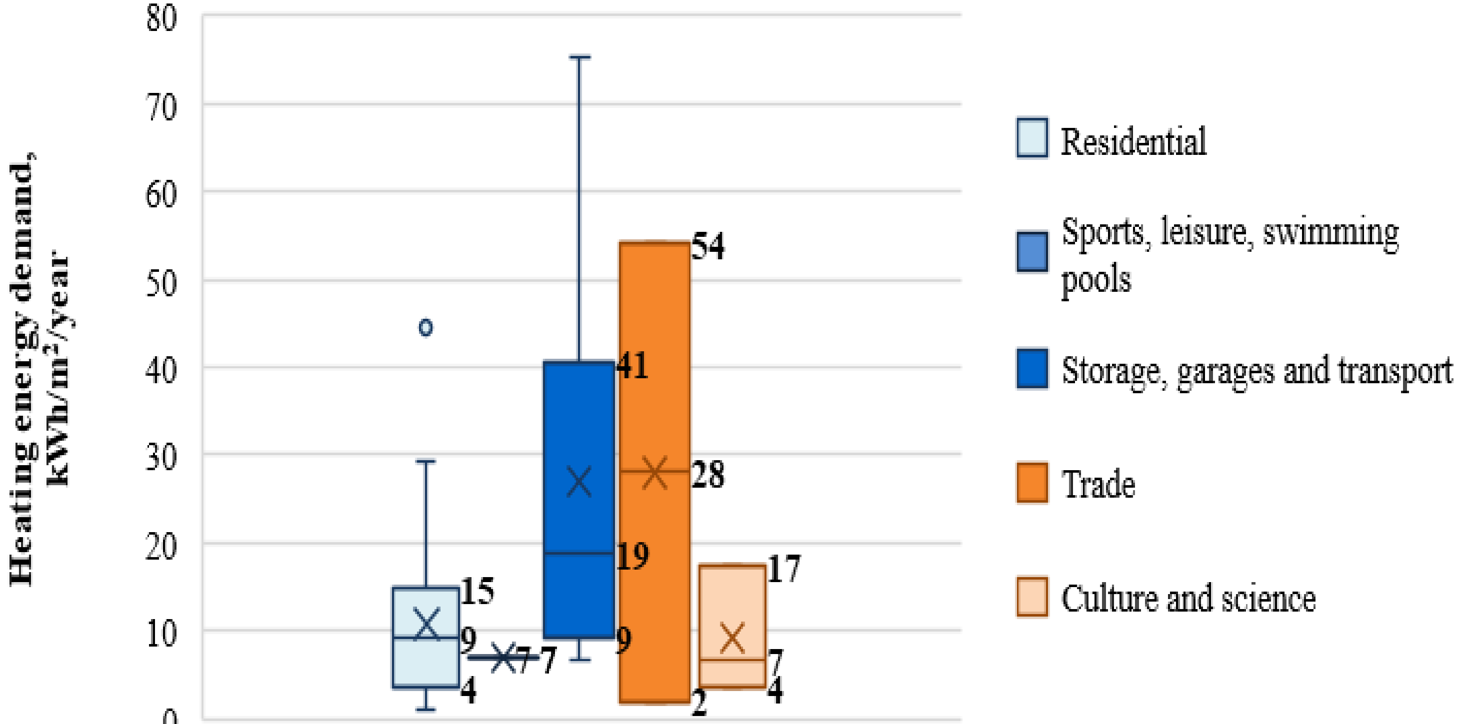
Annual predicted heating energy demand of different type Class A + buildings (Sample data – 2483)



For residential buildings variation of predicted demand is high and very similar to the A buildings – from 1 to 91 kWh/m^2, the median is 19 kWh/m^2

Source: Motuziene et al. 2021

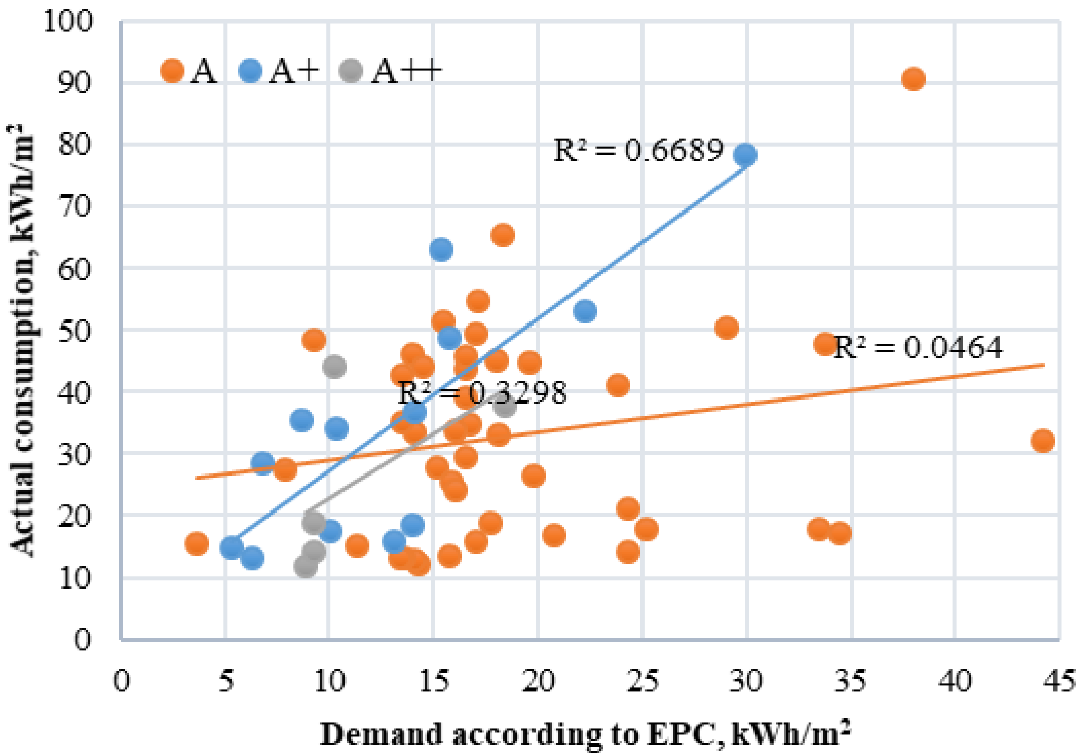
Annual predicted heating energy demand of different type of Class A ++ buildings (Sample data – 61)



For residential buildings variation of the energy demand for heating (1-29 kWh/m²), median value (9 kWh/m²)

Source: Motuziene et al. 2021

Correlation between theoretical and actual heating energy demand



- For Class A the variation of the percentage error is from –101 % to +77 %.
- A+ and A++ variations are within more narrow interval +18-76 % and +23-77 % accordingly.

Source: Motuziene et al. 2021

What are the causes of EPG?

Factors influencing energy consumption	Why the Gaps occure?
(1) Climate (2) Building characteristics (type, size, orientation, etc.) (3) Occupants characteristics, except social and economical (4) Building energy systems and their operation and maintainane **(5) Occupants‘ behaviour** (6) Social and economical occupants‘ charatectirstics (7) Desired IDA quality.	*Design stage* *Construction* *Operation*

What are the causes of EPG? (*more detailed classification*)

Table 2
List of causes for energy performance gap.

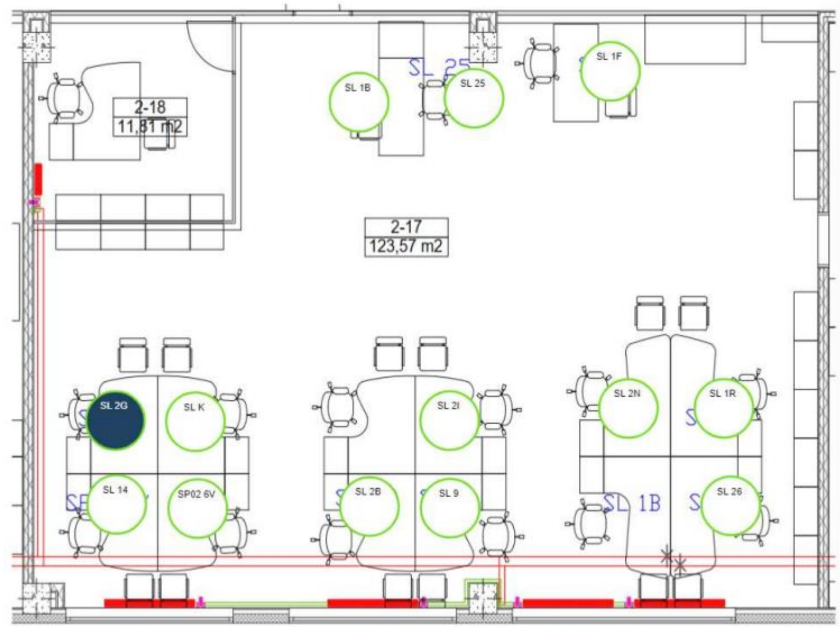
Category	Causes	Description	Ref.
Technical	Modelling tools	• Building energy modelling software can contain fundamental errors embedded in the equations used by the program, leading to inaccuracies in the predictions	[4,31,36,37]
	Failure with energy technologies	• A correct and efficient functioning Building Management System (BMS) is very important • Thermoset and relative humidity setting in different seasons affected the actual building performance a lot	[4,30,37,38]
	Appliances	• More equipment were added into the building	[4,37]
	Operational schedules	• Operational hours were longer than designed	[4,37]
Social	Project vision	• Poor boundary definition and design assumptions • Decisions were influenced by learning garnered from previous successful buildings (rating, awards, effective marketing), rather than verified performance in practice • Poor definition of performance objectives in design briefs • Conflict between energy and IEQ objectives	[31,36,39,40]
	Facility management	• Facilities managers lacked of skill set to operate the building well; • Operators not involved early in the process, sequences of operation not aligned with design intent, and information not accessible, interpretable and actionable • Faults often occurred and remained invisible • Control manual was usually very complex and difficult to understand	[4,24,31,36,37,39,40]
	Occupancy behavior	• Occupancy behavior varies significantly • Occupancy behavioral parameters were not well known specially at design stage • Occupancy used more energy and more occupancy were added in during operation	[30,31,37,40]
	Commissioning	• Individual components commissioned instead of entire systems • Problems were often undetected or unresolved	[4,36,39]
	Communication and alignment	• Misaligned incentives, difficulties of communication, lack of feedback processes, boundaries of responsibility not defined	[24,39,41]
	Isolated knowledge island	• Designers, engineers, operators had different knowledge background and it was difficult for them to transfer their own knowledge	[4,36,40]
	Procurement process	• Insufficient information passed from design to construction	[36,40]
	Stakeholder engagement	• Weak working relationships between the key external and internal stakeholders.	[24,39]

Source: Wu et al., 2020

PerfoGap project results: Monitoring

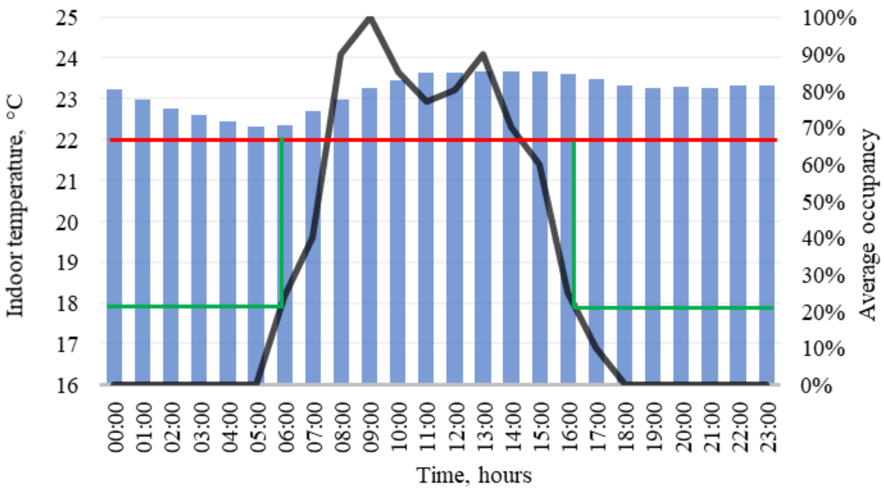
Monitoring process of open offices

Design: 43 kWh/m2
Actual: 59 kWh/m2

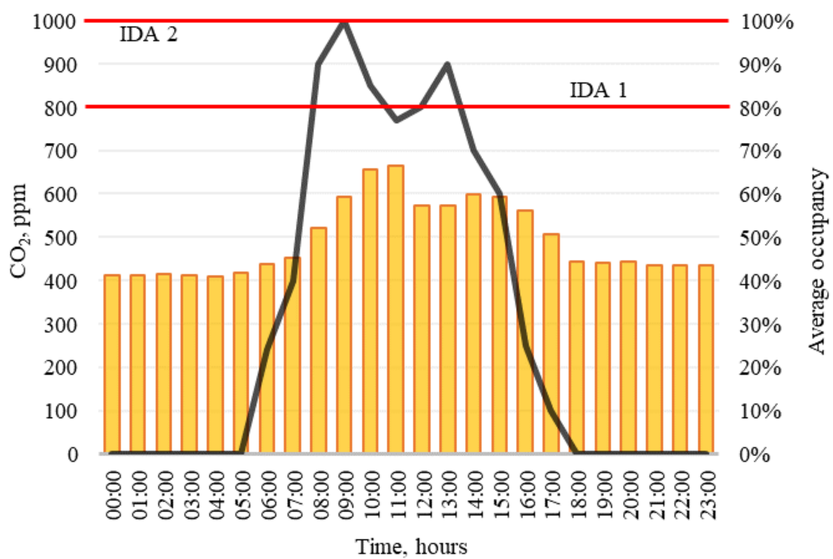


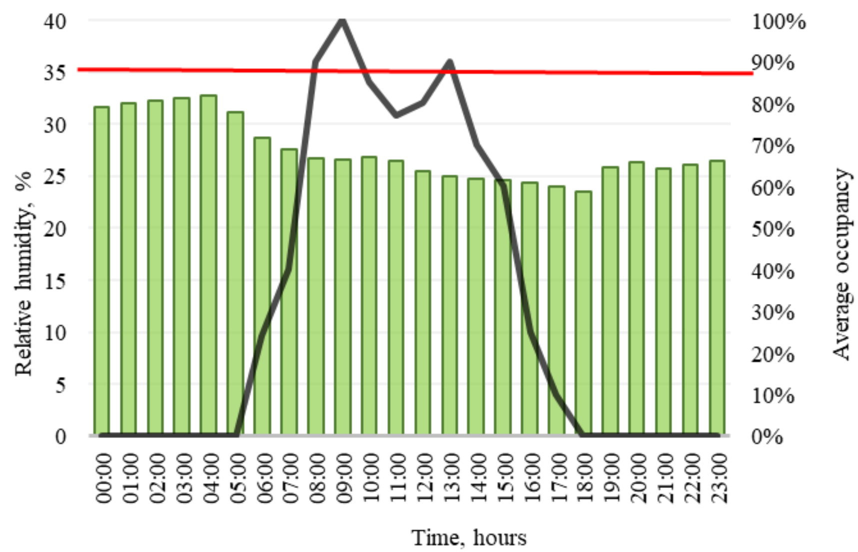
- Measured parameters:
- CO_2 (every 5 min.)
- Temperature, humidity, air velocity
- Occupancy
- VOC‘s

Potential for savings

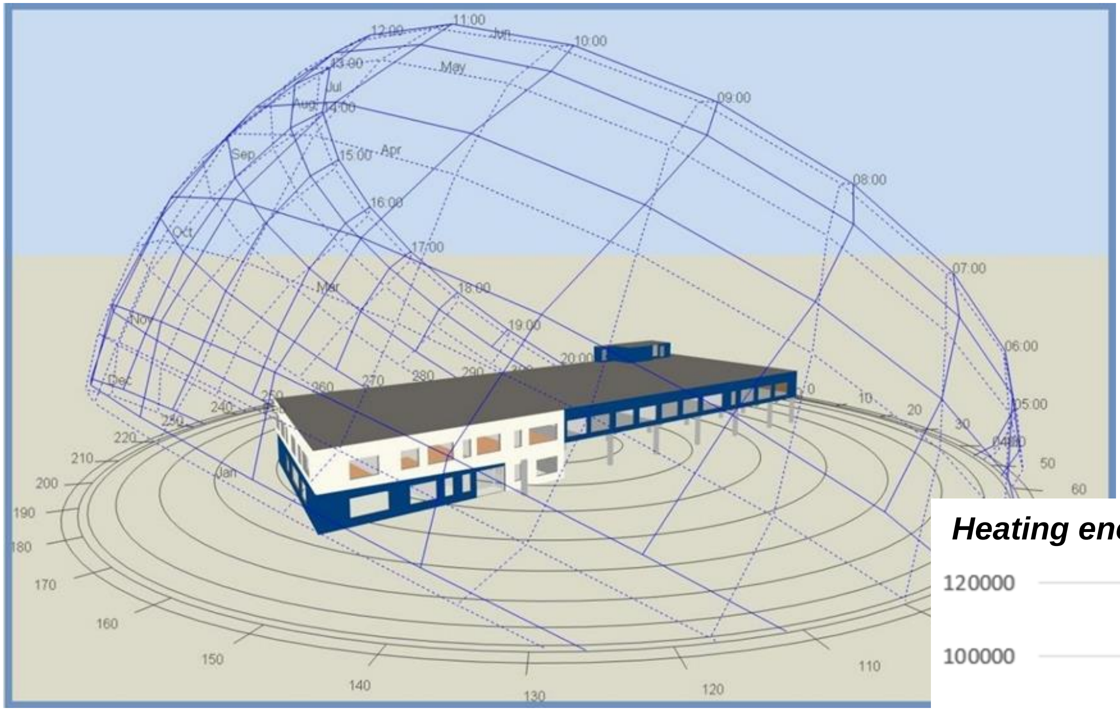


- *Typical indoor comfort in winter in the office shows that control of temperature and ventilation is not sufficiently controlled and not corresponding to the demand;*
- *Similar situation is found in other monitored offices proving that there is a tendency*

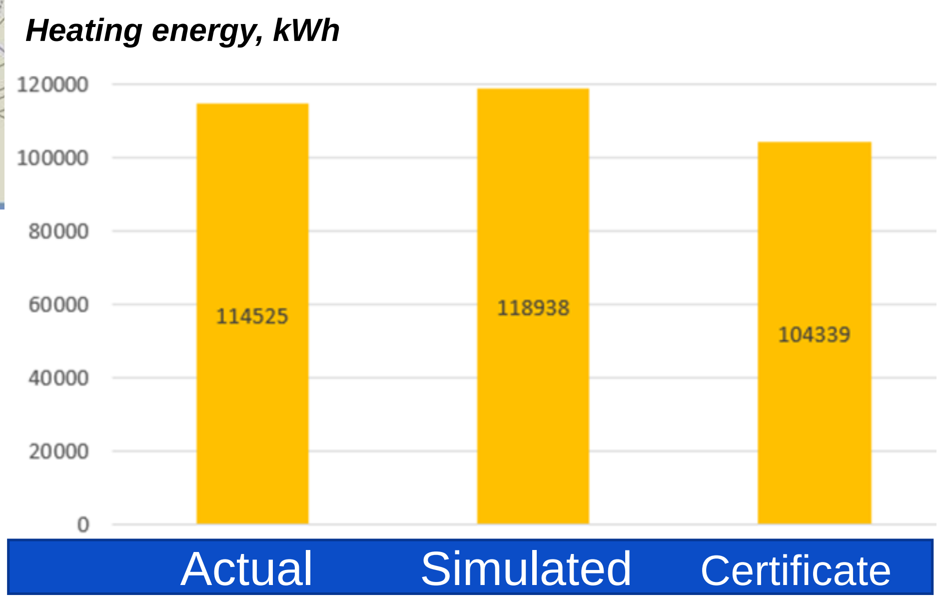




Assessment of the saving potential through simulation

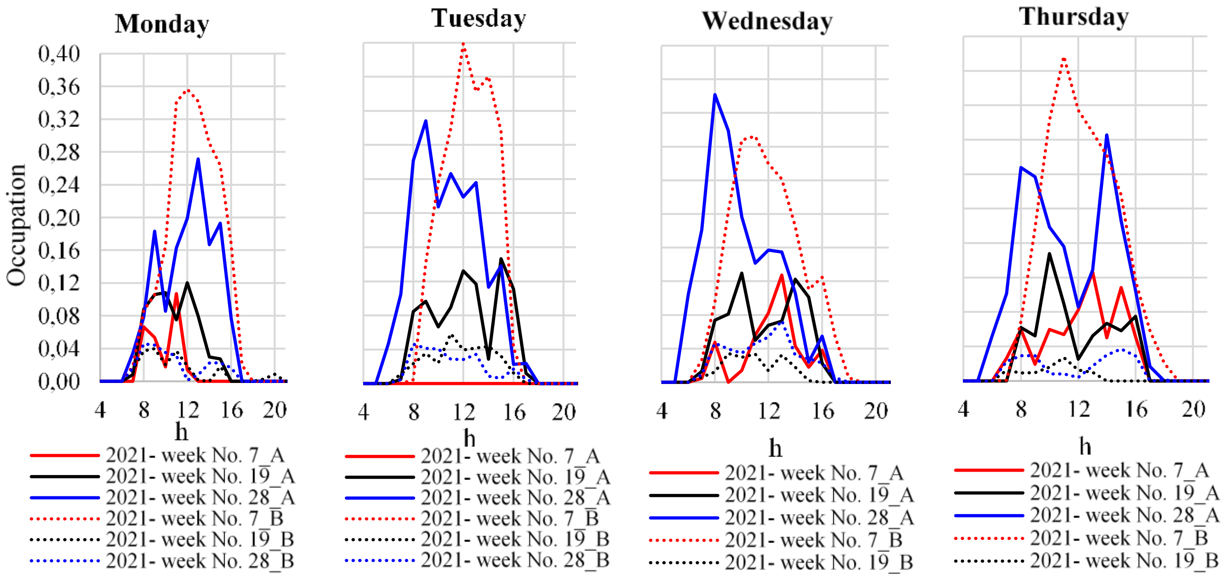


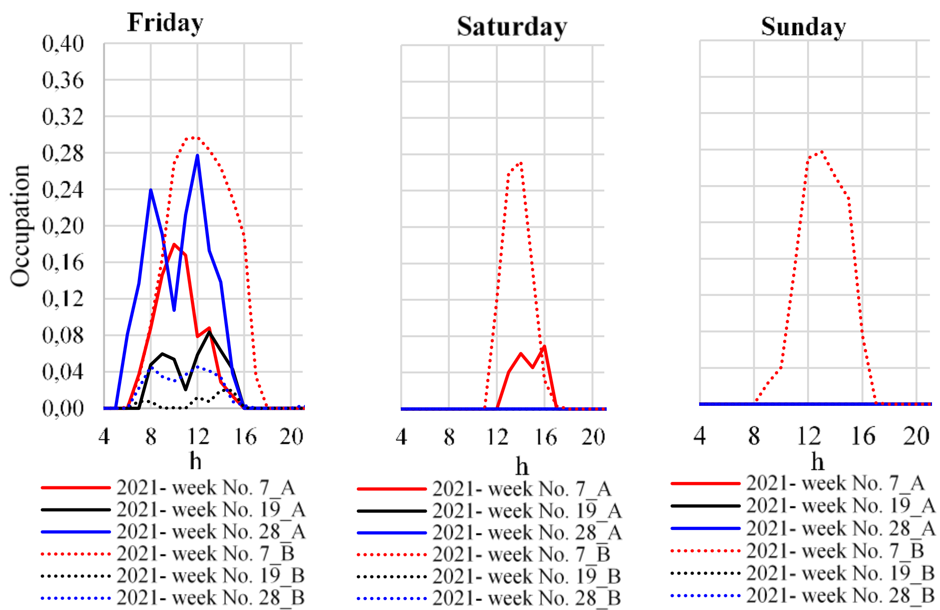
Model calibration



Optimised schedules of the heating and ventilation systems enable to save at least 20 % of heating energy.

Measured occupancies for separate weekdays





Occupancies provided in:

- ASHRAE 90.1 (peak occupancy fraction **0.9**)
- EN 16798-1 (maximum occupancy fraction **0.7**)

Real occupancies in open offices are much lower than design values!!!

Source: Motuzienė et al. 2022

Occupancy density frequencies for separate pandemic periods

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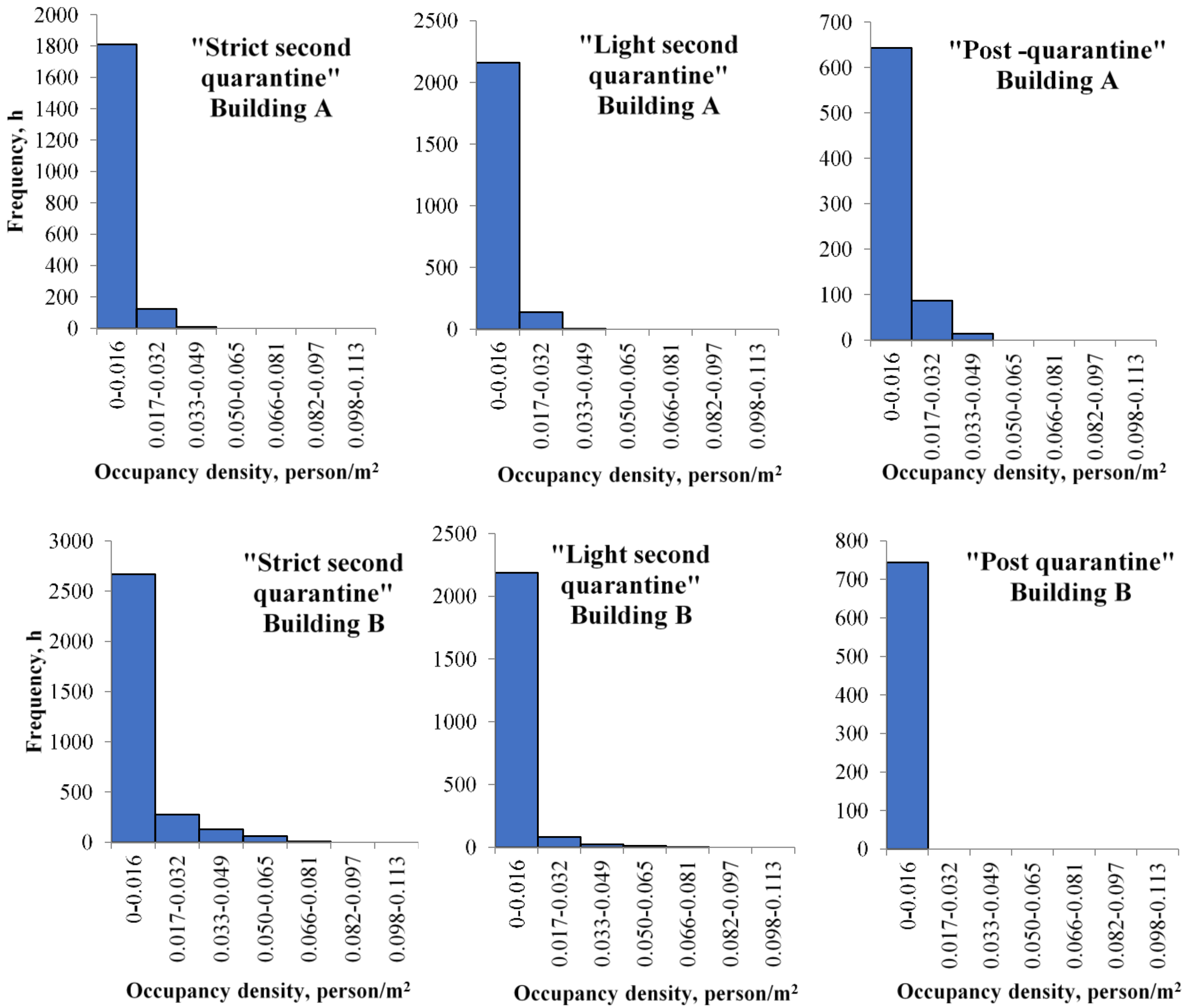


The density of persons in offices is strongly overestimated and it has a tendency to decrease in the future.

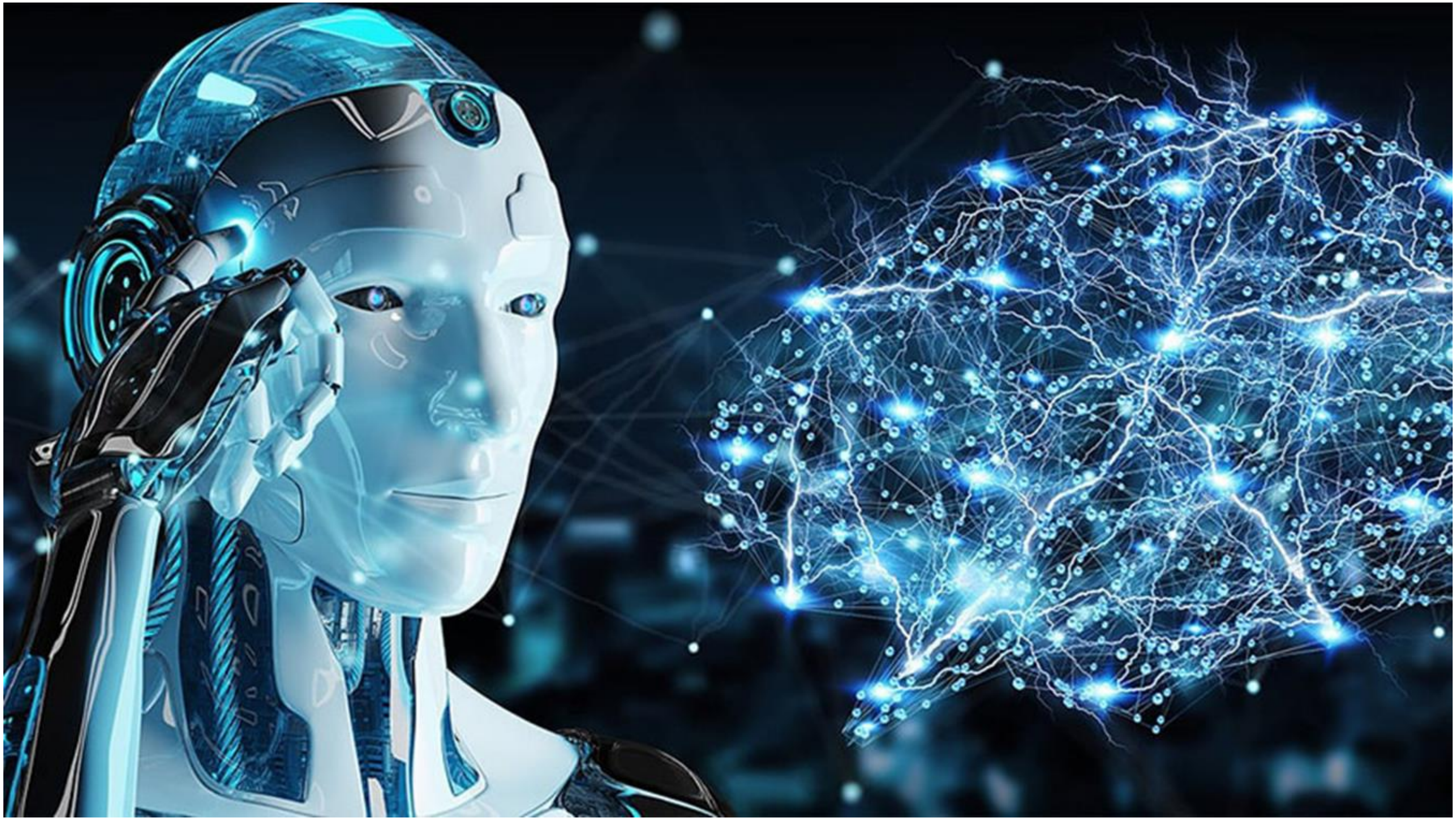
In DesignBuilder simulation software for open-office buildings – **0.11 persons/m2**, in Lithuanian standard for Buildings energy performance assessment (STR 2.01.02:2016) proposes one common value for all types of offices – **0.05 persons/m2**

Source: Motuzienė et al. 2022

What can be done?

- Predict better
- Construct better
- Operate and maintain better
- Make buildings smarter and better controlled...

... and use Artificial Intelligence

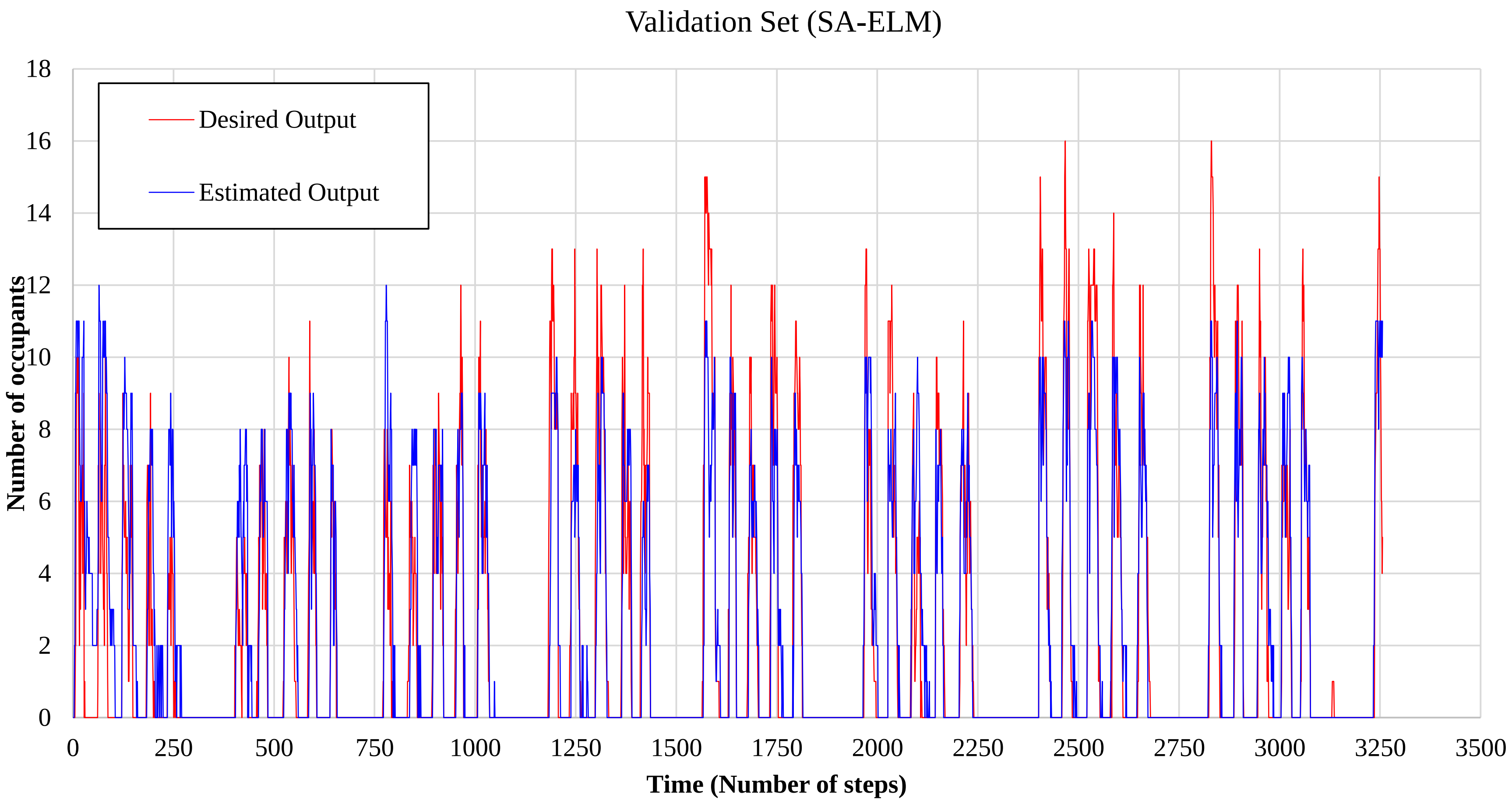


PerfoGap project results: Prediction models

Occupancy prediction modelling for better control of the energy using systems

- **Buildings' occupancy is** one of the **important** factors causing the energy performance and sustainability gap in buildings.
- **Better occupancy prediction** decreases this gap both in the design stage and in the use phase of the building.
- **Machine learning-based models** proved to be very accurate and fast for occupancy prediction when buildings are exploited under normal conditions.

Validation example of Extreme Learning Machine (ELM) models



Source: Motuzienė et al. 2022

Model validation for SA-ELM

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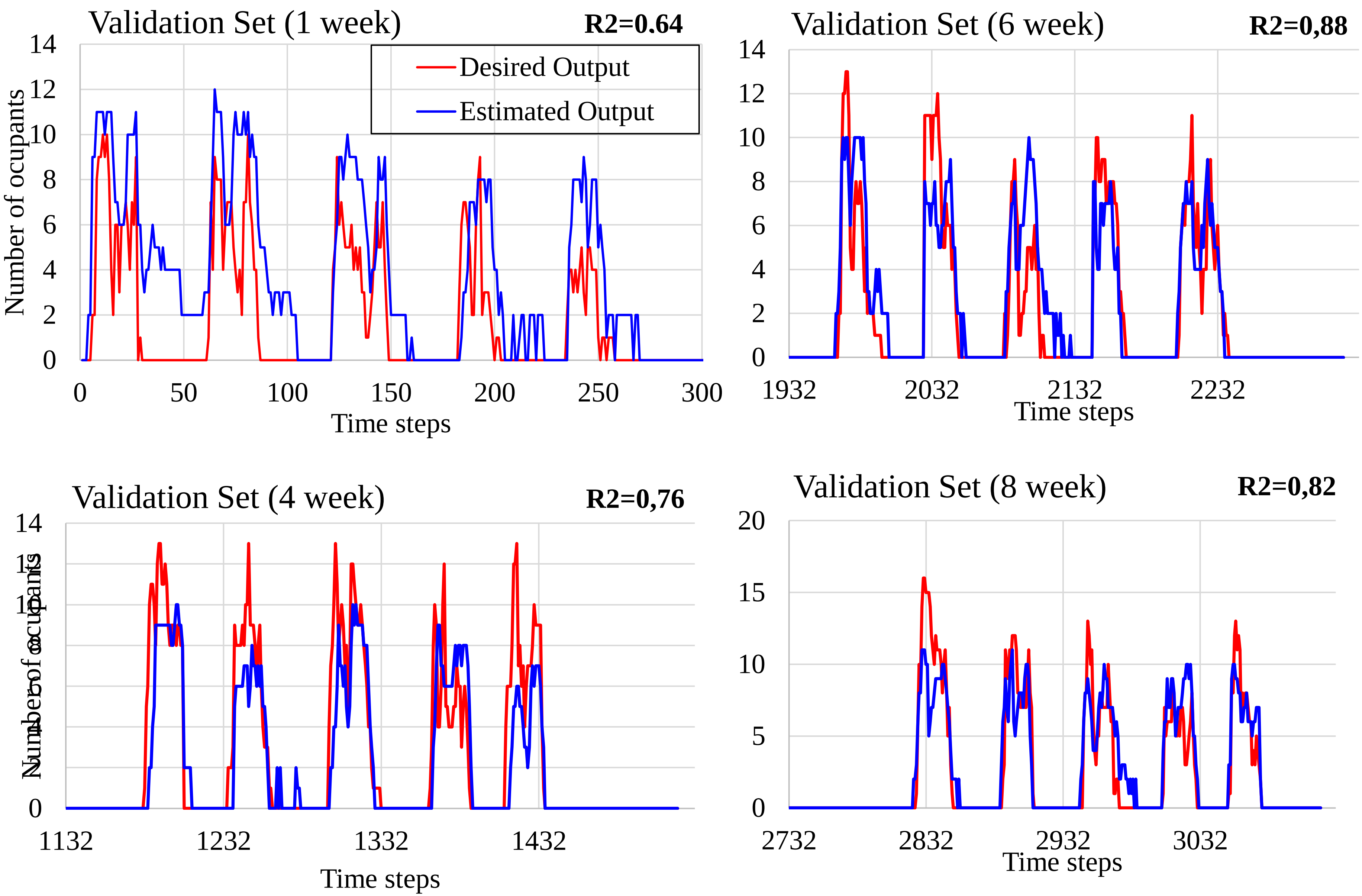

Contacts

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