# Increasing water and energy efficiency in university buildings: A case study


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# Outline

**Introduction**

- Justification of the issue under study
- Objectives

**Case study**

- Methodology
- Civil Engineering Department – University of Aveiro

**Conclusions**

- Results and Discussion
- Conclusions

# Justification of the study

- Considering the water-energy nexus, the reduction of water consumption in the building cycle is also reflected in significant energy efficiency, taking into account the reduction of energy consumption to heat sanitary hot water to pressurize the water, and in the public systems in the abstraction, pumping and treatment of water and wastewater.

# Objectives

- Describe an audit of water efficiency carried out by ANQIP (Portuguese Association for Quality and Efficiency in Building Installations) in the Department of Civil Engineering of the University of Aveiro,
- The results obtained in terms of reduction of water consumption in the building, as well as the corresponding estimates for the reduction of energy consumption, as a consequence of the water-energy nexus.
- The overall objective of the Department was to increase the water and energy efficiency of the building, so the results of a complementary energy efficiency audit are also presented.

- **Introduction**

# Case study - Methodology

- Water efficiency audit

In November 2016, ANQIP conducted a water efficiency audit in the building in which sequence was decided to adjust the flow rates/volumes of the various water devices to the reference values of letter "A" of the ANQIP labelling system. Although this labelling system covers devices with higher efficiency (categories "A+" and "A++"), their application is not generally considered for public buildings, in order to ensure proper functioning of drainage systems, adequate levels of users' comfort and for health reasons.

- **Network Characterization**

# Case study - Methodology

- Water efficiency audit

The building has 69 **water devices** distributed by:

- Urinal flush valves (17);

- Showerheads (2);

- Flushing cisterns, complete discharge (16);

- Flushing cisterns, double discharge (3);

- Self-closing taps (23);

- Laboratory taps, conventional (11).

# Case study

- Water efficiency audit - proposed measures

Urinal flush valves - In 14 of the urinals, only a small reduction on the discharge time was made, from 7.12 seconds (on average) to 5 seconds.

Showerheads - The initial flow rate was 12 L/min, which was reduced to 8 L/min by the application of a reducer previously tested by ANQIP, in order to guarantee the desired flow rate for the local pressure conditions.

Flushing cisterns, complete discharge - By simple regulation of the water inlet mechanism, it was possible to reduce the initial discharge volume from 9 L (on average) to 6 L.

Flushing cisterns, double discharge - By simple adjustment of the water inlet mechanism, the average volume of the discharge was reduced from 6 L to 4.5 L.

# Case study

- Water efficiency audit - proposed measures

Self-closing taps - These taps had an average flow rate of 7.6 L/min, which was reduced to 4.0 L/min by application of a calibrated reducer, as in the case of showerheads. It was not considered advisable to reduce the opening time (close between 6 and 8 seconds), since lower values lead to successive actuations.

Laboratory and service taps, conventional ones - In these taps, due to their functions, it was not considered appropriate any operation.

# Case study

- Water efficiency audit – results

The water efficiency measures proposed in the audit have been progressively implemented. The flushing cisterns adjustment were implemented during the auditing (November 2016) and the placement of flow reducers in the taps in October 2017.

Table 1 – Water consumption reduction by type of device, in percentage

| Device | Number of devices | Average reduction |
|---|---|---|
| Urinal | 17 | > 0% |
| Shower | 2 | 33% |
| Toilet (complete discharge) | 16 | 33% |
| Toilet (double discharge) | 3 | 25% |
| Washbasin (self-closing tap) | 23 | 40% |
| Laboratory sink (conventional tap) | 11 | 0% |

Table 2 - Water consumption of the building per device (estimated values)

| Device | % |
|---|---|
| Urinals | 12.5 |
| Showers | 2.5 |
| Toilets | 40.0 |
| Washbasins | 35.0 |
| Sinks (and other consumption) | 10.0 |
| Total | 100.0 |

# Case study - Methodology

- <u>Energy efficiency audit</u>

Between 13th of October and 20th of November 2017, an energy audit was performed to assess the major energy consumption by building floor level including HAVC.

# Case study

- Energy efficiency audit – implemented measures

In 2016/2017 several energy efficiency measures were introduced, namely the changing of lamps type and electric lighting control:

**Replacement of corridors' lighting systems**: In corridors, all the projectors were replaced by new LED solutions reducing installed power by 25 times, and consequently a decrease in luminous power was introduced.

**The set point of the AVAC system was reduced** from 24/25° C to 20/21ºC.

**The classrooms and offices lighting systems** were gradually been replaced by LED systems.

# Case study

- Energy efficiency audit – results

In 2016 the energy management in the Civil Engineering Department reached 11% of electricity savings with regard to the previous year.

In 2017 the energy savings were even higher than in 2016, **achieving 25%**.

With the energy efficiency plan implemented by the energy management the total's building electricity needs were reduced by 30% in the last 2 years, which represents savings around 5260 € per year.

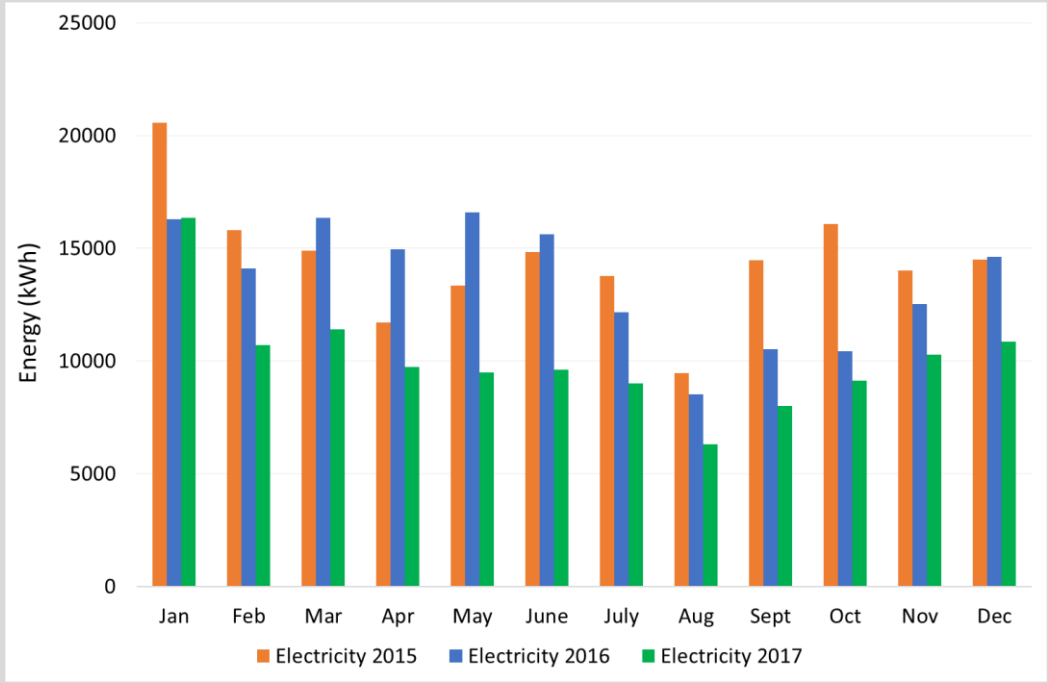


**Fig. 9 - Monthly average energy consumption in 2015, 2016 and 2017**

# Results Discussion

The water consumption records show a reduction from 568.8 m3 in 2016 to 358.8 m3 in 2017 (36.9% less).

According to studies carried out in Portugal by ANQIP (in the region of Aveiro) the energy consumption related to the consumption of water in dwellings corresponds to almost 75% of sanitary hot water (SHW) heating and of about 25% of energy consumption in the public water supply network, in the public drainage network and in the wastewater treatment.

- **Conclusions**

# Results Discussion

According to data provided by the local water authority (AdRA), energy consumption in the supply public water network of the municipality of Aveiro is 0.838 kWh/m3, and in the public drainage network and wastewater treatment is 0.818 kWh/m3.

According with the records of AdRA, in the municipality of Aveiro an increase coefficient of 1.33 should be considered to include water losses, affecting essentially the volumes abstracted, treated and pumping.

- **Conclusions**

# Results Discussion

It was registered the reduction of the annual water consumption from 568.8 m3 to 358.8 m3 (210 m3 in total) leading to a reduction of energy consumption in public system of 406 kWh/year (210 m3/year x 1,933 kWh/m3 = 406 kWh/year).

The measures already implemented as a result of the building audit will lead to a reduction in emissions of almost 100 kg CO2/year.

- **Conclusions**

# Results Discussion

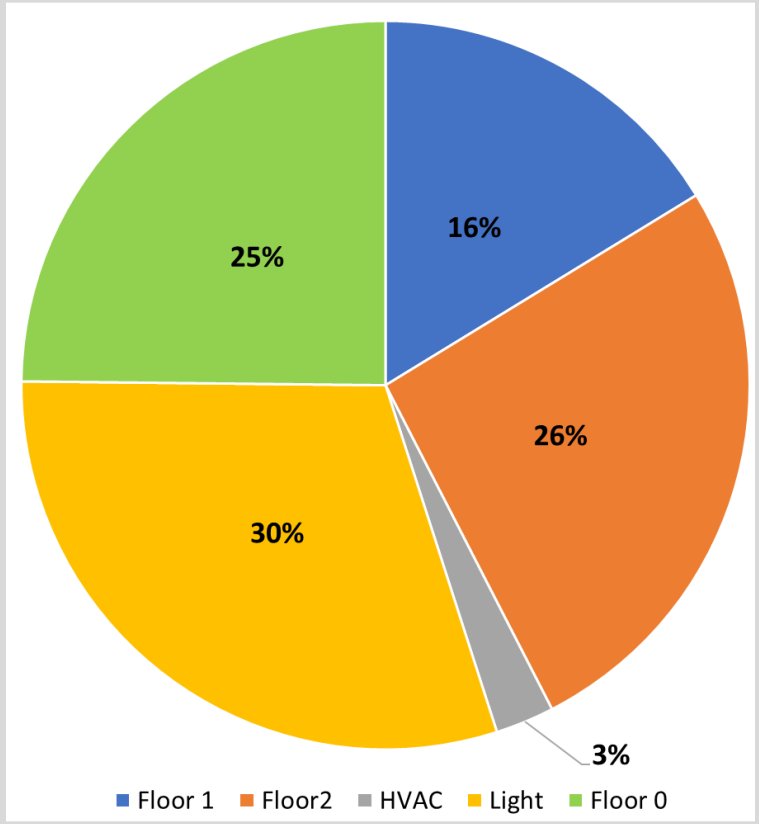


**Fig. 10 - Energy consumption between 16th and 22th of October, with an average energy consumption of 295 kWh/day**

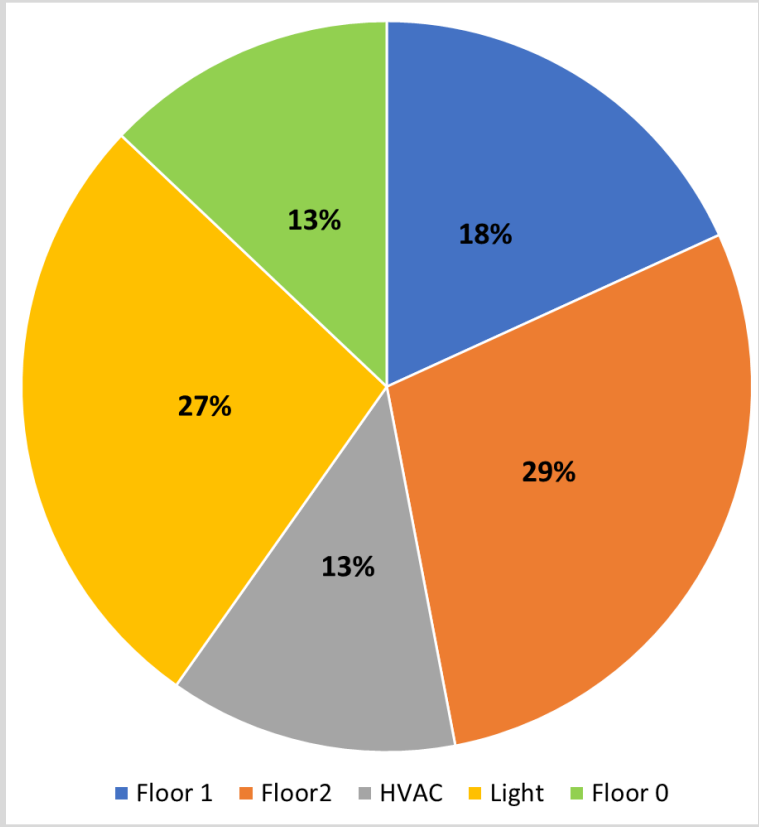


**Fig. 11 - Energy consumption between 13th and 19th of November, with an average energy consumption of 361 kWh/day**

- **Conclusions**

# Results Discussion

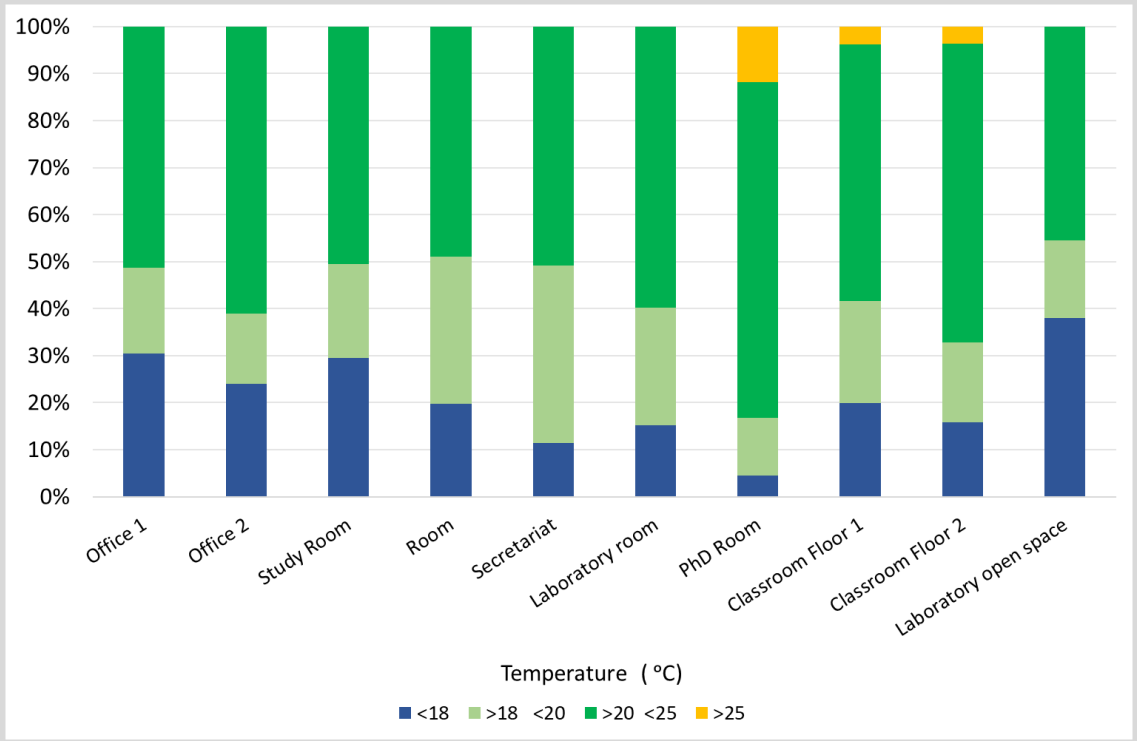


**Fig. 12 – Spaces temperatures for working days between 8am and 8pm**

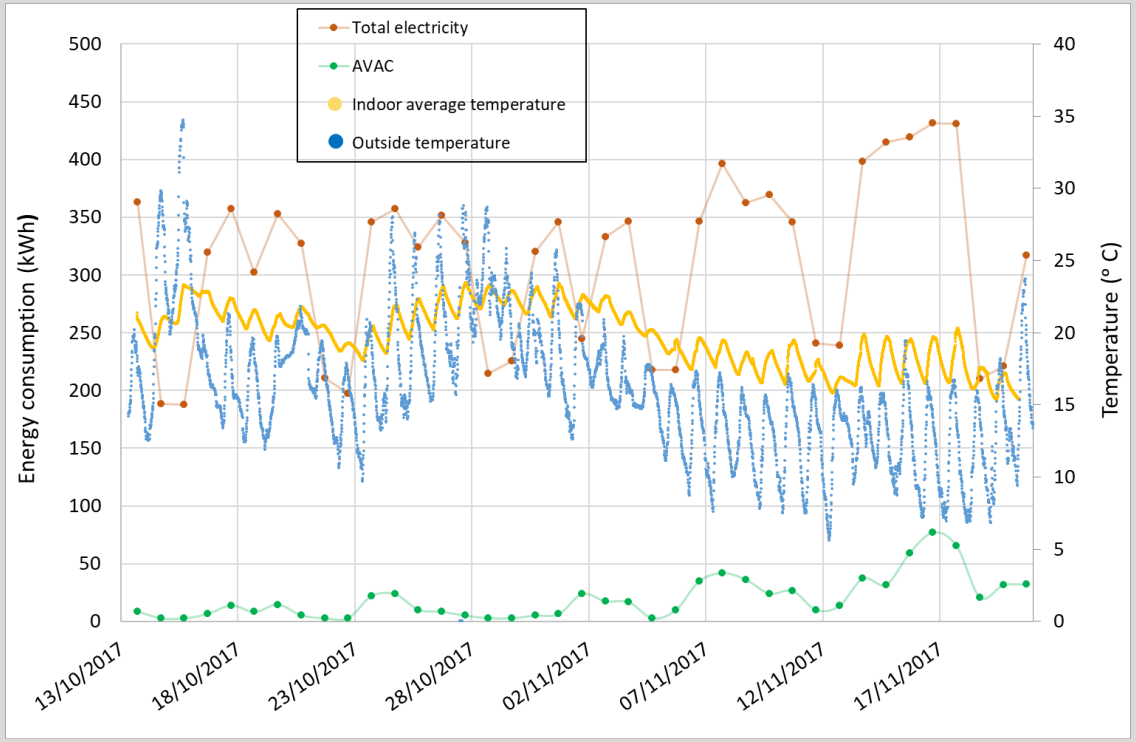


**Fig. 13 – Comparison of the inside building average temperature with the daily average total building electricity consumption and HVAC electricity consumption**

- **Conclusions**

# Results Discussion

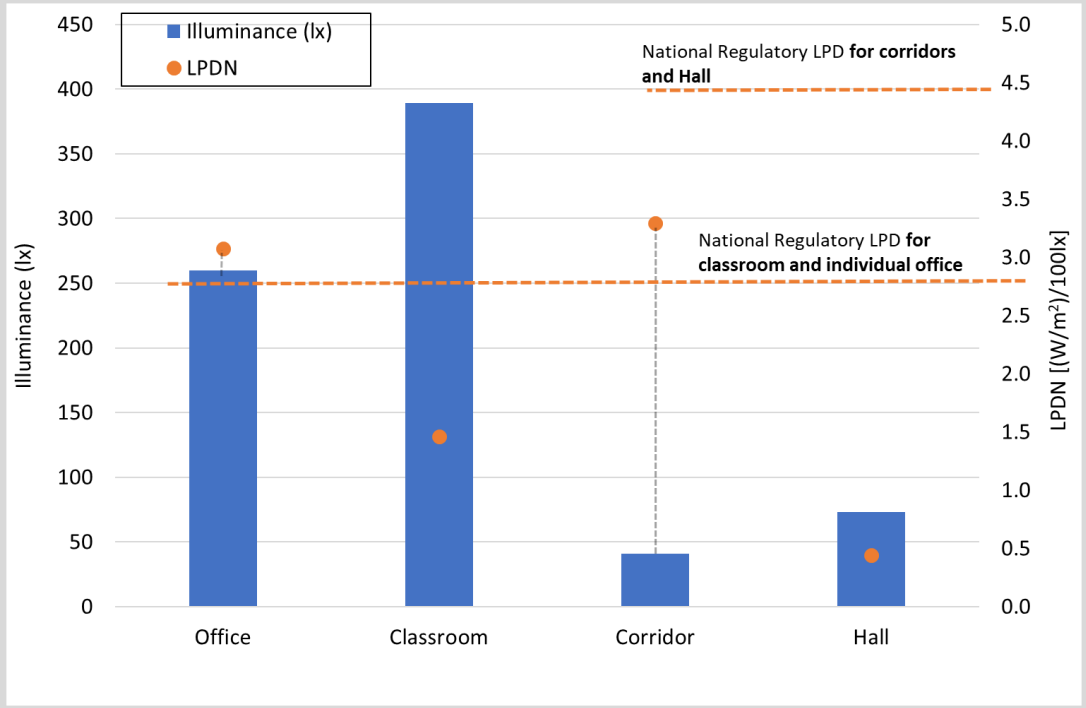


**Fig. 14 – Illuminance and Normalized Light Power Density**

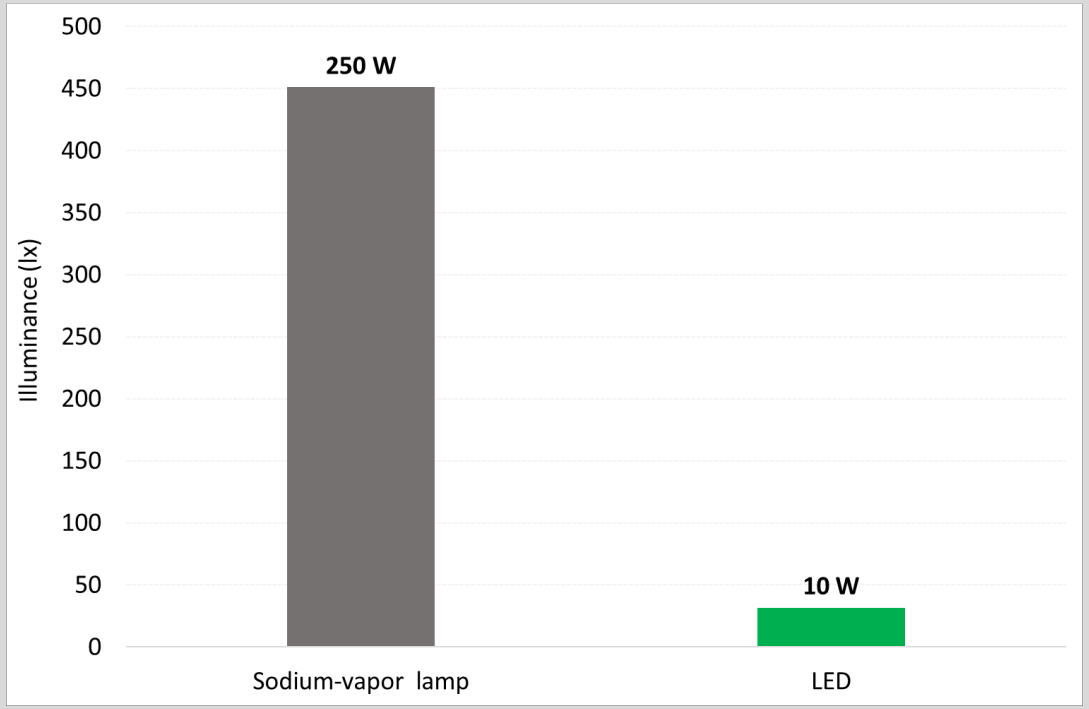


**Fig. 15 – Energy consumption and LPD for Sodium Vapour and LED lighting projectors**

- **Conclusions**

# Conclusions

• The estimated reduction of 210  m3 in water consumption in the building leads to reductions in energy consumption in public water supply and wastewater networks of around 406 kWh/year. In the building, only 2.5% of the consumptions (showers) imply the water heating, being the majority of the water consumption in the building of cold water. Thus, the effects of the nexus water-energy are not significant in this case at the building level, where there is a reduced production of domestic hot water, but are significant at the level of public networks.

• In the energy audit, it was observed that thermal comfort conditions are provided to the building occupants in most of the time (70%). In cold months (November to March) the building tends to be cold and the heating system are required to provide thermal comfort, increasing the building energy demand from 17 MWh/month to 26 MWh/month, meaning that building thermal envelope should have better thermal insulation.

# Conclusions

• With the implementation of energy efficiency measures involving the electric lighting system and better management of the building energy systems, the electricity consumption decreased by 30%.

• In the building almost 30% of electricity consumption is related with electric lights and 45% with office and testing equipment's.

• The efficient electric lighting measures contribute for around 35%, 14200 kWh/year, of the electrical consumption reduction reached between 2016 and 2017.

• The remaining energy reduction can be explained by the occupancy variation, by the activity in the building rooms and by the decrease of the HVAC setpoint temperature.

• Despite the holidays period in August, a large energy consumption occurs due to the fact of several equipment stay working and also several researchers in spite of the holiday period stay working in the building.

• It can be also concluded that the significant energy reduction in the last two years, has a relative small impact in the thermal comfort conditions.

# Increasing water and energy efficiency in university buildings: A case study

## Thank you for your attention!


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