Mogućnost primene plafonskog sistema grejanja za zagrevanje sportkih dvorana

POSSIBILITY OF APPLICATION OF RADIANT CEILING SYSTEM FOR HEATING SPORTS HALLS

DRAGAN CVETKOVIĆ, ALEKSANDAR NEŠOVIĆ, JASMINA SKERLIĆ, DANIJELA NIKOLIĆ

Fakultet inženjerskih nauka u Kragujevcu, Univerzitet u Kragujevcu

dragan_cw8202@yahoo.com

1. Introduction

The low temperature panel heating system offers special benefits in terms of heat comfort and energy consumption, which allows for its combination with lower temperature sources (for example: ground heat). Such systems, however, are not suitable for the heating of large buildings, such as sports hall.

This study analyzes the possibility of implementing a radiant panel ceiling heating system with a gas boiler for heating a sports hall located in Belgrade, Serbia. The aim of the paper was to show that the temperature at the entrance to the ceiling panel affects the ambient conditions in the sports hall, with a temperature range of 40 to 90°C. This paper analyzes the behavior of the mentioned heating system and depending on the value of the heat transfer coefficient of the elements of the thermal coating (carpentry, roof and external walls).

The research was carried out numerical simulation of dynamics of building energy performance BPS (Building Performance Simulation) using the EnergyPlus software package.

2. Description of the analyzed building

The subject of research is a standard sports building (Figure 2.1). The building has a sports hall and a large number of additional rooms, including locker rooms, showers, toilets, etc. The net area of sports is 1130 m2.

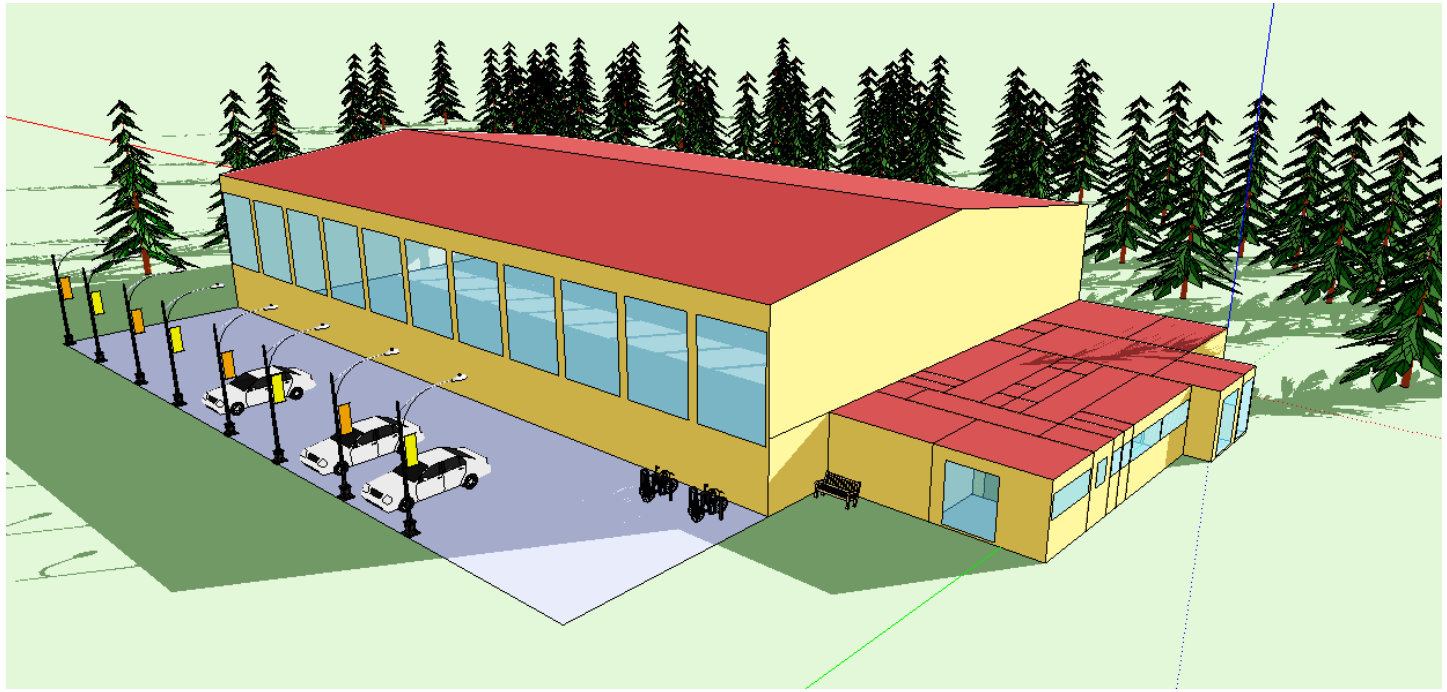

Fig. 2.1 – Analyzed building

Table 2.1 – Thermal characteristics of the building constructions

Construction	U [W/m2K]
Ground floor	0.32
Roof	0.31
Exterior wall	1.8
Window	2.72

3. Location of the building

Table 3.1 – Cilmate data for Belgrade

Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Insolation [kWh/m²/day]	1.31	2.15	3.27	4.36	5.46	5.95	6.03	5.41	3.80	2.49	1.46	1.10
Temperature [°C]	0.64	1.75	6.24	11.96	17.68	20.85	3.39	3.60	8.71	3.26	6.41	1.48
Wind speed [m/s]	4.02	4.39	4.40	4.35	3.85	3.68	3.63	3.44	3.54	3.71	3.99	4.15
Precipitation [mm]	47	44	46	56	71	91	67	53	51	46	57	59

4. Mathematical model

4.1 Panel heating system

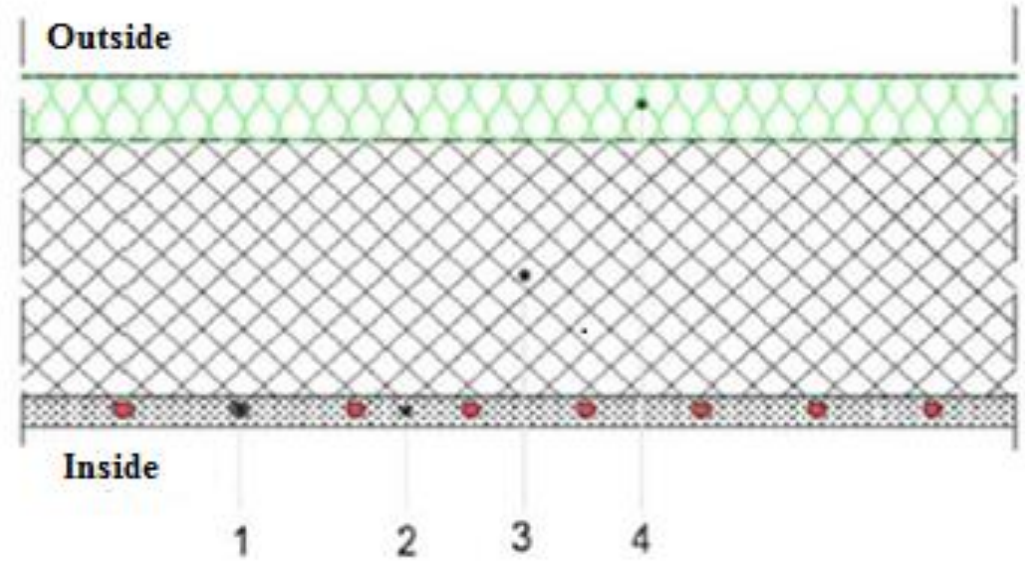

Fig. 4.1 – Construction of a ceiling panel
1 - Heating serpent, 2 - Mortar, 3 - Hollow block, 4 - Styrofoam

4. Mathematical model

4.2 Energy consumption for heating sports halls

$$E_{SYS} = E_{NG} + R \cdot E_{EL}$$

E_{NG} [kWh] - Consumption of natural gas during the heating period;
E_{EL} [kWh] - Consumption of electricity for heating the object during the heating season;
R [-] - Coefficient of primary energy transformation(R=3.61 [26]).

4. Mathematical model

4.3 Scenario simulations

Table 4.3 – Scenario simulations

Construction	U [W/m2K]				
	Scenario I	Scenario II	Scenario III	Scenario IV	Scenario V
Ground floor	0.32	0.32	0.32	0.32	0.32
Roof	0.31	0.31	0.14	0.31	0.14
Exterior wall	1.8	1.8	1.8	0.26	0.26
Window	2.72	1.32	2.72	2.72	1.32

5. Results

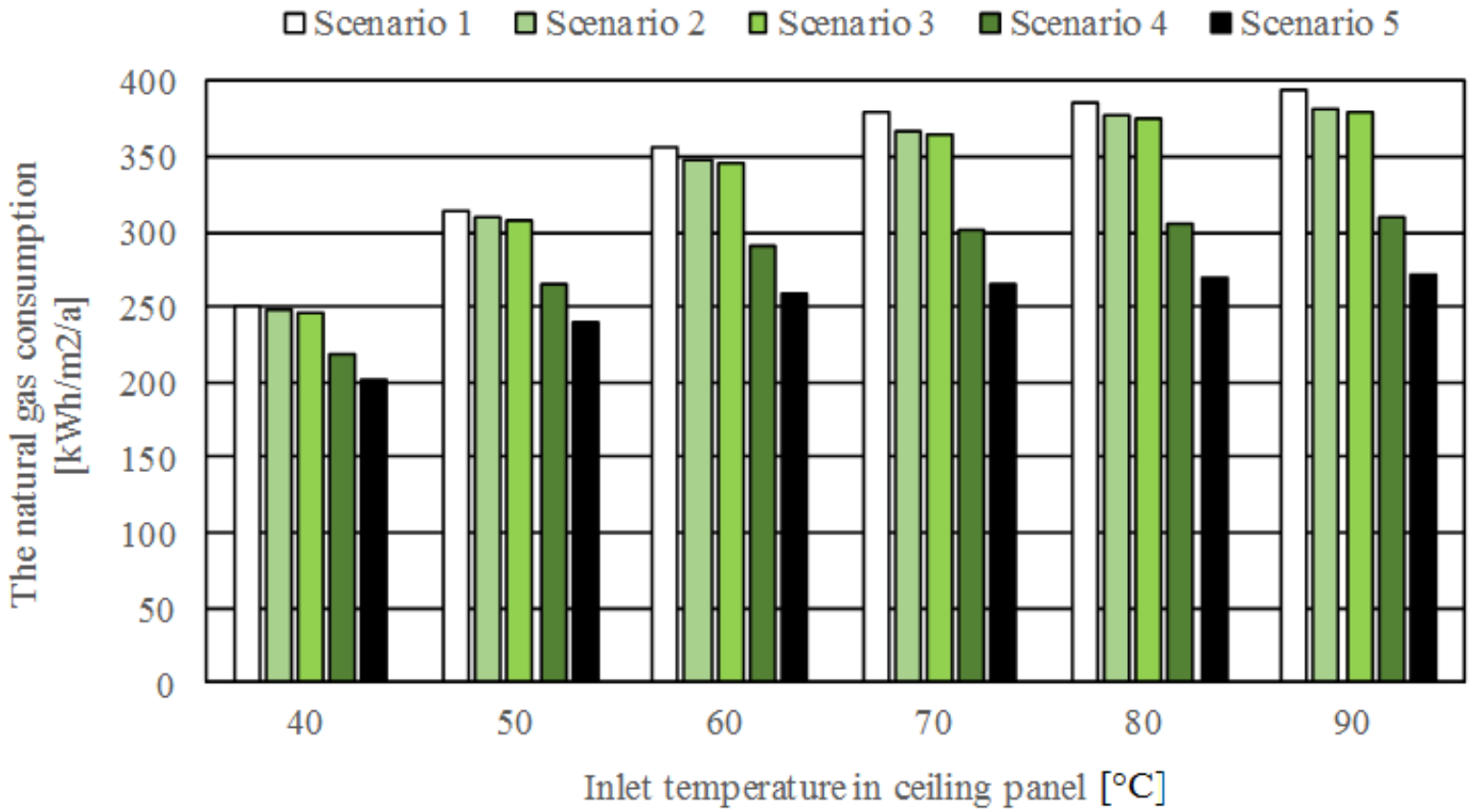

Fig. 5.1 – Consumption of natural gas for heating sports hall during the heating season

5. Results

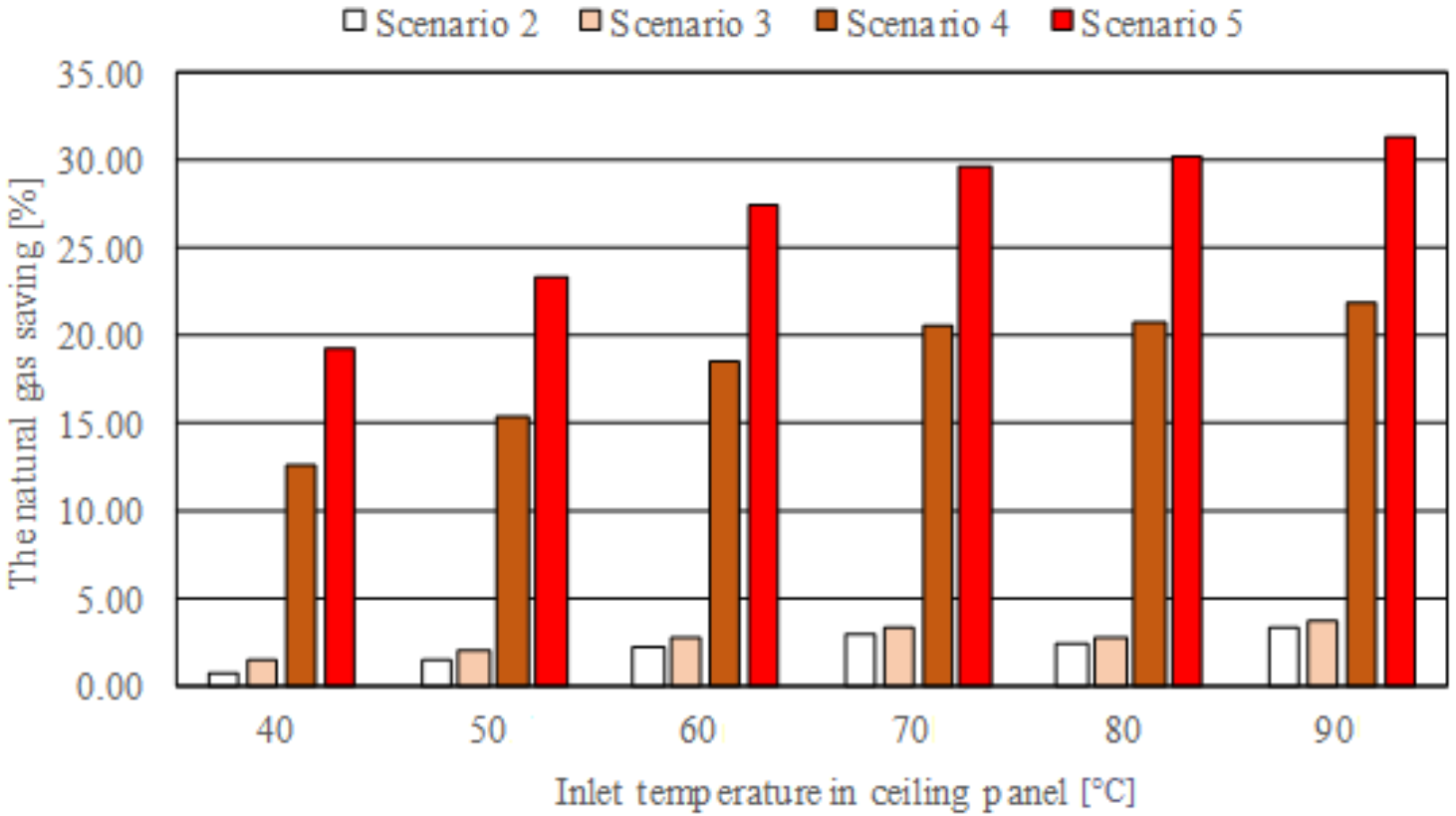

Fig. 5.2 – Percentage savings during the heating season

5. Results

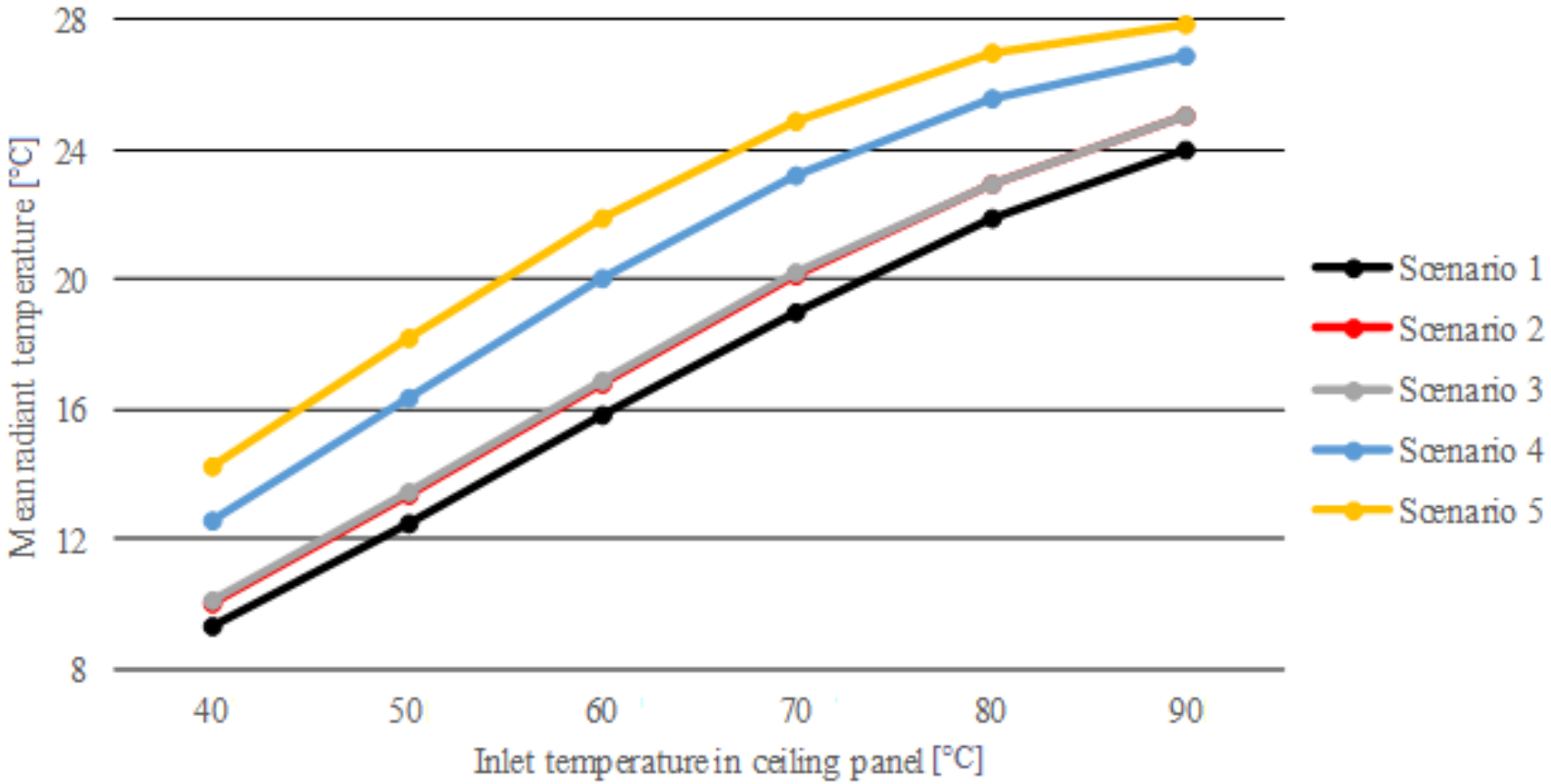

Fig. 5.3 – Mean Radiant Temperature in sports hall (12.24)

5. Results

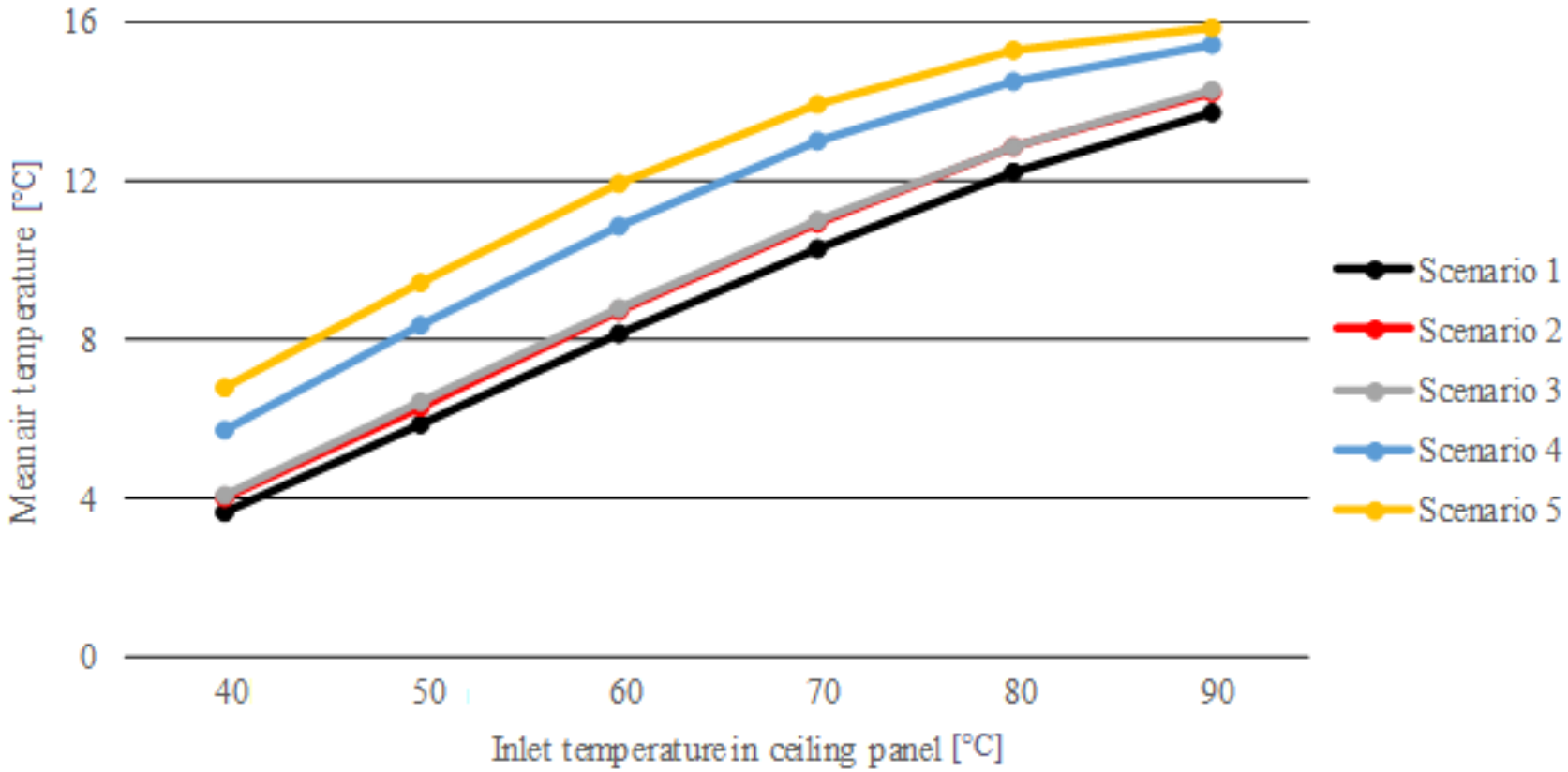

Fig. 5.4 – Mean Air Temperature in sports hall (12.24)

5. Results

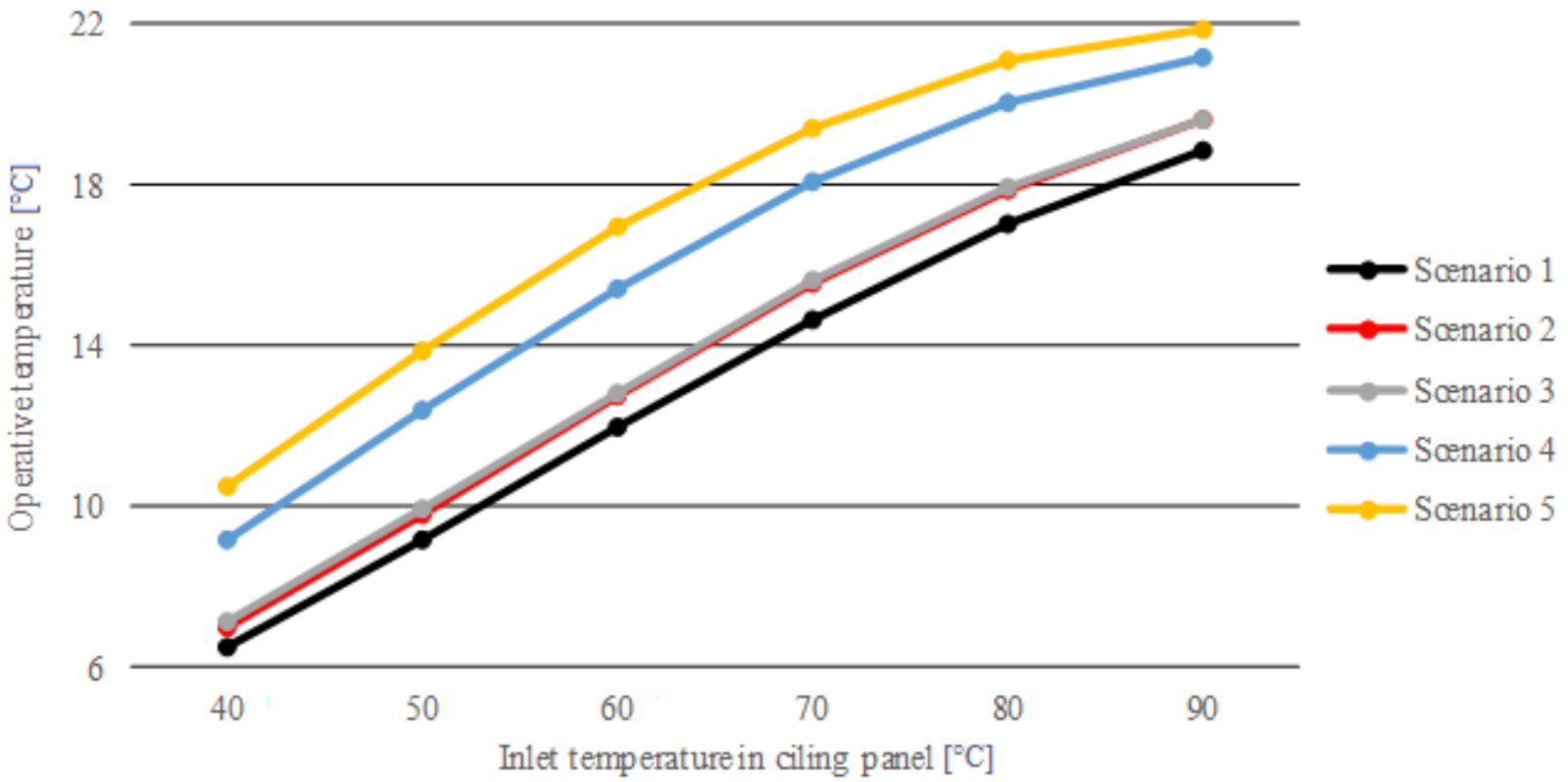

Fig. 5.4 – Operative Temperature in sports hall (12.24)

6. Conclusion

An analysis of the influence of the inlet temperature of the working fluid (water) into the ceiling panel and the construction of various construction elements on the consumption of natural gas and temperature inside the heated space was performed. A thermal gas boiler was used as a source of heat. The circulation of water through the heating system provides a circulation pump. The analyzed sports hall is located in the city area of Belgrade, where the architecture of the building represents a typical construction for this type of buildings in Serbia.

The heating system with an input temperature of 40°C has lower energy consumption, while the system with an input temperature of 90°C has the highest energy consumption.

However, adequate ambient conditions (operating temperature) are not achieved with an input temperature of 40°C. The first temperature that meets the operating conditions of 18°C is a central system with an input temperature of 85°C. In order to reduce energy consumption for heating, i.e. lowering the input temperature, measures such as carpentry replacement and roof insulation can be applied (the input temperature is then lowered to about 80°C. If the outer walls are insulated, the input temperature can then be about 70°C. The best results are obtained by combining all of the aforementioned measure, allowing the water temperature at the entrance to the ceiling panel to be about 65°C.