Example name: **PASSIVE TROMBE WALL (roof)**

Template completed by:
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Photographs

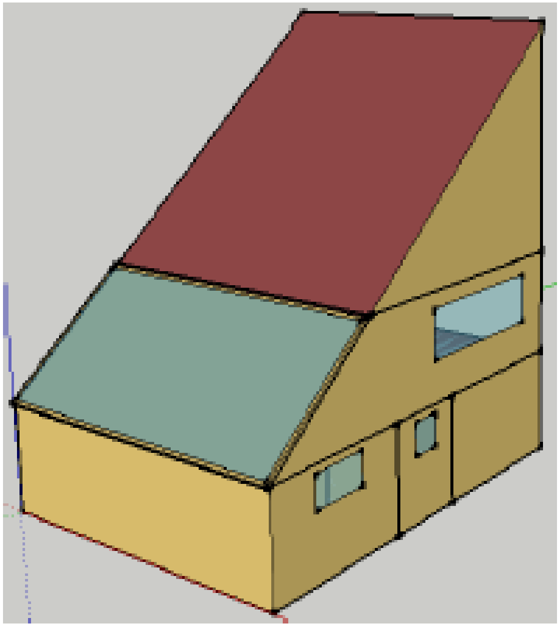


Figure 4. MODEL KTrZ

For installations

BISTS Location:
place=Belgrade, Serbia,
***longitude=* 20° 28' 5" E,**
***latitude=* 44° 49' 6" N**

Climate Type: *Köppen climate classification=Dfb*
Building Use: *Residential house*

Level of BISTS integration
Level 3. Visible, surface change

Ox New Build
O Refurbishment
O Other: ……………………

Type of BISTS:

Passive

Function(s):
Ox Air heating
Ox Cooling/ventilation/shading

Trombe wall as a passive solar system is set on the vertical and sloped south side of the house. Trombe wall consists of solid parts (reinforced concrete), a thickness of 30 cm and a thickness of three-layer glass (4, 18, 4; 13, 4) mm [12]. The glass structure is set at 10 cm of reinforced concrete. The front of reinforced concrete is painted in black.

Building element:

O Roof

BISTS characteristics:

Trombe wall consists of solid parts (reinforced concrete), a thickness of 30 cm and a thickness of three-layer glass (4, 18, 4; 13, 4) mm [12]. The glass structure is set at 10 cm of reinforced concrete. The front of reinforced concrete is painted in black.
To reduce winter night cooling of concrete, and in the summer day prevent it from overheating, and thous the rooms of the house, between the concrete and glass is placed blind [15]. It goes down at night in the winter, and in the summer by day.
For the one-year period frame, EnergyPlus simulation software showed that the highest specific energy of total electricity is for the house without Trombe wall (122.41 kWh/m2), then for the house with vertical Trombe wall (118.53 kWh/m2), for the house with a sloping Trombe wall (106.77 kWh/m2) and the lowest total specific consumption of electricity is for the house with 2 Trombe walls (104.24 kWh/m2). These results are shown in Figure 10.

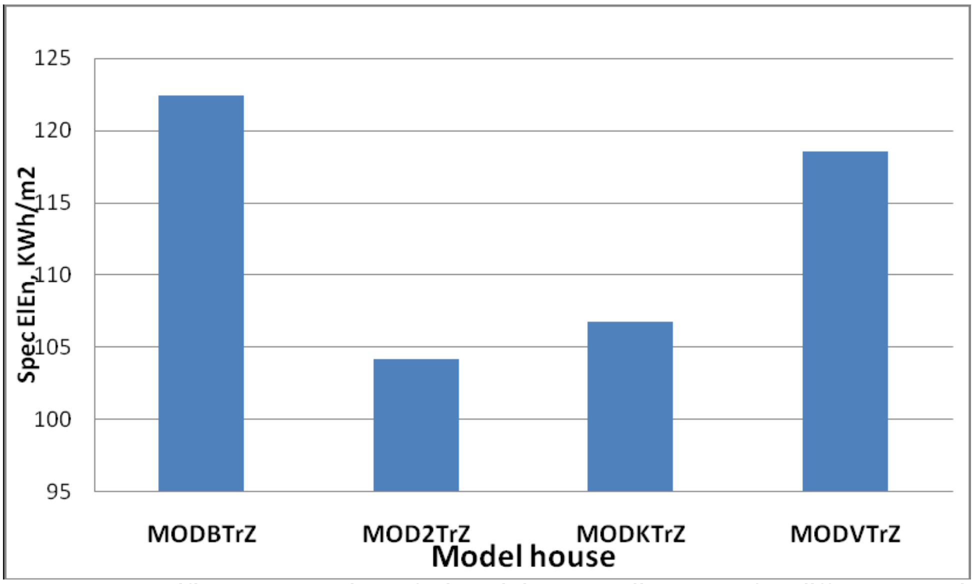


Figure 10. Specific consumption of electricity overall energy for different models

If it is considered only the use of electricity for heating, the results are as follows: the highest specific energy consumption for heating is the house without Trombe wall (56.30 kWh/m2), then the house with vertical Trombe wall (51.00 kWh/m2), for the house with a sloping Trombe wall (36.40 kWh/m2) and the lowest specific electricity consumption is for heating the house with 2 Trombe walls (32.83 kWh/m2). The results are presented in Figure 11.

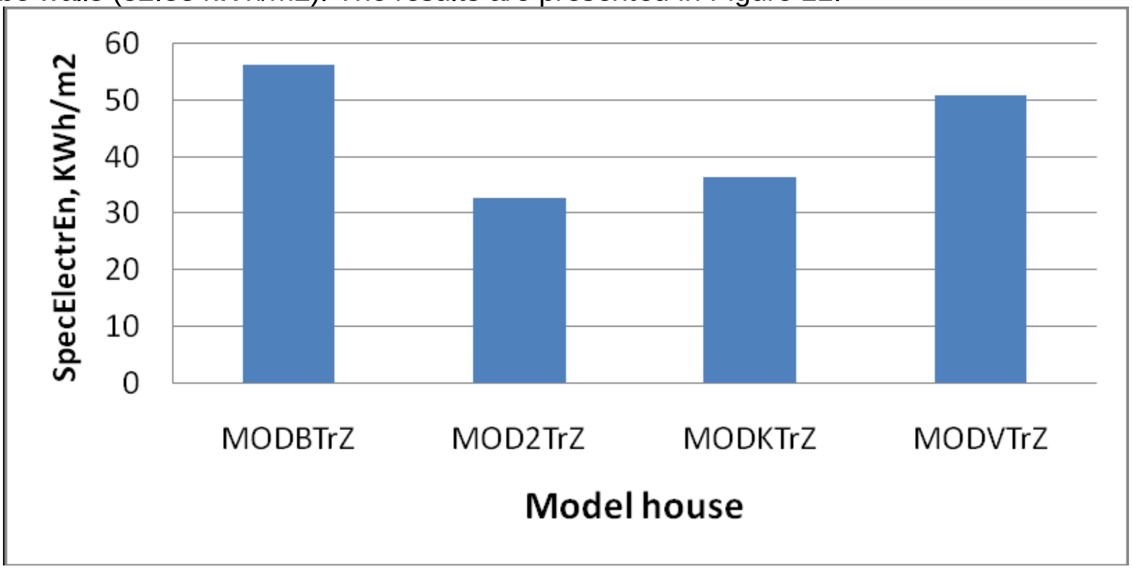


Figure 11. Specific consumption of electricity for heating

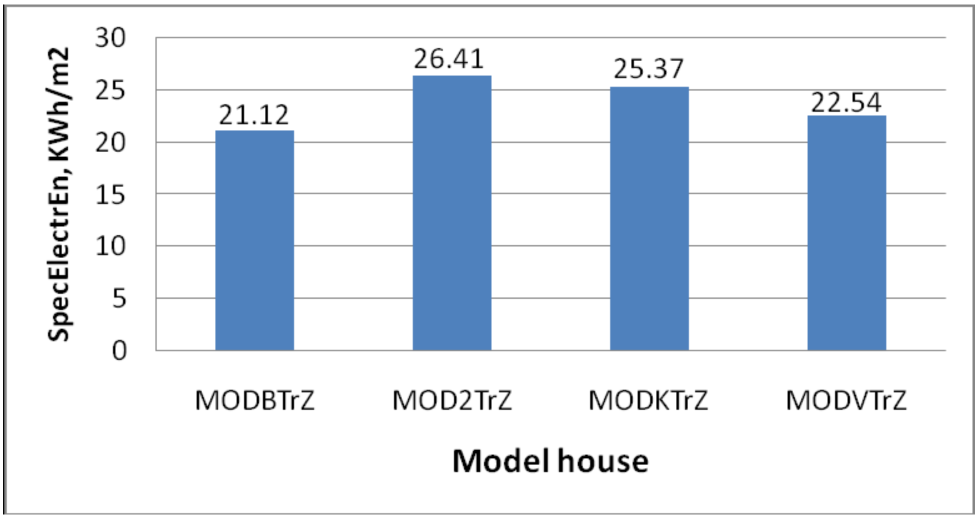


Figure 12. Specific electricity consumption for cooling

If it is observed the use of electricity for cooling results are as follows (Figure 12): the highest specific power consumption is for the house with 2 Trombe walls (26.41 kWh/m2), then for the house with a sloping Trombe wall (25.37 kWh/m2), for the house with vertical Trombe wall (22.54 kWh/m2) and the lowest power consumption is for cooling the house without Trombe wall (21.12 kWh/m2), as expected.
However, the positive influence of Trombe wall on heating, in the heating season, is much larger than its negative influence on cooling (overheating of the rooms), in the cooling season. This conclusion is confirmed by the following Figure 13, on which is shown the electricity consumption for heating and cooling aggregate for all models of houses.

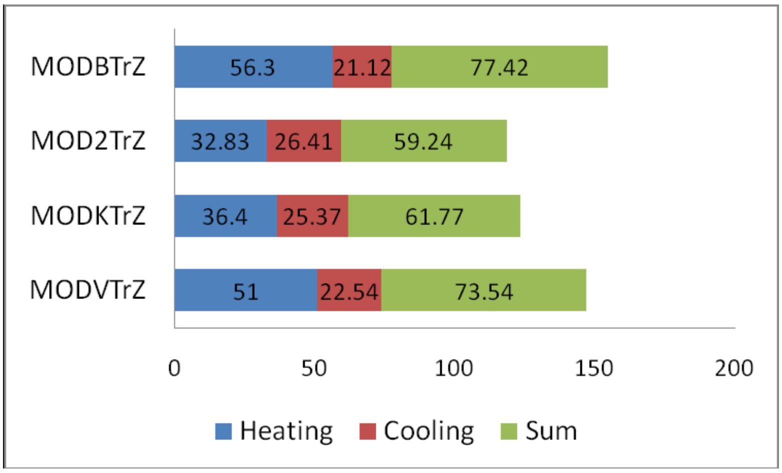


Figure 13. Specific energy consumption for heating, cooling and summary in KWh/m2

Stage of Development: **Responsible:** *Faculty of Engineering, University of Kragujevac, Serbia.*

Ox Idea/Patent ……………………………………..

BISTS description and context

Modelians are four net zero energy houses. The basic model for the simulation is a house without Trombe wall (MODEL BTrZ). The simulation was performed for models of houses with a vertical Trombe wall (MODEL VTrZ), for a model home with a sloping Trombe wall (MODEL KTrZ) and for a model with both of these Trombe walls (MODEL 2TrZ).

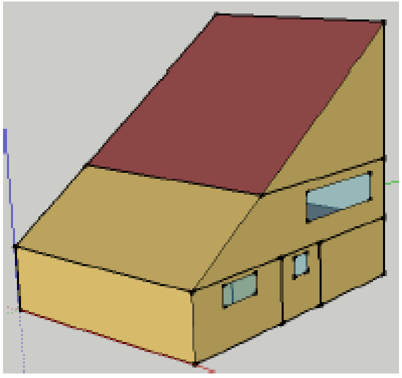


Figure 2. MODEL BTrZ

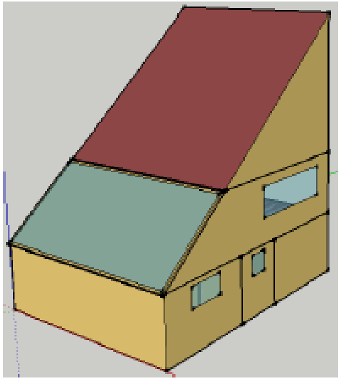


Figure 4. MODEL KTrZ

Each of the models of net zero energy house consists of six rooms that are heated (living room, two bedrooms, bathroom, hall and floor), and four rooms are cooled (living room, two bedrooms and first floor). The cross sections of the house for the ground floor and upper floor of the house are shown on the following pictures:

Figure 6. Cross section of the ground floor of the house in 3D

Figure 7. Cross section of the ground floor of the house in 2D

The electricityis used for heating and cooling. Electric heat is done by the Norwegian radiators series ADAX NEO. For cooling are used split air conditioners of LG. At each heating body and room conditioner exists thermostatic valves in order to save energy.

System viability

Economic viability-not calculated, maintenance-not calculated, embodied energy- not calculated, environmental impact and sustainability- not calculated. Wider social contexts- not calculated

Modelling and simulation tools developed/used

Houses with heating system, cooling system and Trombe walls, are modeled using the software Google SketchUp and software EnergyPlus.

These two software are connected by Google SketchUp provides a net zero energy house geometry, which is simulated in the EnergyPlus. The EnergyPlus has no graphical user interface for a graphical definition of the geometry and graphical presentation of results, so there is a need to use the programs to construct a net zero energy house and to show the calculation results. For this purpose, the Google SketchUp with the addition OpenStudio and Microsoft Excel have been used.

To simulate the heating, cooling, ventilation, lighting, and other energy flows in the net zero energy house was used in version 7.0.0 and EnergyPlus. This software models the energy use in a particular home. EnergyPlus takes into account all the factors that affect the thermal load of the house, such as electrical appliances, lighting, the presence of people in the house, the influence of solar radiation, wind influence, infiltration, shading open spaces. This software allows us to perform a simulation of the energy behavior of net zero energy house over a defined period of time.

BISTS Performance data Based on: Ox Detailed simulation EnergyPlus, *Specify software(s) used* O Measurement/testing O Long-term monitoring *tick all that apply* **Performance parameters** For integrated systems: key performance indicators - *Solar savings fraction: %* *Light transmittance: %* *Solar transmittance: %* *Total solar energy transmittance: %:* *Solar heat gain factor: %* *Building fabric U-values: W/m^{2}K* *Noise, fire, etc ratings* *Other:* For separate collectors: performance rating coefficients - (EN12975, a0,a1,a2), ASHRAE, etc	In this labor, the results of the effect of the Trombe wall on electric heating and cooling net zero energy house are shown. On heating and air conditioning bodies are thermostatic valves to regulate the room temperature and energy savings. Heating and cooling of four model houses have been modeled. The simulation is done for the whole year. The heating season lasts from October 15th till April 15th following the calendar year, and the season of cooling from April 15th till October 15th of the same year. Simulation results are obtained and displayed every 15 minutes. In addition to the basic model (house without Trombe wall), heating and cooling simulation was performed for the models of houses with vertical Trombe wall, for the house model with a sloping Trombe wall, for the house model with both Trombe walls. Based on the simulation results it can be concluded that the savings of the total electricity generated with the house model with vertical Trombe wall on facade is 12.78%. Energy savings is much higher if one considers only its consumption for heating: for the house model with vertical Trombe wall on facade it is 35.35%.

Additional information:

Sources and references:

[1] D. Crawley, L. Lawrie, F. Winkelmann, W. Buhl, Y. Joe Huang, C. Pedersen, R. Strand, R. Liesen, D. Fisher, M. Witte, J. Glazer, EnergyPlus: creating a new-generation building energy simulation program, Energy and Buildings. 33 (2001) 319-331.

[2] Website – http://en.wikipedia.org/wiki/SketchUp, [accessed 18.3.2012].

[3] Jovan Malesevic, Milos Milovanovic, Slobodan Djordjevic, Milorad Bojic, Nebojsa Lukic, The influence of the trombe wall on energy consumption for heating and cooling of net zero energy house, 7th International Quality Conference, May 24th 2013 Center for Quality, Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia, www.cqm.rs

INSTRUCTIONS

Please fill in as much information as possible.

Tick where appropriate.

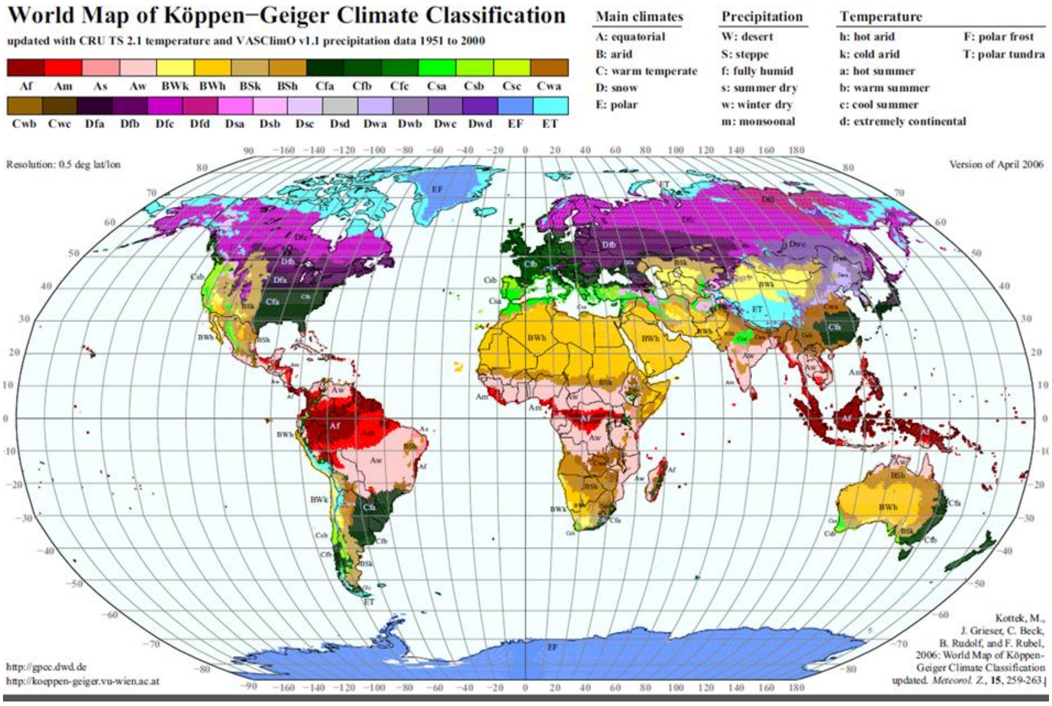
Text in red is suggested guidance. Insert information in provided space, removing red text as appropriate

If possible, use metric values.

If necessary, supply additional information on separate sheets

Reference listing

Köppen climate classification



(Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006: World Map of Köppen-Geiger Climate Classification updated. Meteorol. Z., 15, 259-263.)

Reijenga classification

The integration of PV systems in architecture can be divided into five categories:

1. Applied invisibly
2. Added to the design
3. Adding to the architectural image
4. Determining architectural image
5. Leading to new architectural concepts.

(Reijenga, TH and Kaan, HF. (2011) PV in Architecture, in Handbook of Photovoltaic Science and Engineering, Second Edition (eds A. Luque and S. Hegedus), John Wiley & Sons Ltd, Chichester, UK)

Rush classification

The architectural/visual expression of building services systems are identified as:

Level 1. Not visible, no change
Level 2. Visible, no change
Level 3. Visible, surface change
Level 4. Visible, with size or shape change
Level 5. Visible, with location or orientation change

(Rush, RD. (1986) The Building systems integration handbook Wiley, New York, USA)

Collector test standards

BS EN 12975-2 2006 'Thermal solar systems and components solar collectors - Part 2 test methods'

ASHRAE Standard 93-2010 ‘Methods of Testing to Determine the Thermal Performance of Solar Collectors’
ASHRAE Standard 95-1987 ‘Methods of Testing to Determine the Thermal Performance of Solar Domestic Water Heating Systems’