COMPARISON OF OFFICE BUILDING MODELS FROM ENERGY AND ENVIRONMENTAL ASPECTS

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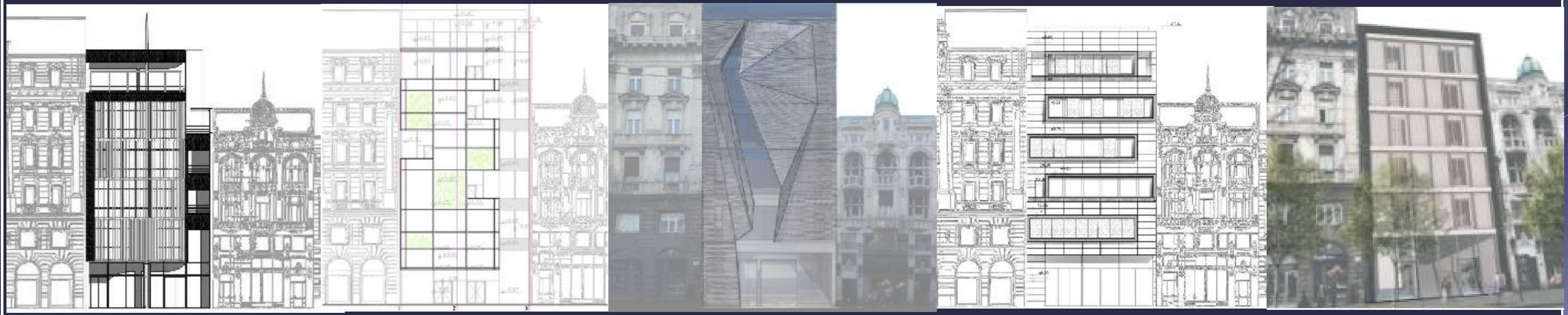
1. Introduction ►

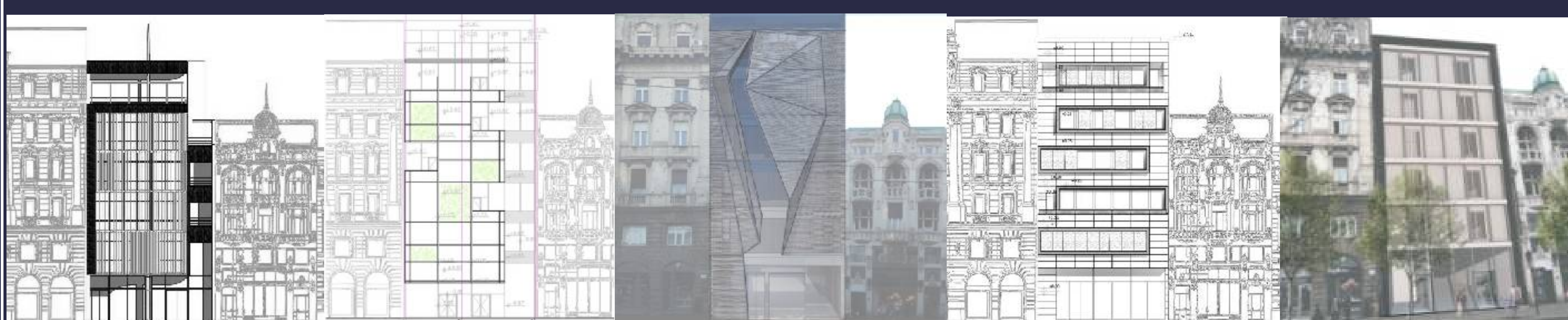
The main concern of this research is estimation of energy performances of different scenarios of the hypothetical models of an office building in downtown of Belgrade.



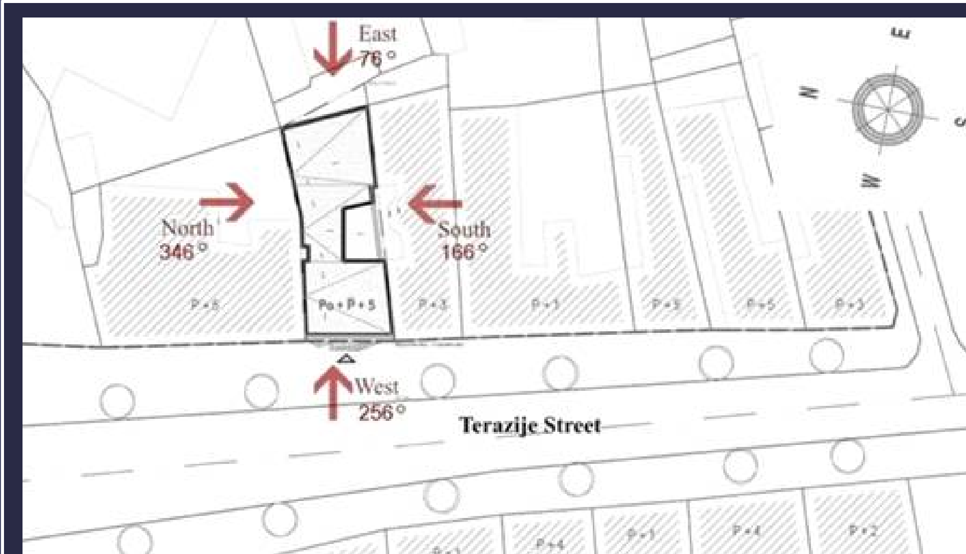
2. The research methodology►

Methodological approach entails three steps:

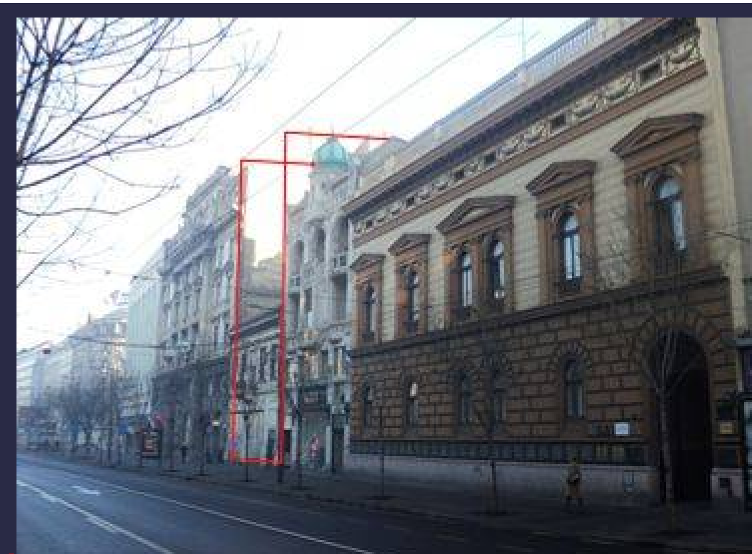
- **design** of different models of the office building,
- **numerical simulations** of the models in PHPP'2007 software and
- **comparison** of the results (models).



Building location



Site layout

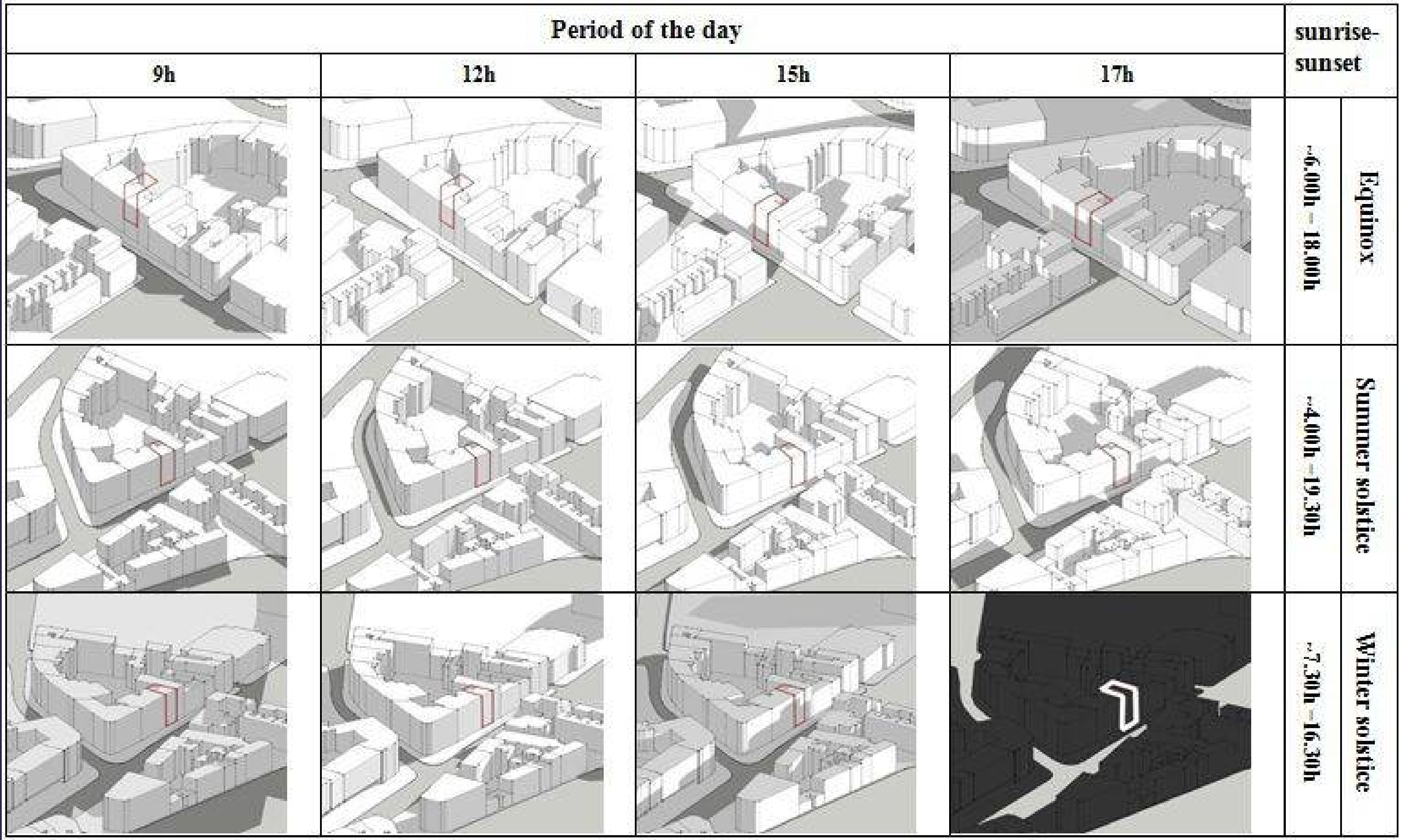


Location of the building in the existing front

Site location on the Belgrade city map

Specific conditions of sites in downtown make limitations in building design and application of energy efficient systems, but also represent a provocation for architects. In the paper the solutions for overcoming the problem are discussed.

Building insolation



Building insolation for different seasons and periods of the day

Characteristics of hypothetical models

For calculation the following characteristics are taken into consideration:

- **Narrow facade fronts caused by site conditions.**
- **Six floor building according to urban planning regulations.**
- **Reinforced concrete skeleton structure.**
- **Inner atrium for the purpose of indoor natural lighting and ventilation.**
- **Flat roof.**
- **100 users.**
- **Indoor air temperature: 20°C in winter and 22°C in summer.**
- **Internal and solar heat gains.**
- **Ventilation:**
  - **-east-west cross-ventilation,**
  - **-facade and atrium windows–"chimney effect“,**
  - **-night ventilation.**

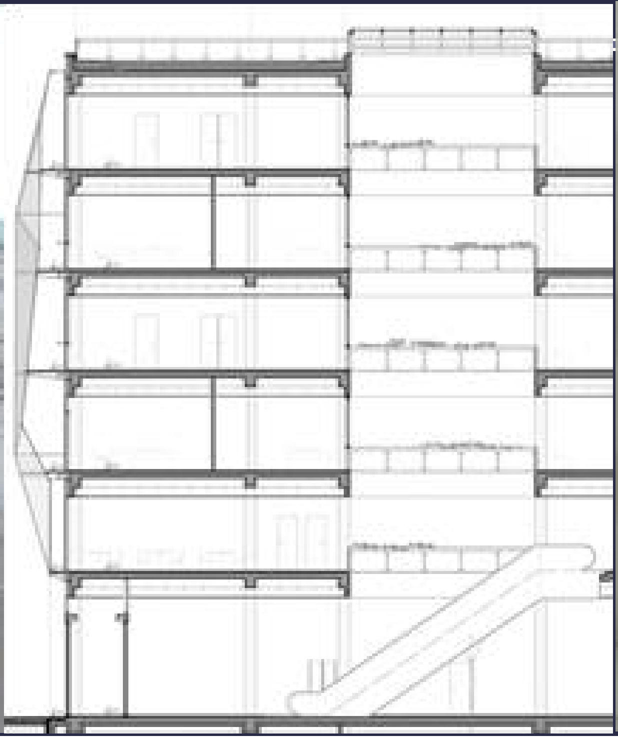
Characteristics of hypothetical models

For each hypothetical model three scenarios are created:

- basic scenario without shading devices and
- two scenarios of different envelope design regarding shading devices types:

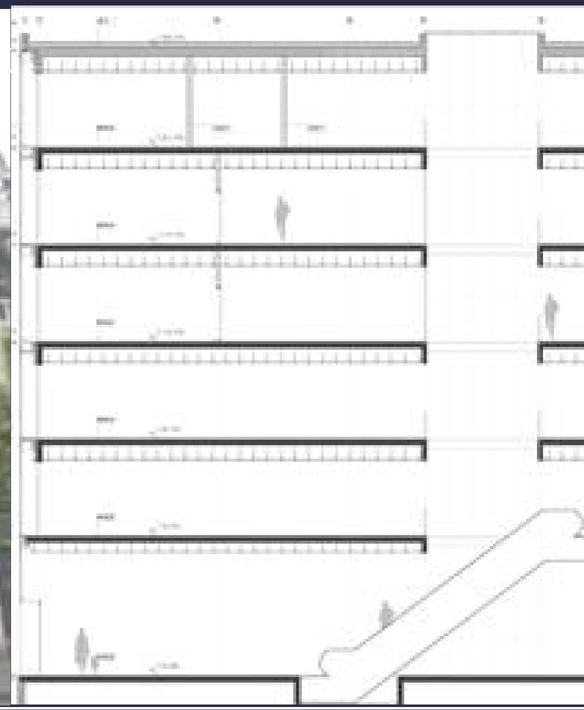
- Internal movable white blinds (temporary shading reduction factor 60%)
- external movable louvers inclined 45° (temporary shading reduction factor 10%)

MODEL M1



- Street glass façade - double glazed thermal insulating panels U=2.70W/m2K, the courtyard facade - massive structure U=0.28W/m2K; one more scenario is created - M1A that includes metal structure suspended in front of the glass facade as shading device;
- Flat roof;
- Not heated basement.

MODEL M2



- Street and courtyard facades – massive structure made of masonry walls with fibre-cement plates as finishing layer U=0.36W/m2K; windows - triple glazed panels with gas fills of argon U=0.63W/m2K; glass protection layer at distance of 65cm suspended in front of the street facade as noise protection;
- Flat roof;
- Not heated basement.

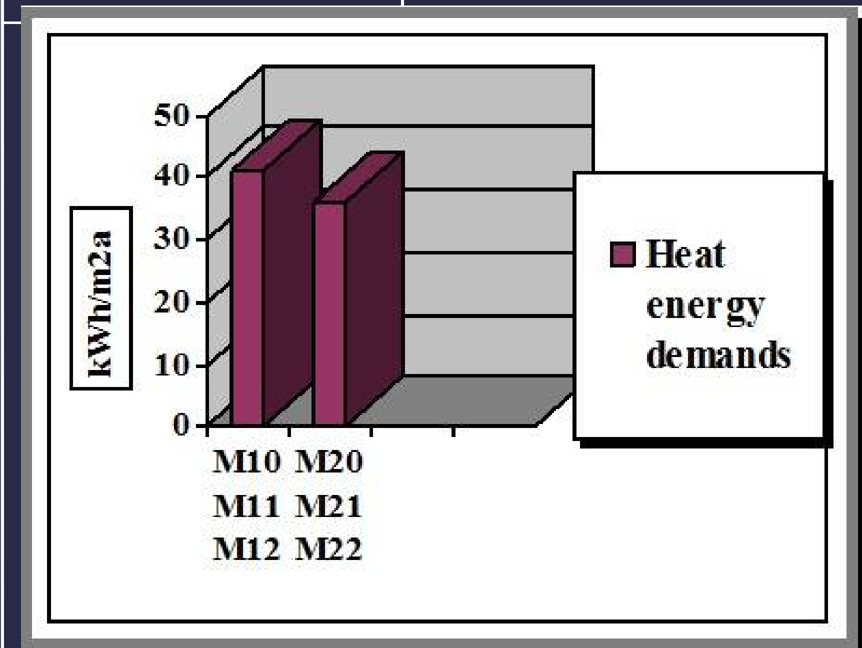
3. Comparison of the models ►

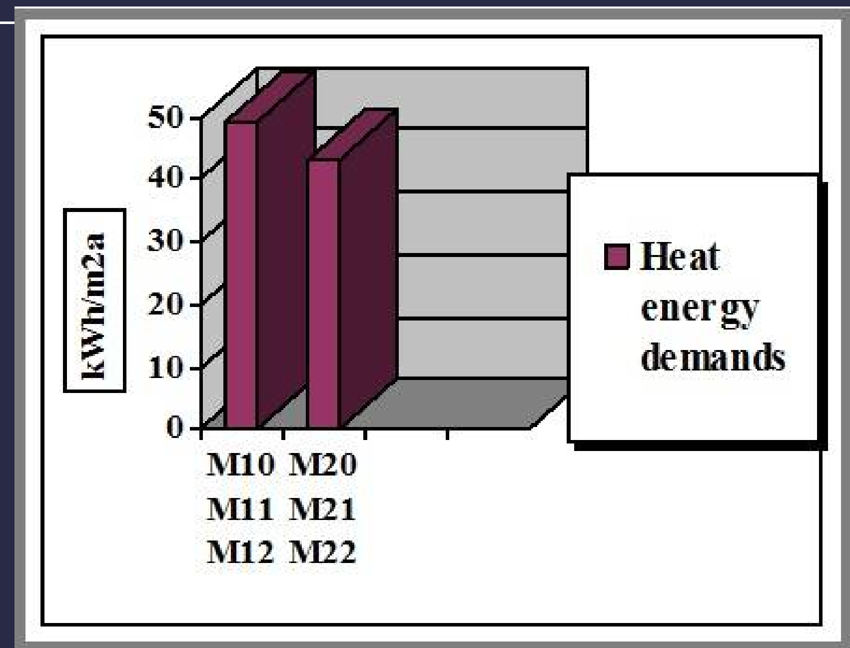
Comparative analysis of energy performances of design variants (different models and scenarios) is carried out according to:

- transmission losses,
- internal and solar gains,
- annual energy demands for heating (final and primary),
- annual energy demands for cooling (final and primary),
- reduction of energy consumption for cooling in summer period by implementation of shading devices,
- frequency of overheating and
- CO_2 emissions.

RESULTS

Final and primary energy demands for heating for model M1and M2



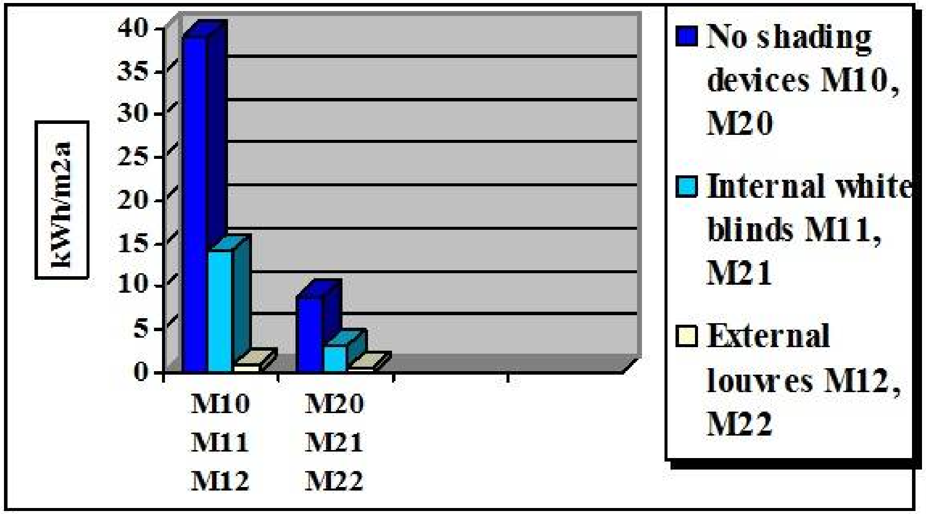


Conclusion: Despite significant differences in the facade concepts, heat demands are similar for the M1 and M2, as the solar gains are smaller in case of the M2 while transmission losses are higher in the case of the M1. The presence of a higher percentage of internal gains is in the case of the massive facade.

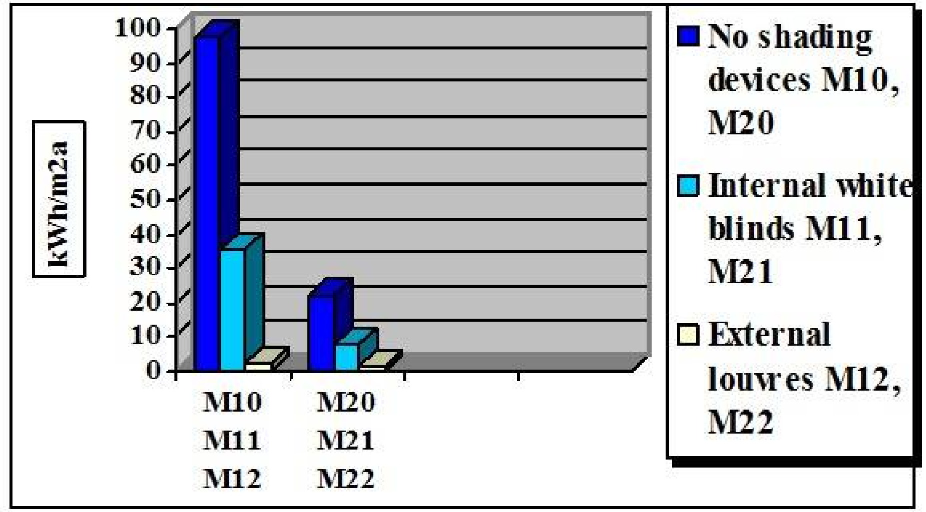
Note: By using the conversion factor of 1.2 for fuel oil as a heat source for space heating, the annual primary energy demands for cooling are calculated.

RESULTS

Final and primary energy demands for cooling for model M1 and M2, and various scenarios- diff. shading devices



Annual final energy dem. for cooling



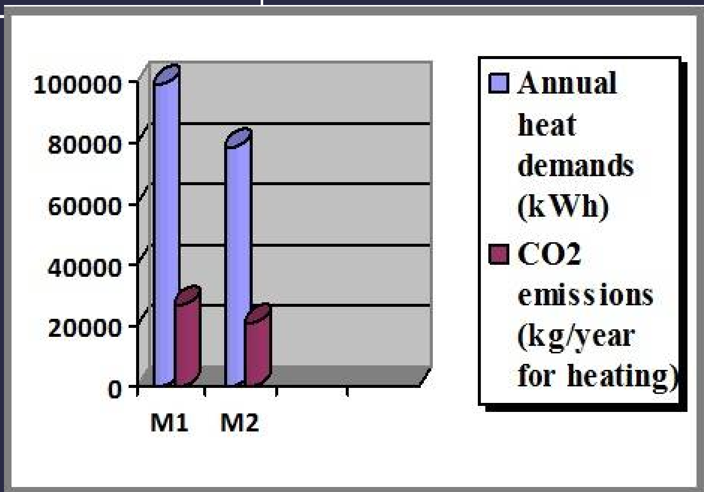
Annual primary energy dem. for cooling

Conclusion: The lowest frequency of overheating is in the case of traditional facade-11% and consequently the lowest primary cooling demands-22.5kWh/m^{2}a. In the case of glass facades frequency of overheating (almost 40%) and the primary cooling demands (98kWh/m^{2}a for M2) are much higher.

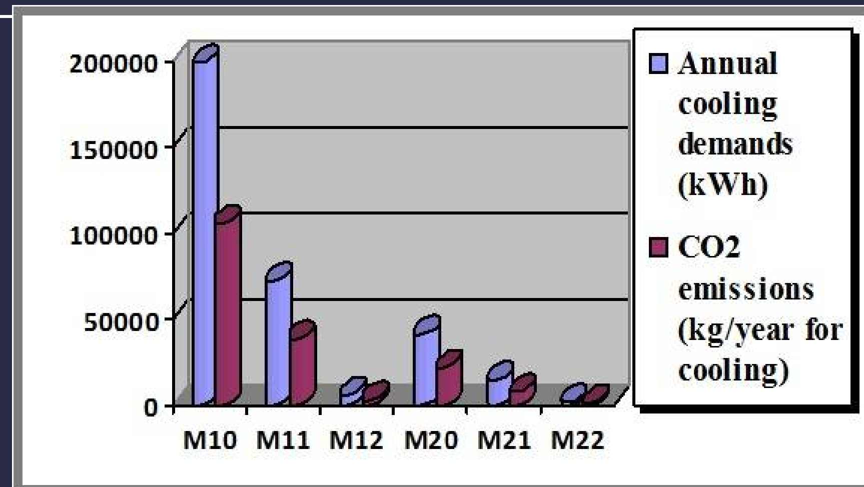
Note: By using the conversion factor of 2.5 for electricity as a heat source for space cooling, the annual primary energy demands for cooling are calculated.

RESULTS

Annual primary energy demands for heating and cooling and CO_2 emissions for models M1, M2, and various scenarios



Annual primary energy demands for heating and CO_2 emissions



Annual primary energy demands for cooling and CO_2 emissions

Conclusion: Due to the significantly greater conversion factor in case of electrical energy than fuel oil, annual primary energy demands for cooling are almost doubled in case of M1 in comparison to the annual primary energy demands for heating, while in case of M2 are twice lower regarding energy for heating. Consequently, significantly higher CO_2 emissions is for the cooling than for heating.

Note: Analysis of CO_2 emissions is conducted according to the Regulations on Energy Efficiency of Buildings (specific emission for fuel oil is 0.265 kgCO_2/kWh, while specific emission for electricity is 0.53 kgCO_2/kWh for Serbia).

4. Conclusions ►

- From the aspect of energy efficiency, office buildings with properly insulated massive facades are suitable for Belgrade climatic conditions contributing to low heat and cooling demands and thus CO_2 emissions.
- Significant reduction of frequency of overheating could be achieved by internal and external shading devices and thus the reduction of cooling energy demands and CO2 emissions, but still advantage of the massive facade is evident.
- Contribution of heat gains in reduction of the heat demands in the winter period is significant. In the summer period by night ventilation (night cooling) heat can be dissipated resulting in reduction of cooling demands.
- At the yearly basis, it is evident that design models M1 and M2 do not exceed the maximum value of annual energy consumption for heating for new office buildings of 55kWh/m^{2}a (according to the Regulations on energy efficiency of buildings).

Thank you for your attention