



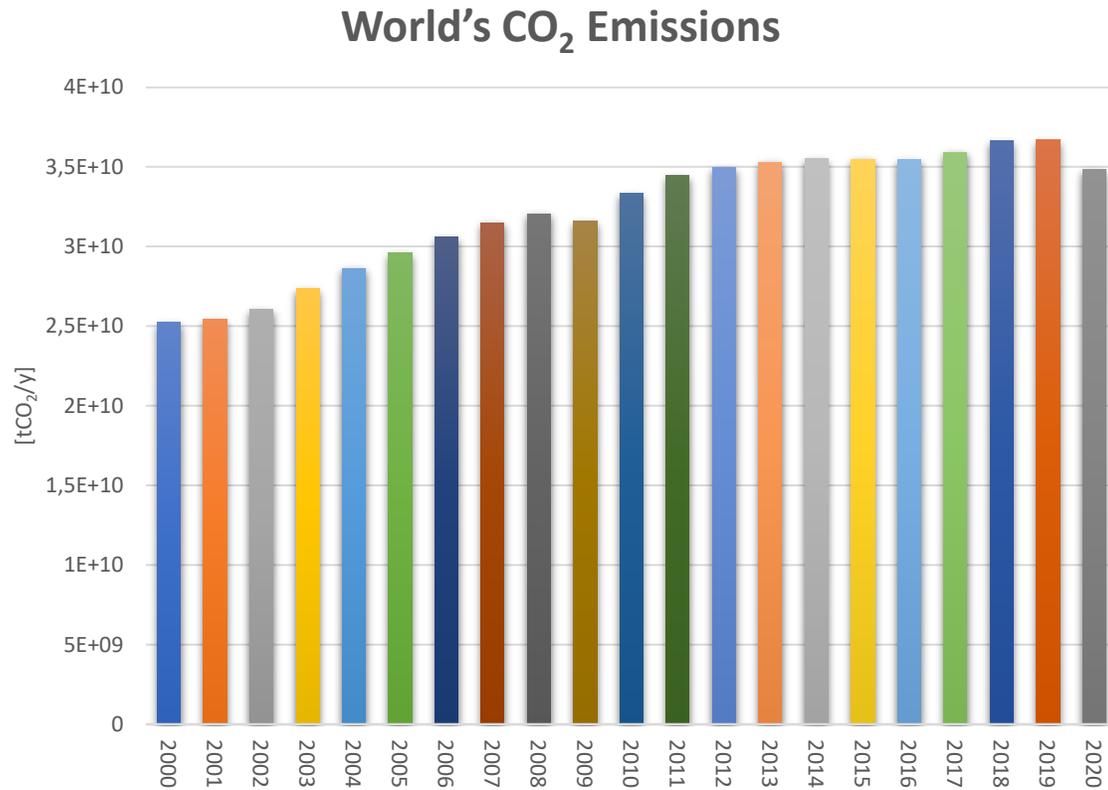
DECEMBER 15, 2021 | 6TH AIEE ENERGY SYMPOSIUM - CURRENT AND FUTURE CHALLENGES TO ENERGY SECURITY

## **Energy Efficiency improvement strategies for important historic buildings used as offices. A case study in Rome**

Alessandro Pelliccia (presenter), Valerio Di Prospero, Laura Antonuzzi, Annalisa Zuppa, Francesco Castellani, Romano Acri, Federico Santi

# Green House Gas Emissions: Global Situation

Emissions have to be reduced in order to keep the global warming below 2°C

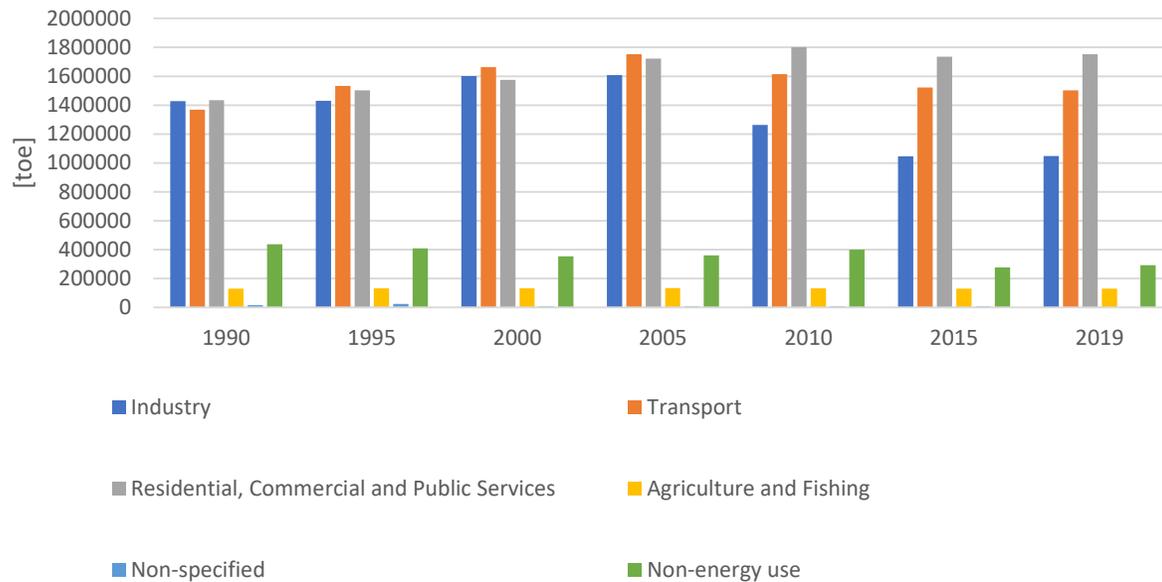


- **Global CO<sub>2</sub> emissions are still rising. Carbon Dioxide emissions grew of 1.7% in 2018 compared to the previous year.**
- **Some of the factors driving this increase are the economic growth, extreme weather events and a slowdown in efficiency improvements.**
- **According to UN IPCC, if we don't keep the global warming below 2°C:**
  - **90 cm Sea level rise**
  - **Evacuation of coastal areas**
  - **Greater risk of extinction for many species**

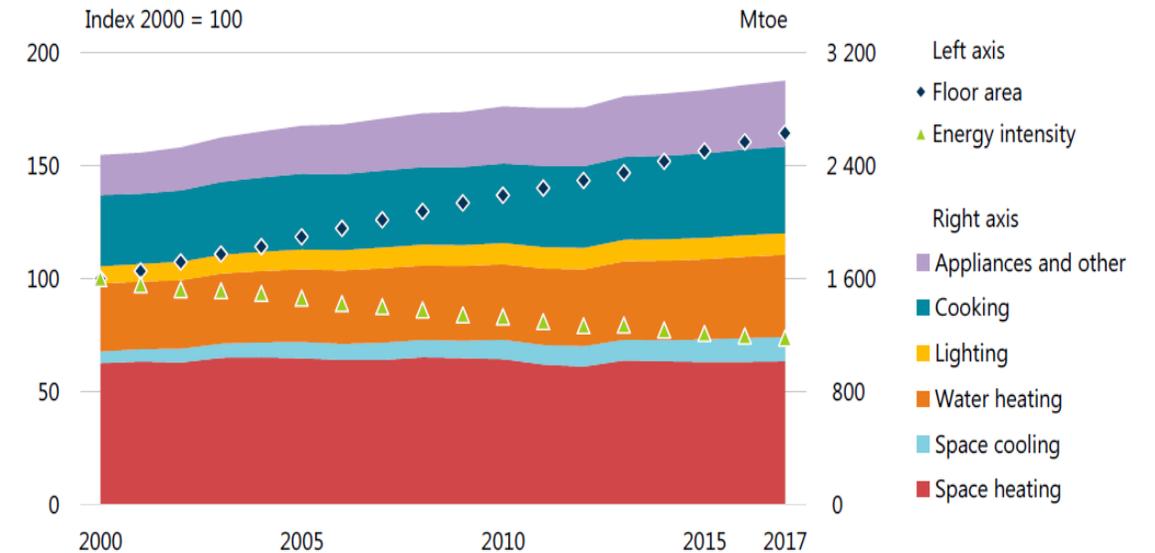
# The Importance of Buildings

Buildings account for almost 40% of the global final energy use and are responsible for more than 30% of global green house gas emissions

## Final Energy Consumption by Sector - Italy



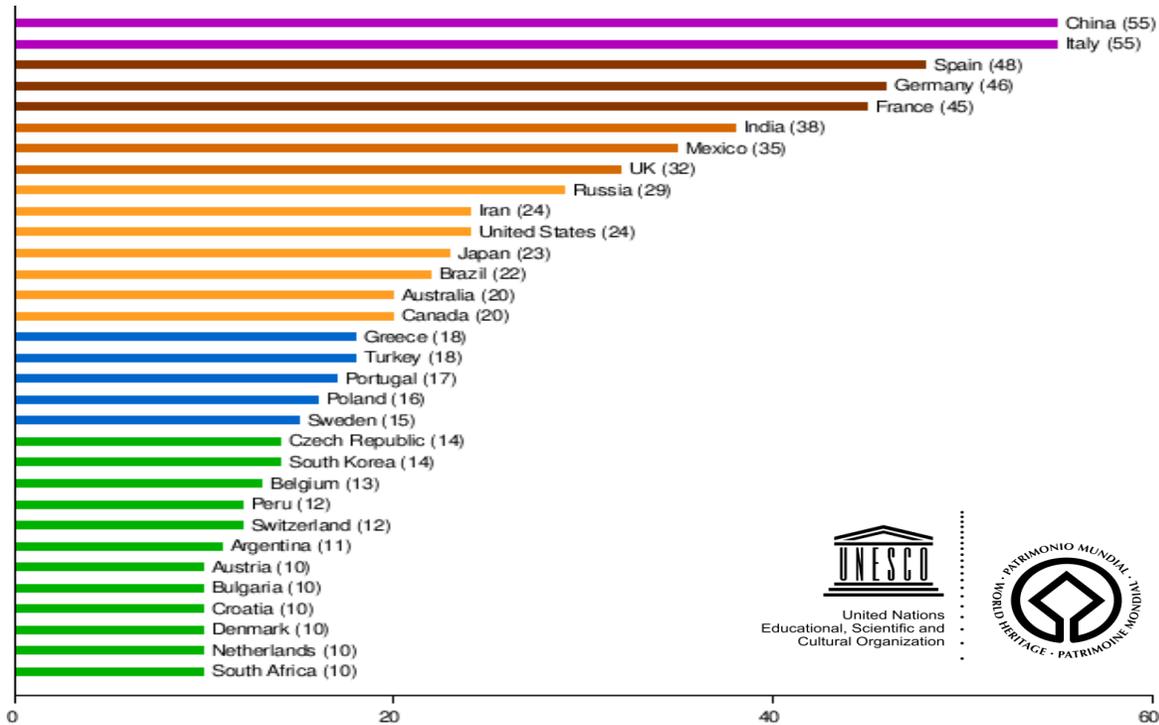
Source: IEA (2019), The Critical Role of Buildings, IEA, Paris  
<https://www.iea.org/reports/the-critical-role-of-buildings>



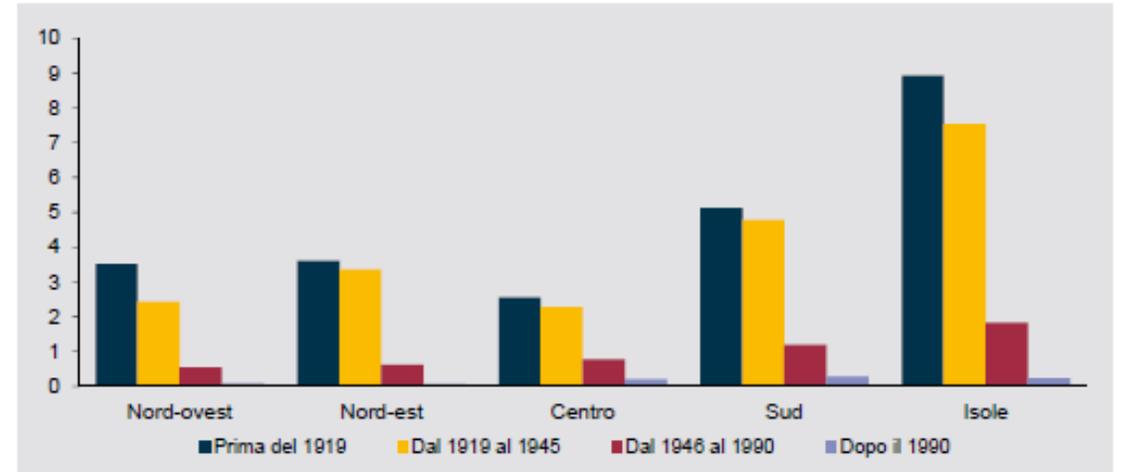
- Despite the improvements made in efficiency, the floor area of buildings increased of 65% in the period 2000-2017

# Italy is slightly different from other countries

Most Italian buildings are 100 years old, this means that renovation is necessary in order to improve their performance



Italy shares the highest number of UNESCO sites of the world with China.

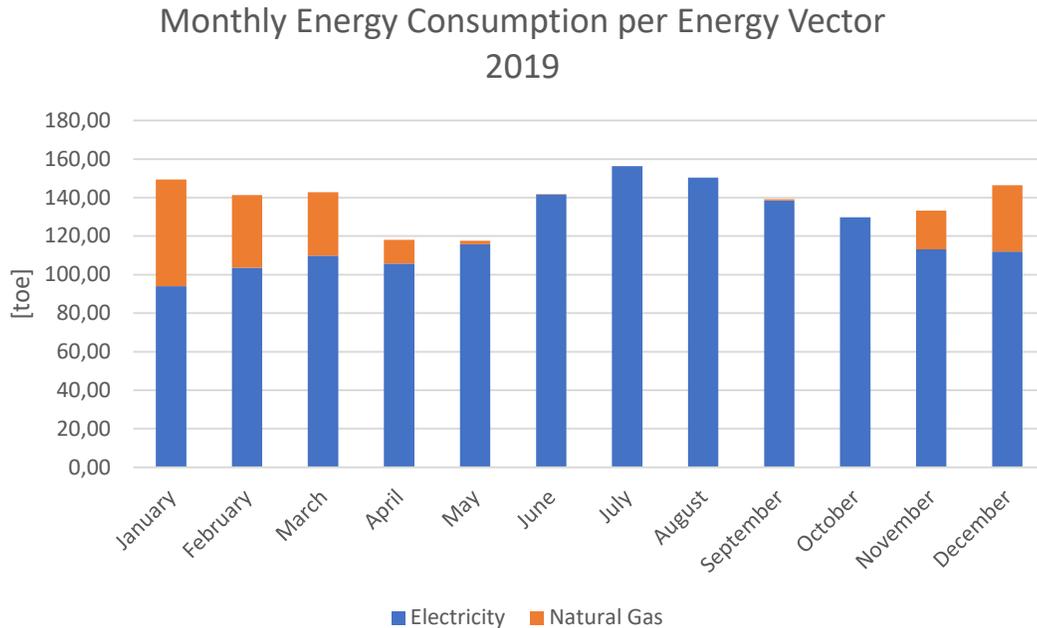


Fonte: Istat, 15° Censimento generale della popolazione e delle abitazioni al 9 ottobre 2011 (R)

- Italy needs to deeply renovate its buildings stock, both private and public, and it is slowly happening. Italian professionals know how to deal with historical buildings; therefore, they should pave the way in this specific sector.

# Case Study of an Historic Building in the Center of Rome

The building was built in the end of the XIX<sup>th</sup> century, and it now houses offices



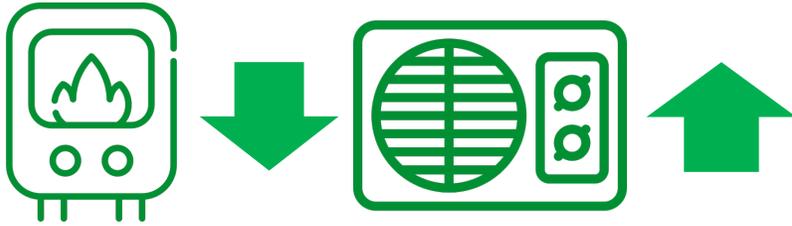
2019 was chosen to avoid the pandemic effect on the consumption.  
Natural Gas is the main energy vector used for heating of building.

## ENERGY CONSUMPTION:

- Electricity (Lighting, Pumps, Air Handling, Fans, Devices) 7.864.082 kWh/y
- Natural gas (Building heating) 233.637 Sm<sup>3</sup>/y
- Total Primary Energy Consumption 1665,90 toe/y
- Annual Energy Cost 1.286.338 €/y
- CO<sub>2</sub> Emissions 3.687 tCO<sub>2</sub>/y

# Electrification of the Heating System: Heat Pumps

Reduction in the use of natural gas as heating energy vector thanks to the installation of heat pumps



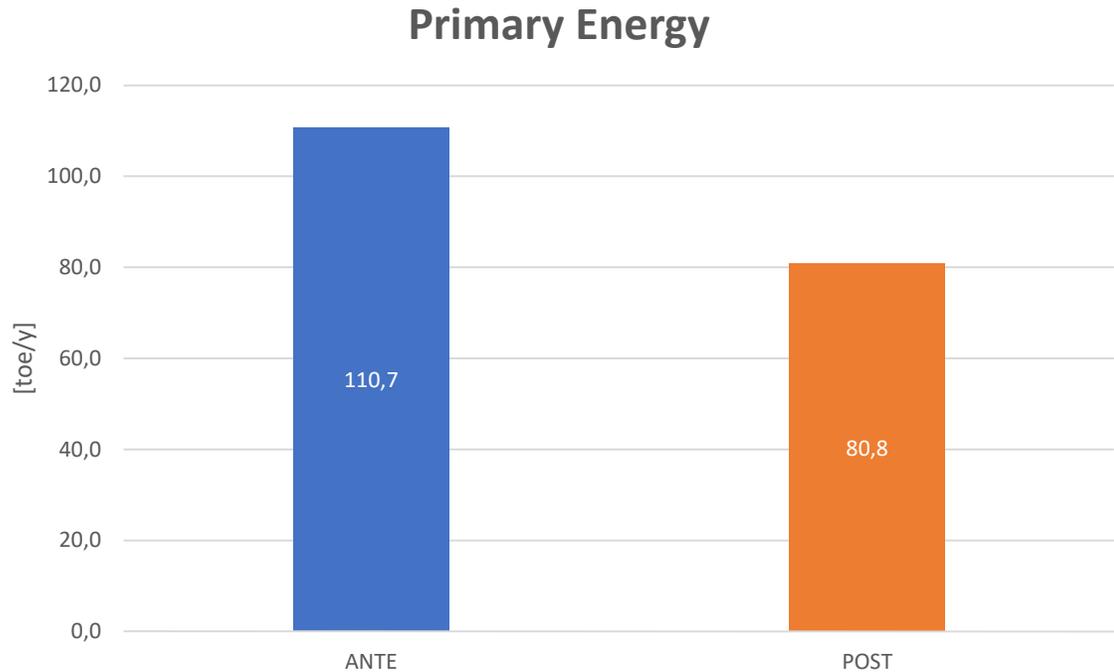
## From Fossil Fuel to (mostly) Renewable Energy

- Heat pumps are considered renewable energy sources because they use the free and unlimited heat of air.
- Reversible action: they can also provide cooling in the summer season substituting the water chillers currently installed.

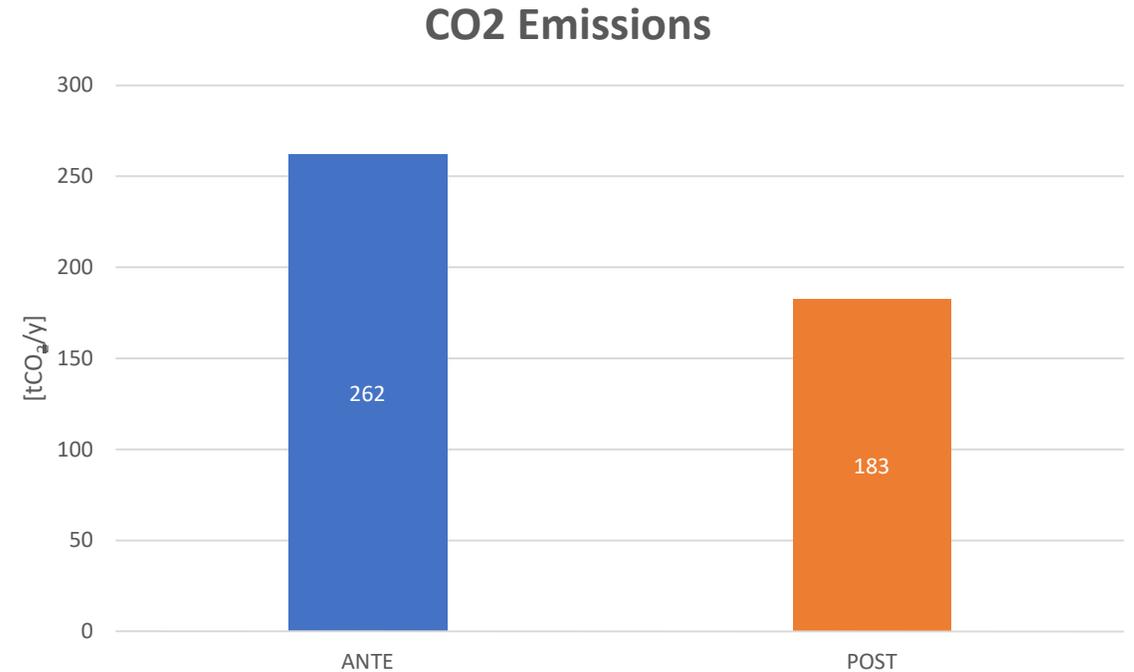


# Reduction of the Primary Energy and CO<sub>2</sub> Emissions

The installation of heat pumps will lead to a reduction of primary energy use and GHG emissions caused by the heating system



**-27% on the Primary Energy of Heating**

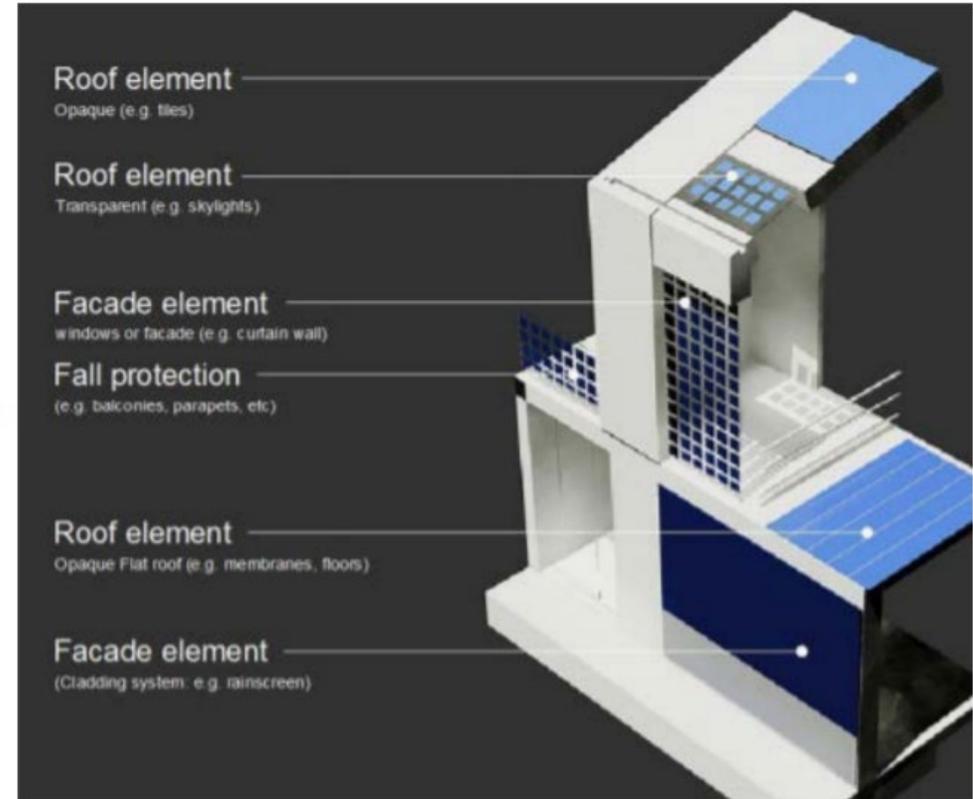


**-30,3% on the GHG Emissions of Heating**

# Renewable energy sources : BIPV (Building Integrated Photovoltaic)

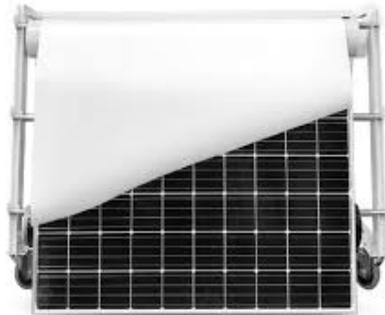
Installation of photovoltaic systems to enhance the self-energy production

- The acronym BIPV refers to systems in which the photovoltaic element assumes, in addition to the function of producing electricity, the role of a building element. In recent years, the integration of modules in architecture is evolving strongly. The new products, due to their dimensions and characteristics, can fully replace some traditional construction components.
- The Ministry of Culture has recently circulated the "GUIDELINES FOR THE IMPROVEMENT OF ENERGY EFFICIENCY IN CULTURAL HERITAGE - Architecture, historic and urban centers and nuclei " to support officials for the planning of PNRR interventions" 1.3 Improving energy efficiency in cinemas, theaters and museums " (300 M€) with an important focus on BIPV in restricted contexts.



# BIPV: Types of Photovoltaic Plant

Different technologies are deployed in order to enhance the possible installation area



- Replacement of the glazing of the skylight with photovoltaic glass with a limited aesthetic impact
- Installation of photovoltaic modules on the roof of the building which are not affected by shading phenomena
- Coloring of photovoltaic modules (applied by means of film, printing, etc.) will be chosen to decrease the aesthetic impact of the PV modules
- Installation of "shelters" with the aim of covering the already existing plants on the roof. The shielding surface is made of PV modules

# Energetic and environmental aspects

Installed power, energy and CO<sub>2</sub> saving

## Energy Savings

Annual production BIPV skylight [MWh]	12,2
Annual production BIPV coverage [MWh]	41
Annual production BIPV plant shielding [MWh]	95,6
<b>Total [MWh]</b>	<b>148,8</b>
<b>Primary Energy Saved [toe]</b>	<b>27,8</b>

## CO<sub>2</sub> savings

Conversion Factors CO <sub>2</sub>	
Electricity in CO <sub>2</sub> equivalent [kg CO <sub>2</sub> /kWh]	0,41
Electricity saved [kWh]	148.800
CO <sub>2</sub> saved [kgCO <sub>2</sub> ]	61.008

# Relighting: from fluorescent lamps to LEDs

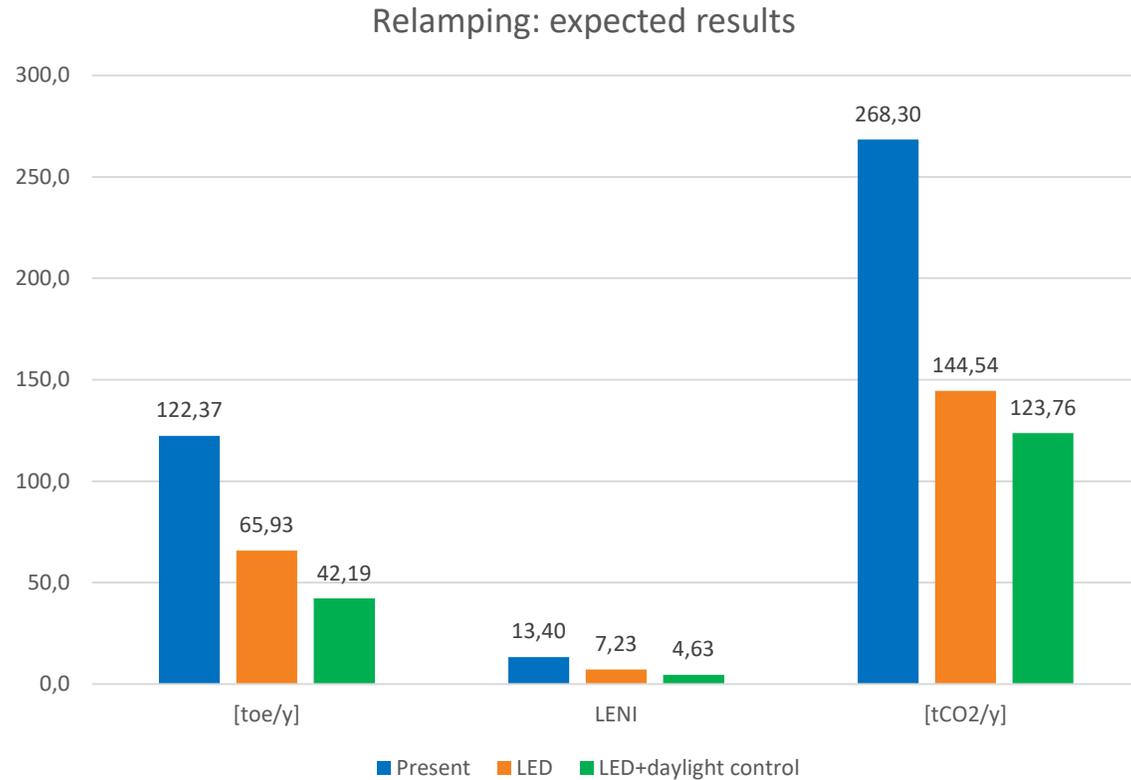
## Intervention Description

- The current installed power amounts to approximately 345 kW, mostly consisting of fluorescent lamps with an average luminous efficiency of 50 lm/W
- In the current situation the electrical energy consumed for the lighting system is approximately 10% of the total electrical energy consumed by the whole complex
- Replacing all the fluorescent lamps with LED technology with a luminous efficiency of 100 lm/W, the total installed power decreases to less than 200 kW
- The fraction of the electrical energy consumed by the lighting systems becomes less than 6%
- Implementing a daylight control system, the total energy consumed can be decreased even more



# Relighting: from fluorescent lamps to LEDs

## Expected results



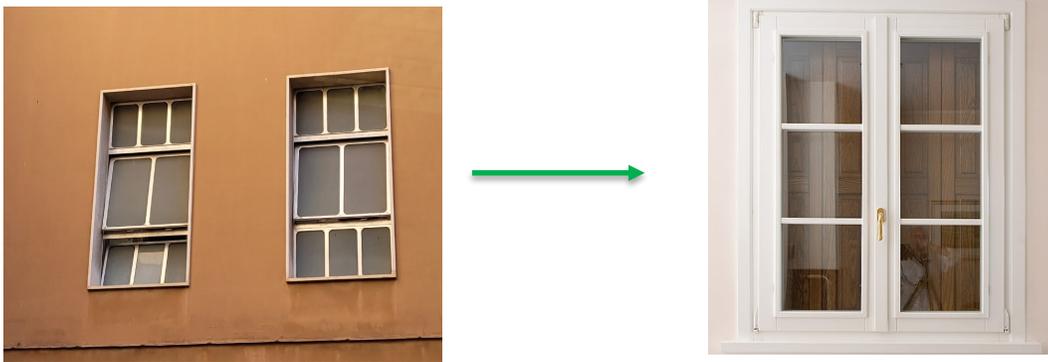
- - 43% energy consumption for the lighting system
- LENI = 7,23 kWh/m<sup>2</sup> y

Introducing daylight control, an additional 36% of energy savings are obtained and a better luminance on the working surface

# Transparent casing: Fixtures Replacement

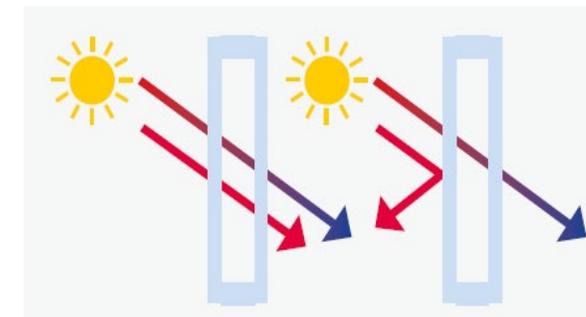
## Intervention description

- Current windows are characterized by aluminium and wood frames and single glazing. In order to improve the building's efficiency, the intervention consists in the replacement of the aluminium frames with wood frames and the single glazing with selective or low-emissive double glazing. Thanks to this intervention it is possible to reduce the heat loss and both heating and cooling energy, because the transmittance and the solar factor characterizing the new fixtures are lower.



- The intervention carried out consists in varying the transmittance, the solar factor and the light transmission of the selective and low-emissive double glazing.

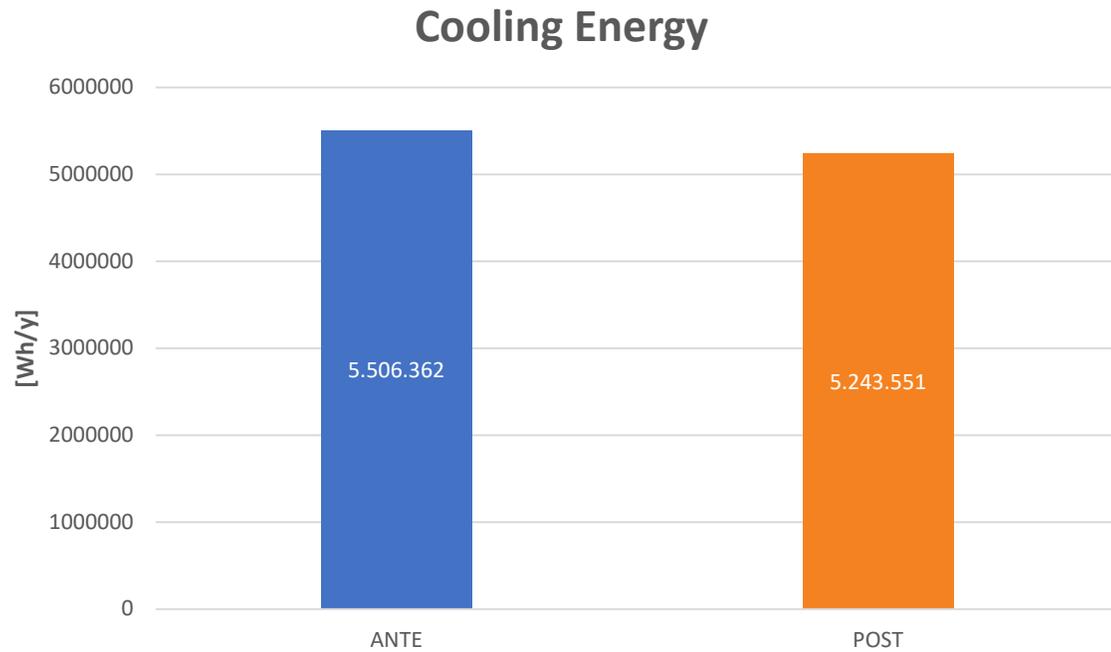
Light Transmission (%)	Solar Factor (%)	U [ $\frac{W}{m^2} \cdot K$ ]
81	64	1,1
74	45	1,1



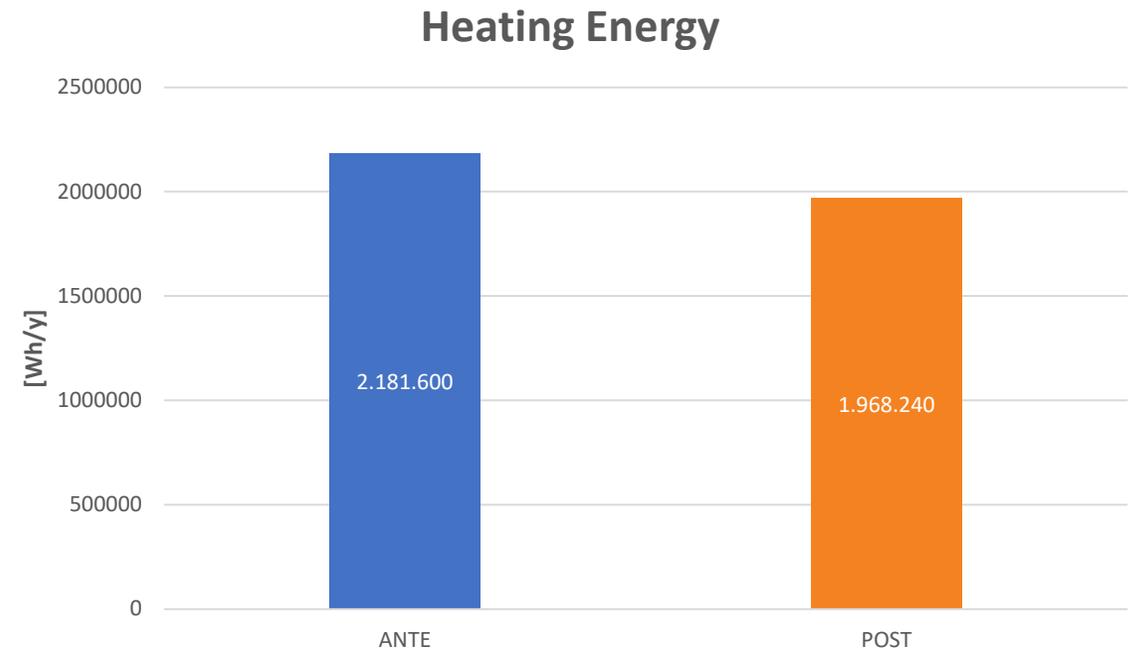
Low emissive glass    Selective Glass

# Transparent Casing: Fixture Replacement

Expected results



**-17,2% on the total Cooling Energy**

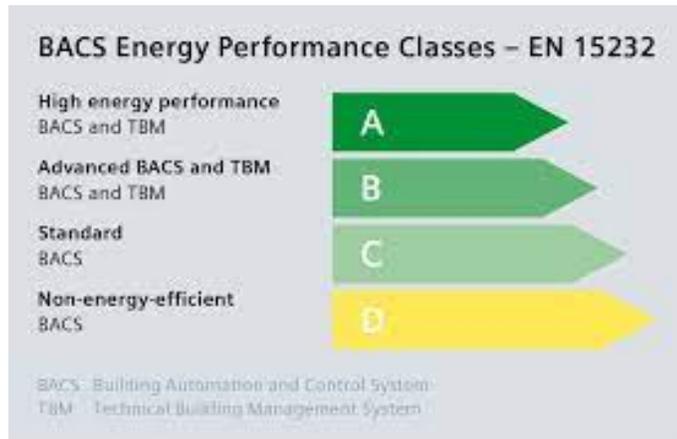


**-9,8% on the total Heating Energy**

## Other Interventions to Reduce the Energy Consumption

Due to the aging of the building, the technical system is very inefficient. Simple actions will lead to an increase of the building's efficiency

- Installation of inverters on electro pumps for heat transfer fluids
- Substitution of the two 400 kVA UPSs, that work with low efficiency (80%) due to the low load factor (about 10%), with two 100 kVA UPSs, raising the efficiency up to 95%
- According to the UNI EN 15232, the building lays in the D class «non energy efficient»

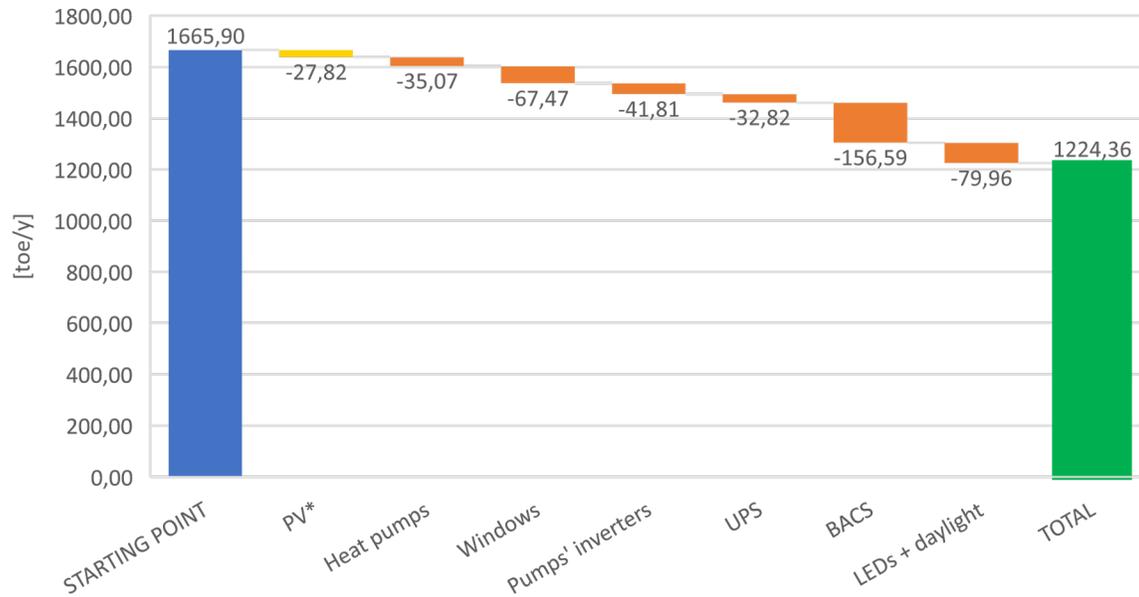


- **223855 kWh<sub>el</sub>/y saved, corresponding to a primary energy saving of 2,51% of the total primary energy**
- **175200 kWh<sub>el</sub>/y saved, corresponding to a primary energy saving of 1,97% of the total primary energy**
- **Just with the introduction of some sensors for the automatic control of emission for heating and cooling is possible to take the building in the C class, saving about 31% of energy for these two uses, corresponding to 9,41% of the total primary energy**

# Final Results

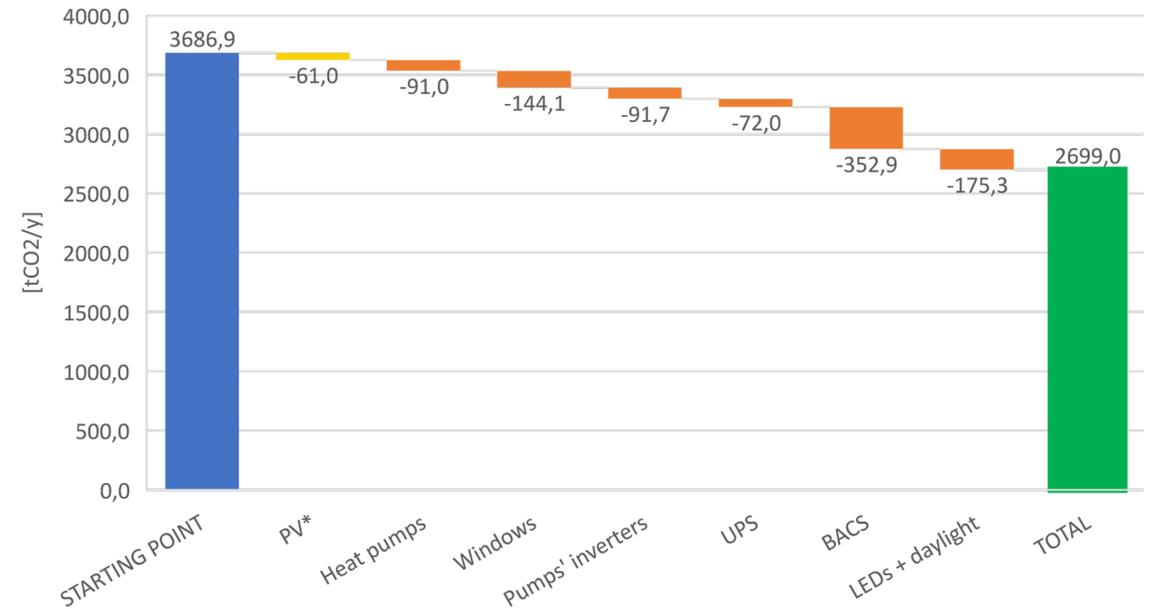
The final primary energy consumption and GHG emissions after the energy efficiency works

### Primary Energy Reduction



**-26,5% on the total Primary Energy**

### GHG emissions Reduction



**-26,8% on the total GHG Emissions**



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