Potential on comfort enhancement and energy saving through behavioural change of energy users in real European buildings.

End-users behaviours & performance models Paper Session

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INTRODUCTION

RATIONALE

- Buildings account for 40% of overall energy consumption in the European Union
- Energy related to occupant behaviour is identified as one of the major factors influencing building energy consumption

OBJECTIVE

- Several European buildings such as schools, office buildings, health care centres and residential buildings have been studied to quantify the potential on comfort enhancement and energy saving through behavioural change of building users towards energy efficiency.
- The most promising users´ behaviours changes in terms of energy saving and comfort enhancement have been identified.

eTEACHER PROJECT (H2020; 2017-2021)

- Develop ICT solutions to change energy behaviour of buildings users towards energy efficiency

METHODOLOGY

EXPERIMENT DESIGN

- **10 buildings** have been intensively **monitored** during 8 months (February - September 2019)
- **Measurements** collected at building and room/apartment level:
  - Energy consumption: HVAC, appliances and lighting
  - Indoor conditions: temperature, CO_2, lighting level, relative humidity
  - Outdoor conditions: temperature, solar radiation, relative humidity
  - Other parameters such as occupancy or windows opening have been collected.

METHODOLOGY

PILOT BUILDINGS

Schools


Residential buildings

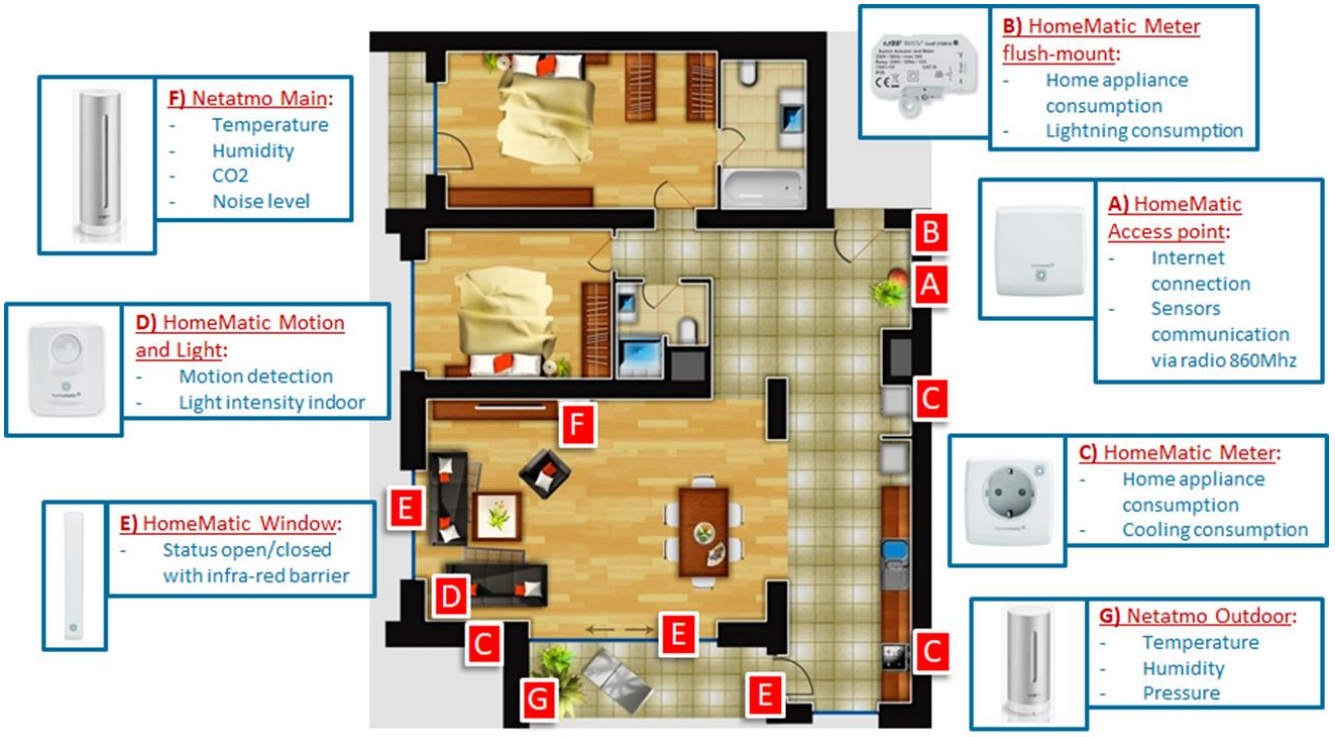

Office

Health Care Centres


EXPERIMENT DESIGN

Monitoring technology:

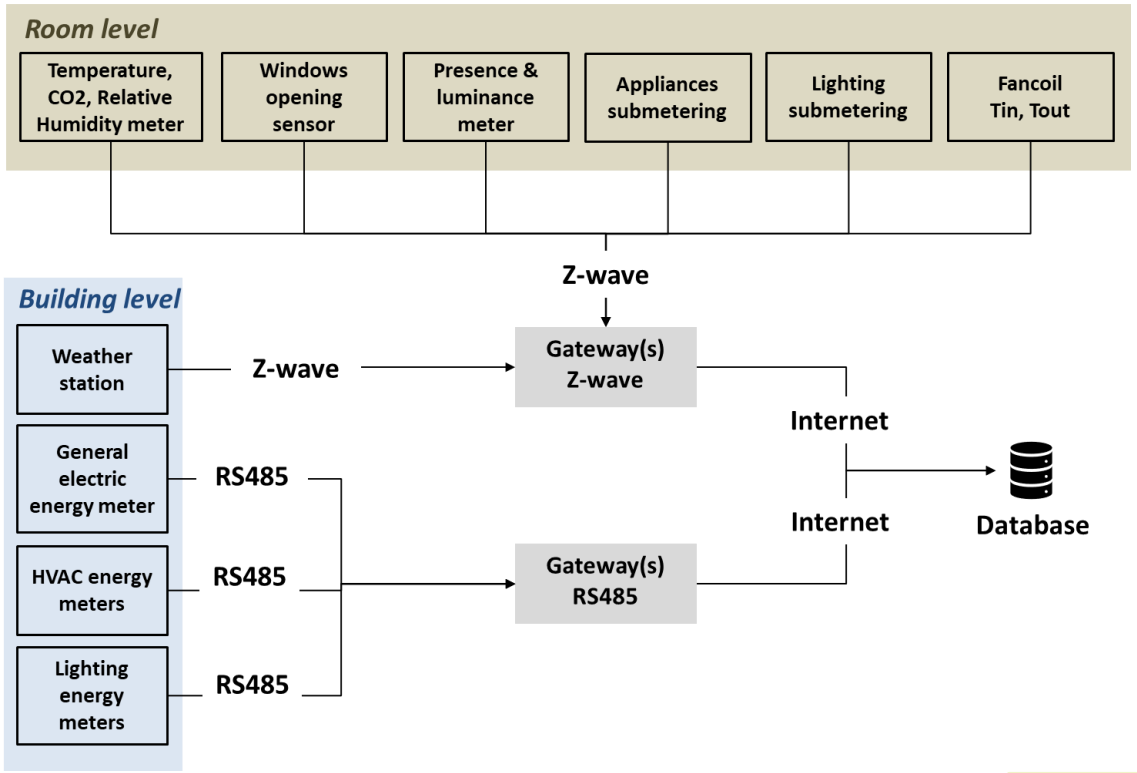
Example at apartment level (HomeMatic & Netatmo)



EXPERIMENT DESIGN

Monitoring technology:

Example room/building level (zwave &)



METHODOLOGY

COMFORT ANALYSIS TO QUANTIFY ENHANCEMENT POTENTIAL

Focus & thresholds

- Indoor Temperature: 21-26 ºC
- Indoor Relative Humidity: 40-60%
- Indoor Luminance: ≥500 luxes (≥150 luxes in residential buildings)
- Indoor CO2 level: ≤ 800 ppm

Potential to enhance comfort

Number of hours where the rooms/zones are occupied and these variables are out of the thresholds where comfort is guaranteed.

METHODOLOGY

TARGET BEHAVIOUR ANALYSIS TO QUANTIFY ENERGY SAVING POTENTIAL

Target behaviours:

Use of lights

- TB1: Turning off lights when leaving a room or at the end of the day
- TB2: Reduce use of unneeded lights checking lighting levels and needs during the day

Use of appliances

- TB3: Turn off appliances at the end of the day
- TB4: Appliances off when away from room for 1 hour or more.

Use of HVAC

- TB5: Reducing thermostat temperature for heating when overheating
- TB6: Increasing thermostat temperature for cooling when undercooling
- TB7: Ensuring that if heating/cooling is on, windows and doors are kept closed
- TB8: Turn off HVAC system if room/building is not in use for more than one hour
- TB9: Ensuring that air-conditioning and heating are not working at the same time

METHODOLOGY

TARGET BEHAVIOUR ANALYSIS TO QUANTIFY ENERGY SAVING POTENTIAL

Energy Saving Potential (based on monitoring data)

- Number of hours (h) that these target behaviours are not carried out by the users of the buildings before eTEACHER is deployed
- Energy (kWh) wasted during those hours
- Cost of the energy wasted during those hours (€).

Example TB1:

Turning off lights when leaving a room or at the end of the day

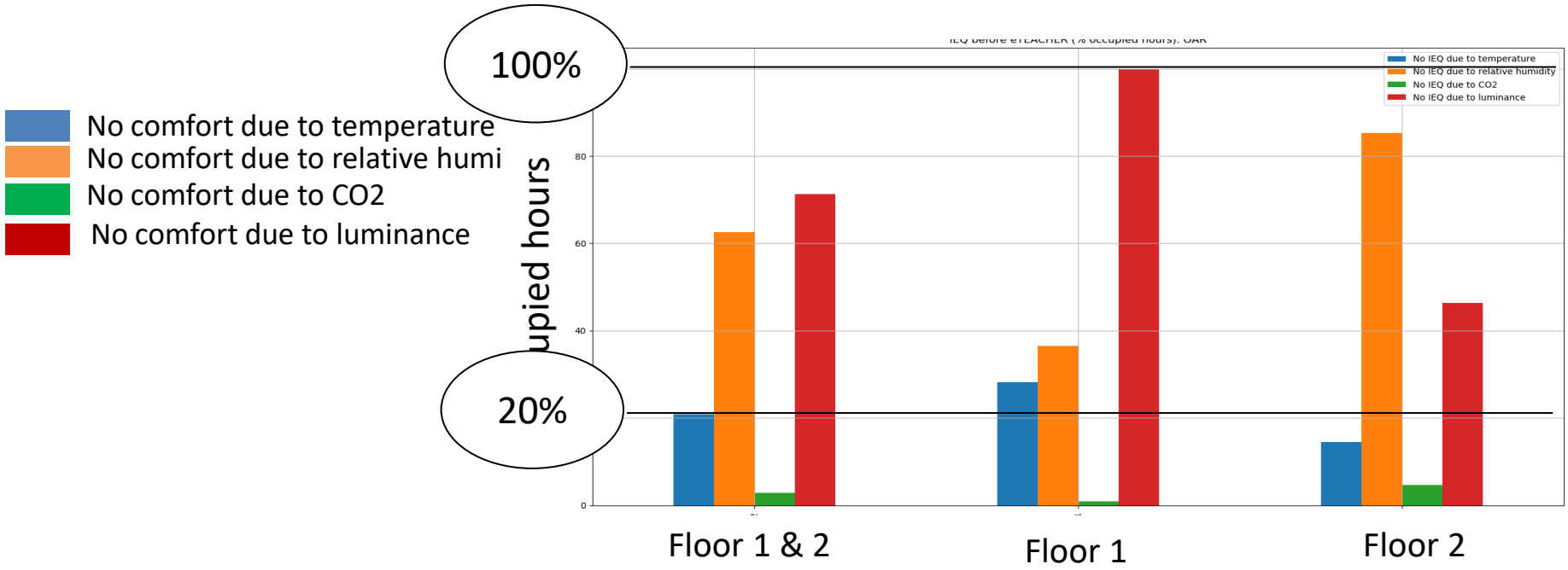
- *Count number of hours in every monitoring room that there is no one and the lights are on: Presence=0 & C_lighting > 0 kWh*
- *Lighting energy consumed during those hours :* $\sum C\_Lighting$*(kWh)*
- *Cost of that energy:* $\sum C\_Lighting$ *kWh x 0.129893 €/kWh)*

RESULTS

COMFORT ANALYSIS TO QUANTIFY ENHANCEMENT POTENTIAL

Office Building (Spain)

- Lighting level: about 70% of the occupied hours out of range
- Relative Humidity: 60% of the occupied hours out of the range

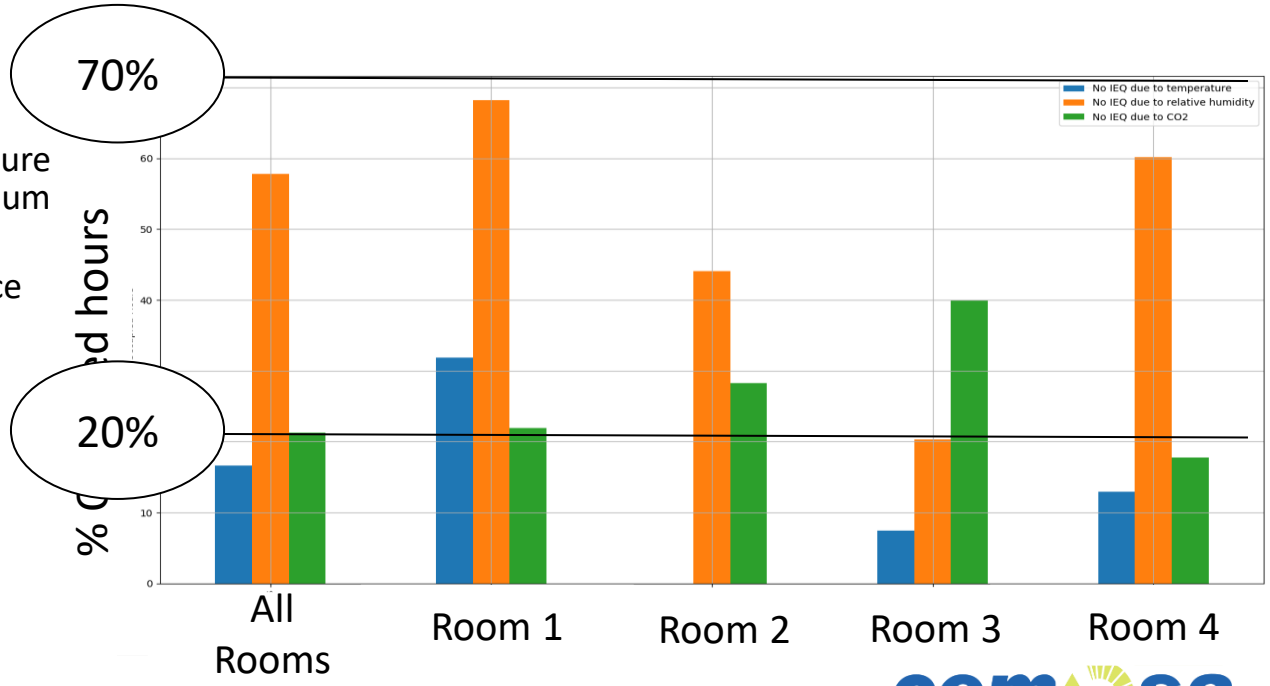


COMFORT ANALYSIS TO QUANTIFY ENHANCEMENT POTENTIAL

Health Care Centre 2 (Spain)

- Relative Humidity: almost 60% of the occupied hours out of the range
- CO2: Only some specific rooms have problems

No comfort due to temperature
No comfort due to relative hum
No comfort due to CO2
No comfort due to luminance



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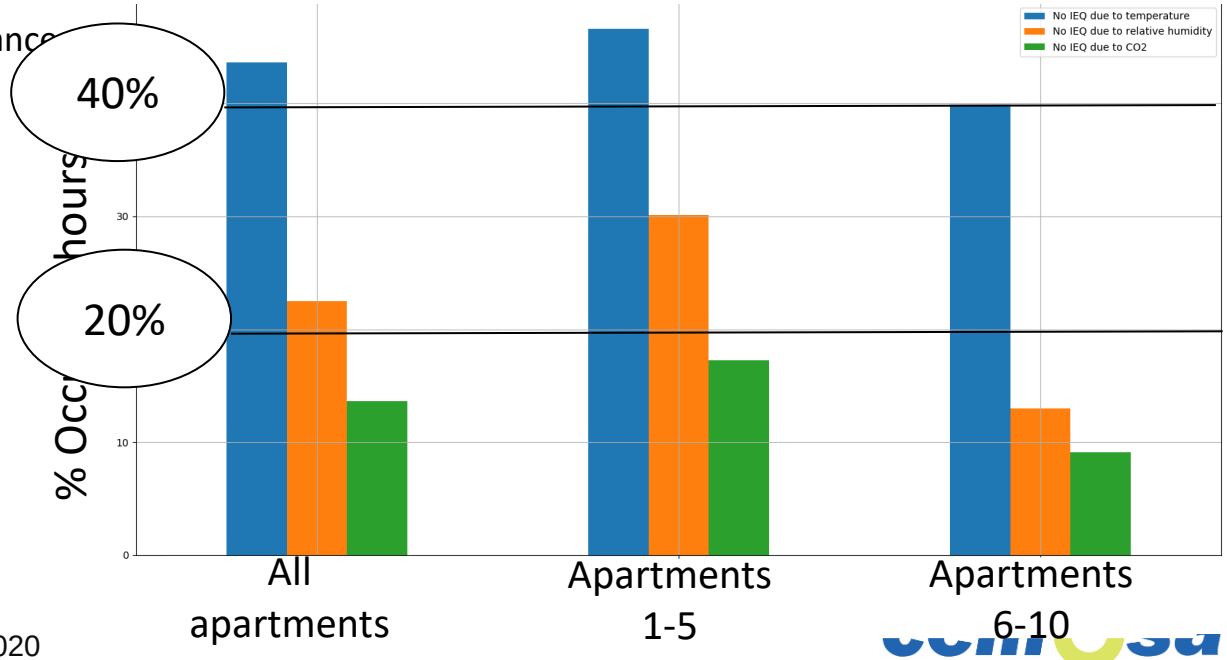
COMFORT ANALYSIS TO QUANTIFY ENHANCEMENT POTENTIAL

Residential buildings 2 (Romanian)

- Temperature: more than 40% of the occupied hours out of the range

No comfort due to temperature
No comfort due to relative humidity
No comfort due to CO2
No comfort due to luminance

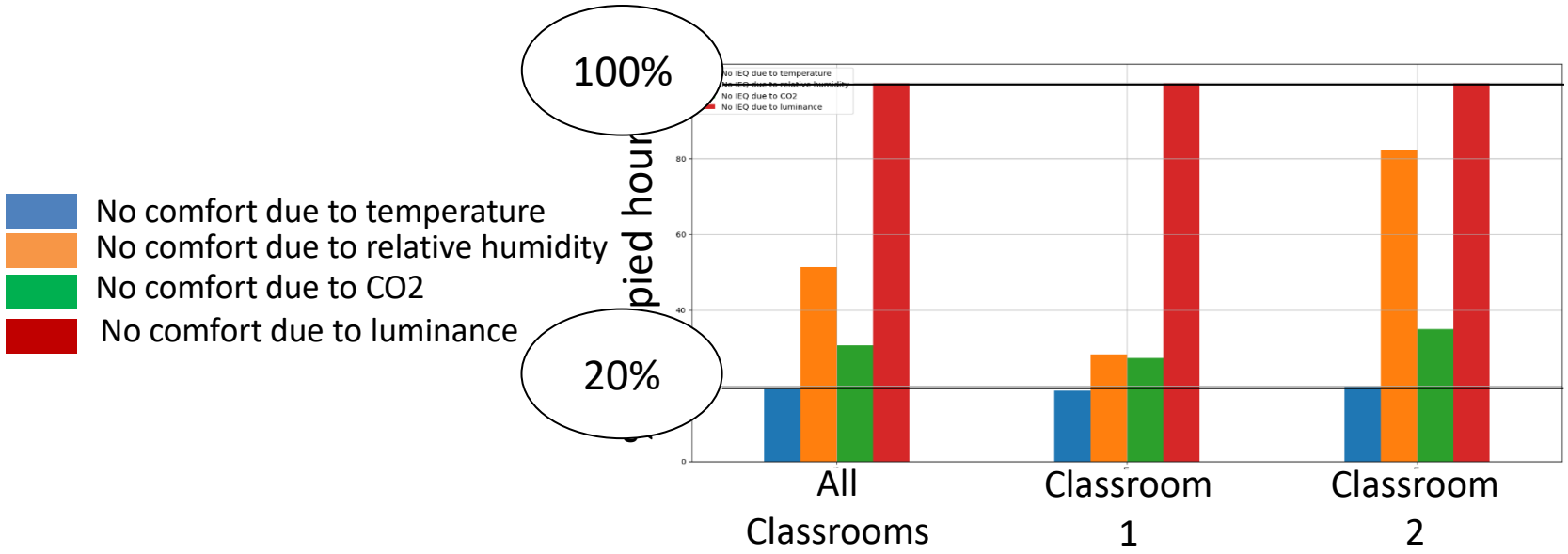


RESULTS

COMFORT ANALYSIS TO QUANTIFY ENHANCEMENT POTENTIAL

School 2 (Spain)

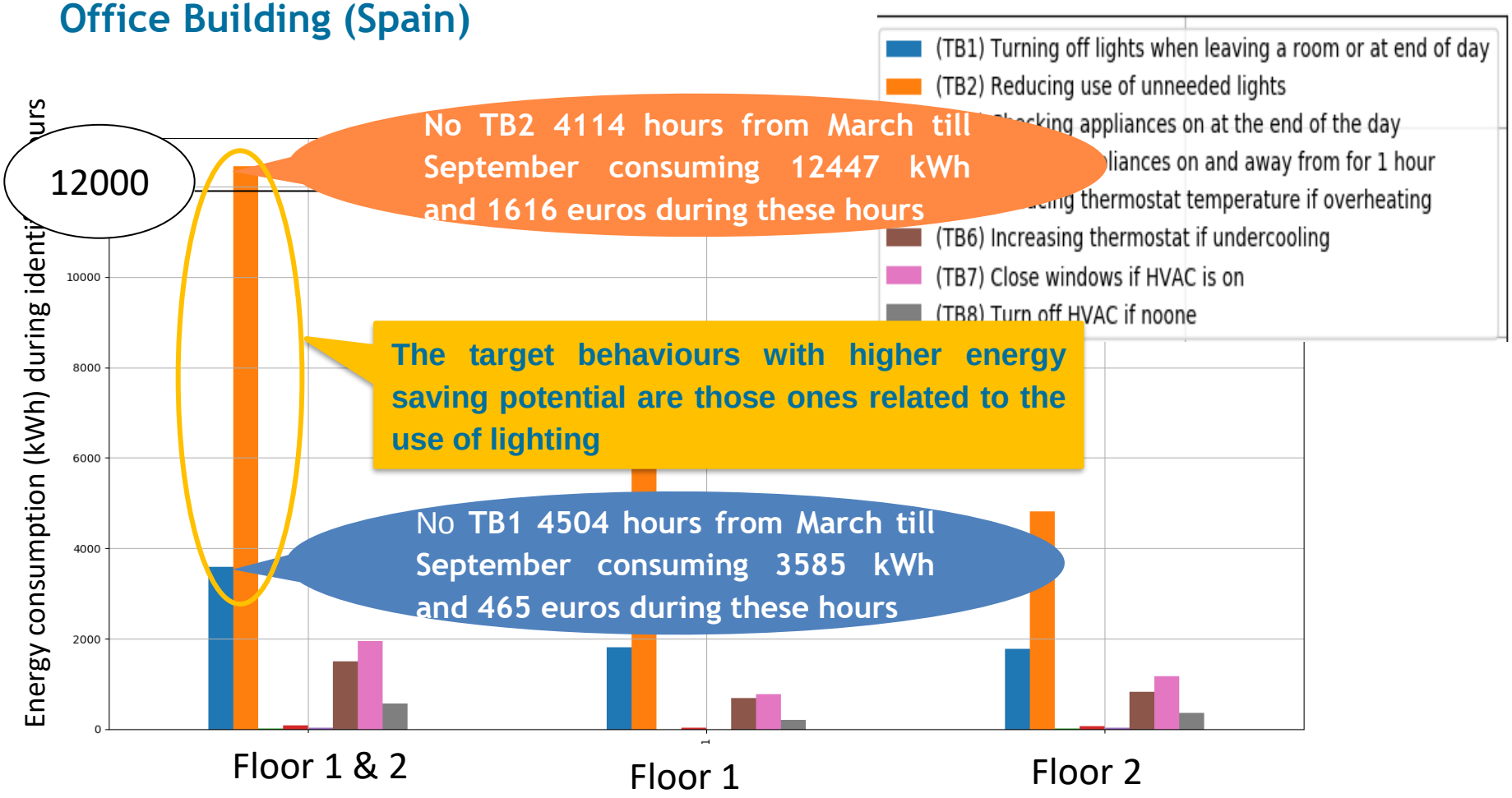
- Luminance: almost 100% of the occupied hours out of the range
- Relative Humidity: more than 50% of the occupied hours out of the range
- CO_2: about 30% of the occupied hours out of the range



RESULTS

TARGET BEHAVIOUR ANALYSIS TO QUANTIFY ENERGY SAVING POTENTIAL

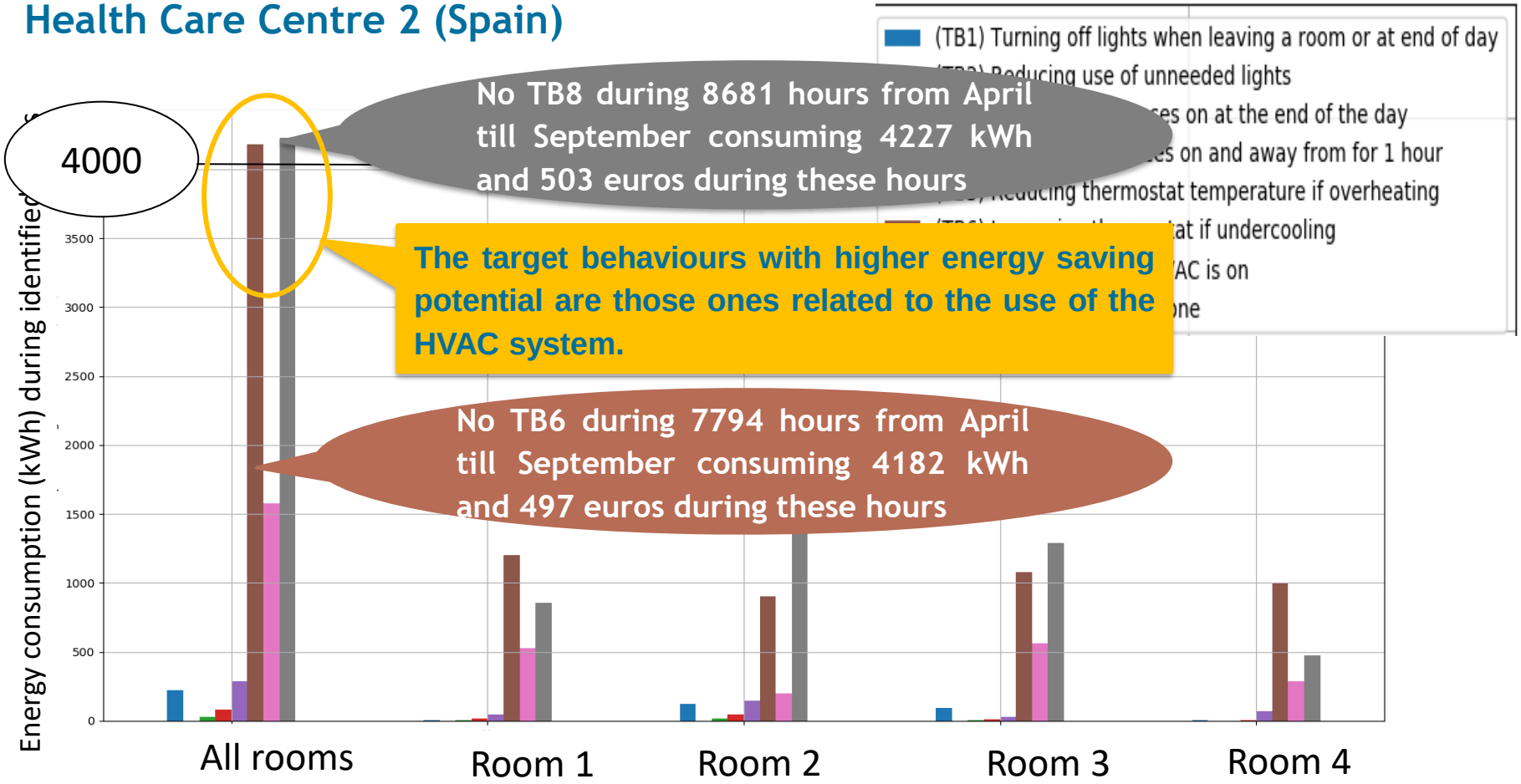
Office Building (Spain)



RESULTS

TARGET BEHAVIOUR ANALYSIS TO QUANTIFY ENERGY SAVING POTENTIAL

Health Care Centre 2 (Spain)

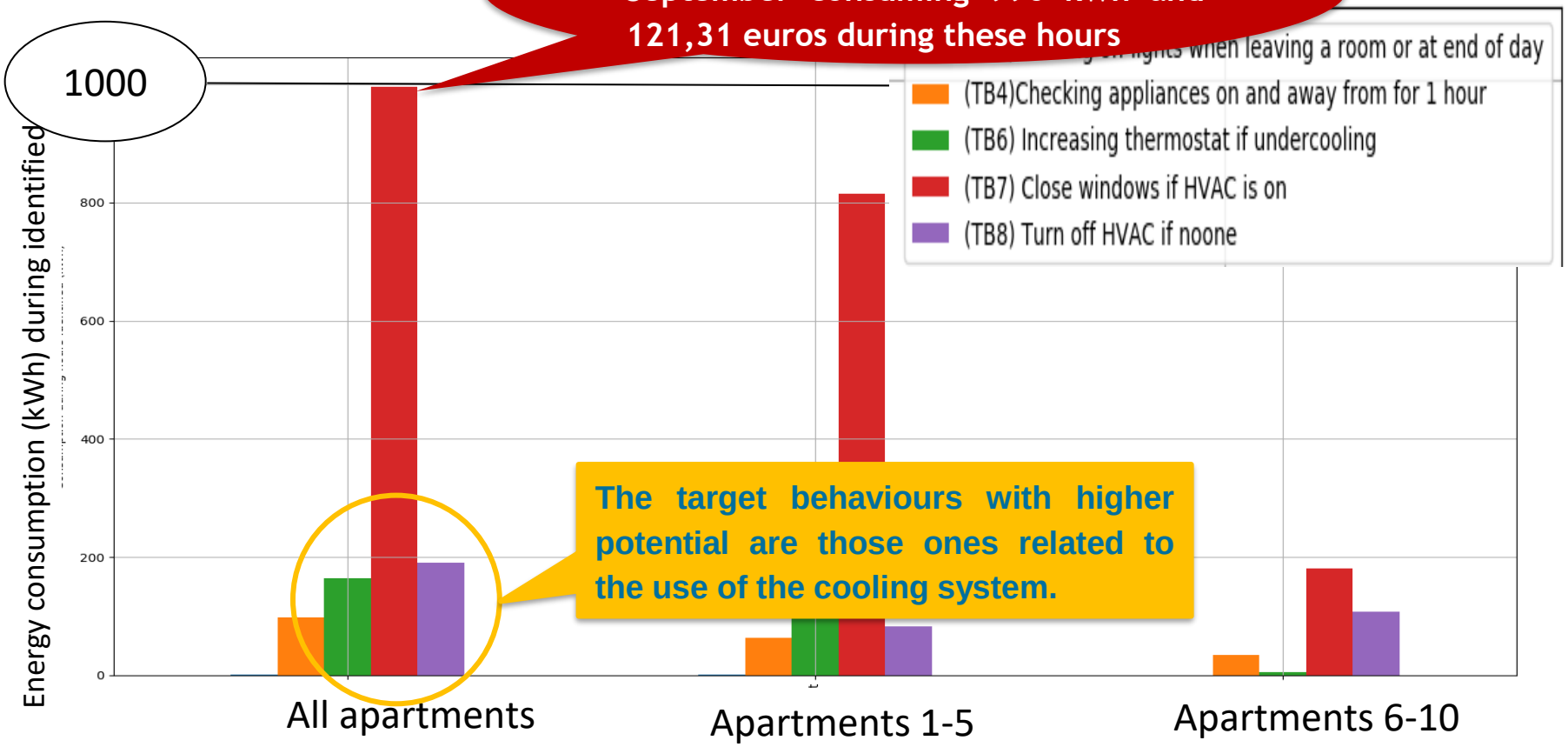


RESULTS

TARGET BEHAVIOUR ANALYSIS TO QUANTIFY ENERGY SAVING POTENTIAL

Residential Building (Romanian)

No TB7 979 hours from April till September consuming 996 kWh and 121,31 euros during these hours

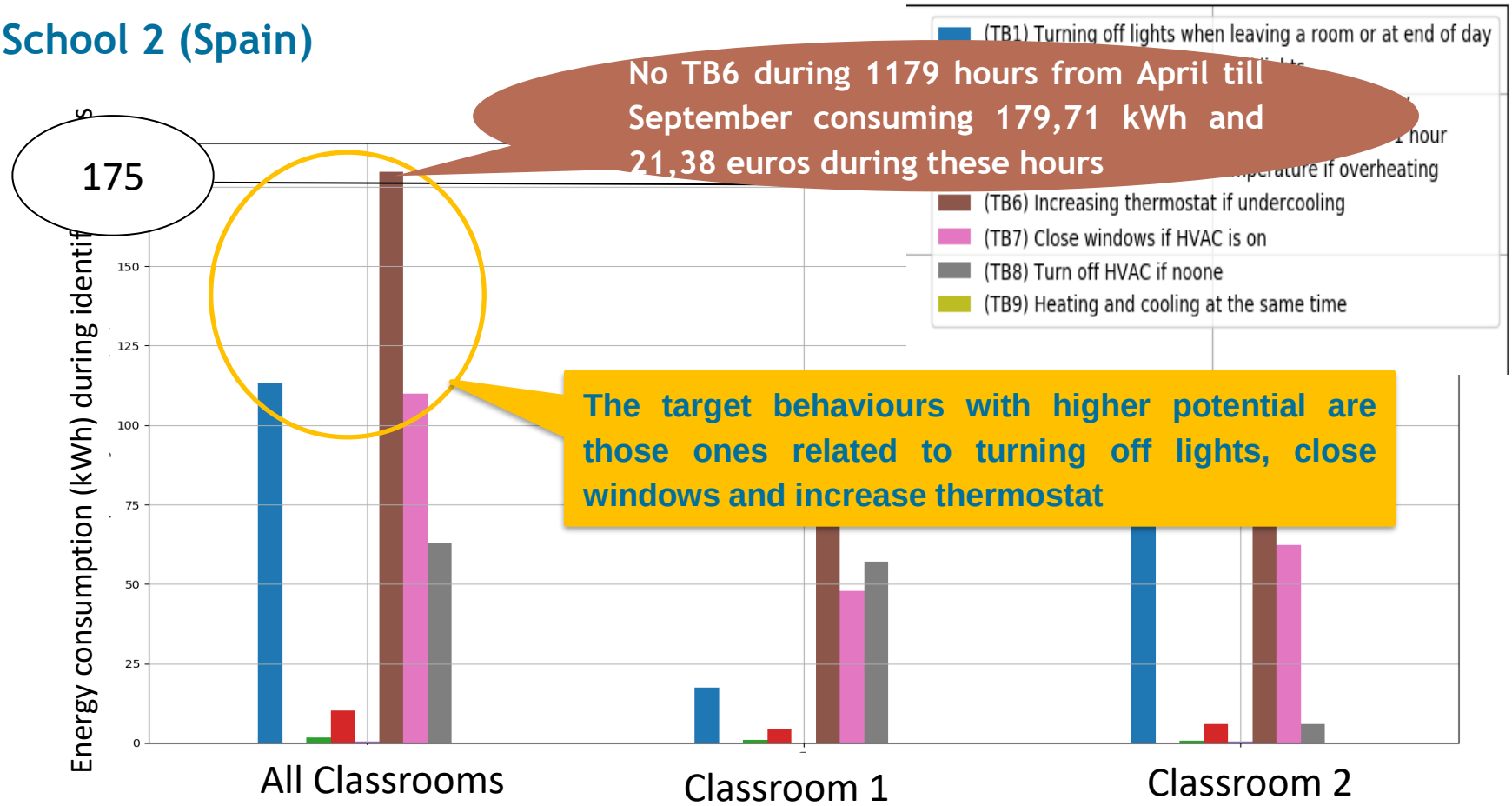


The target behaviours with higher potential are those ones related to the use of the cooling system.

RESULTS

TARGET BEHAVIOUR ANALYSIS TO QUANTIFY ENERGY SAVING POTENTIAL

School 2 (Spain)



CONCLUSIONS

COMFORT ANALYSIS TO QUANTIFY ENHANCEMENT POTENTIAL

- All buildings have something to improve in terms of comfort (temperature, relative humidity, luminance or CO2 level)
- The highest potential is related to luminance (and relative humidity)
- CO_2 levels are quite good

Building	Temp	Rel. Humid	CO2	Luminance
Office		50%		50%
HCC 1	30%	60%	40%	
HCC2		60%		
School 1	80%	80%		90%
School 2		50%		95%
Residential 1	50%	60%		100%
Residential 2	40%			

CONCLUSIONS

TARGET BEHAVIOUR ANALYSIS TO QUANTIFY ENERGY SAVING POTENTIAL

Conclusions

The most promising target behaviours to be changed are those ones related to the use of the **cooling system**:

(TB6) Increasing thermostat if undercooling

(TB7) Close windows if HVAC is on

(TB8) Turn off HVAC if none.

	Lighting		Appliances		Cooling System				
Building	**TB1**	**TB2**	**TB3**	**TB4**	**TB5**	**TB6**	**TB7**	**TB8**	**TB9**
Office	■	■							
HCC 1								■	
HCC2						■		■	
School 1									
School 2	■					■	■		
Residential 1						■		■	
Residential 2							■		

■ Most promising TB in terms of energy saving potential

CONCLUSIONS

NEXT STEPS

- Check other weather conditions: **Office & School in UK**
- Deploy ICT solutions to change energy behaviour of these buildings users: **eTEACHER demo**
- Check if the energy saving potential and comfort enhancement potential can be achieved: **eTEACHER validation analysis**

THANK YOU

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