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Research Article

Energy Efficient Building Systems For Urban Transformation Projects: Case Study

Vail Karakale[1], Ismail Eekmekci[2], Nevzat Sadoglu[3]

[1] Professor, PhD, Civil Engineering Department, Faculty of Engineering and Natural sciences, Istanbul Medeniyet University, Unalan Mah, Unalan Sok, D100 Karayolu yanyol 34700, Uskudar /Istanbul, Turkey

[2] Prof.Dr: Faculty of engineering, Istanbul Commerce University Istanbul, Turkey

[3] Energy expert Endustriyel Enerji San Tic Ltd Sti,Istanbul, Turkey

Abstract: In last decades uncontrolled rapid urbanization in Turkey led to existence of squatter areas and disaster-vulnerable building stocks. After 1999 Marmara earthquake urban renewal has become the base of urbanization politics and planning agenda in Turkey. Turkish building industry usually uses RC buildings in the urban renewal projects. In recent years cold formed steel CFS and 3D panel building systems due to its lightweight, fast constructed, energy efficient , and economy start to be used as an alternatives to reinforced concrete buildings especially in seismic areas. In this paper energy performance of three building systems were investigated on a case study school building. Analysis results shows that 3D panel and CFS buildings systems will established with 59% and 36% less energy requirements with respect to traditional reinforced concrete non-insulated buildings.

Keywords: Building systems; Energy efficiency; CFS buildings ;3D panel.

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Corresponding author: Vail Karakale, vail.karakale@medeniyet.edu.tr

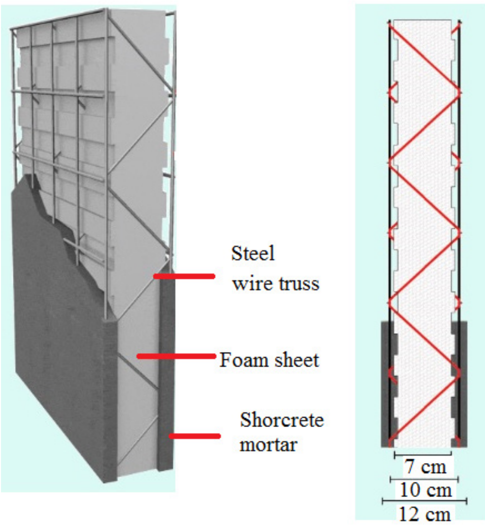
1 Introduction

With increasing urbanization especially in developing countries, the number and size of buildings in urban areas will increase, resulting in an increased demand for electricity and other forms of energy commonly used in buildings. With increasing electricity demand, new generation needs to be brought in. Although renewable sources of electricity such as hydro, geothermal or wind provide electricity at a much lower cost, their capital outlay is large, they are complex and take much longer to implement. Approximately 30% of a country energy is consumed in buildings so that conservation of energy is become very important and urgent need. To conserve energy, it is essential to make energy efficient (EE) buildings and re-examine and modify the existing buildings. The EE of a building is defined as the extent to which the energy consumption per m2 of floor area of the building measures up to established energy consumption benchmarks for that building under defined climatic conditions. Energy efficiency measures are meant to reduce the amount of energy consumed while maintaining or improving the level of comfort in the building; among the benefits arising from energy efficiency investments in buildings are: reducing energy use for space heating/cooling and water heating; reduced electricity use for lighting, office machinery and domestic appliance ;lower maintenance requirements; enhanced property value[1,3]. Buildings with improved efficiency create up to15% more profits and 4 % higher tenure rates than without energy efficient buildings. Retrofitting can save owners 10 to 50% in energy expenses and energy-efficient investments in lighting are as high as 85 percent[2,4]. Improving the insulation of the building fabric will reduce the heating and cooling energy demand. In recent years in Turkey new building materials and building systems such as

Cold formed steel and 3D panels building systems start to be used to reduce buildings energy demand. The 3D panel consists of a welded wire space truss integrated with a polystyrene core sheet, with shotcrete concrete applied from both sides of the polystyrene sheet to convert the panel to a structural wall. A general view and cross-sectional details of the 3D panel is given in Figure 1. Cold-Formed Steel (CFS) structural systems are increasing used in Turkey especially in seismic areas, where they have found a brilliant and diffused application in low-rise residential and commercial constructions as shown in Figure 2. In this paper the energy efficiency of a two-story school building made of three building system materials were investigated. The first building system is a cold form steel building system, the second is a 3D panel building system the third is a reinforced concrete building system with and without insulation materials on its exterior walls.

2. Case study school building

The case study in this research is two story school building located in the city of Istanbul. The building is approximately 1152 square meters, and with a constant story heights of 3.1 m. Story plans are identical, and the foundation system is a continuous footing system. The first story plan, front view, and an elevation view and a cross section are shown in Figure 3a, Figure 3b, and Figure 4, respectively.



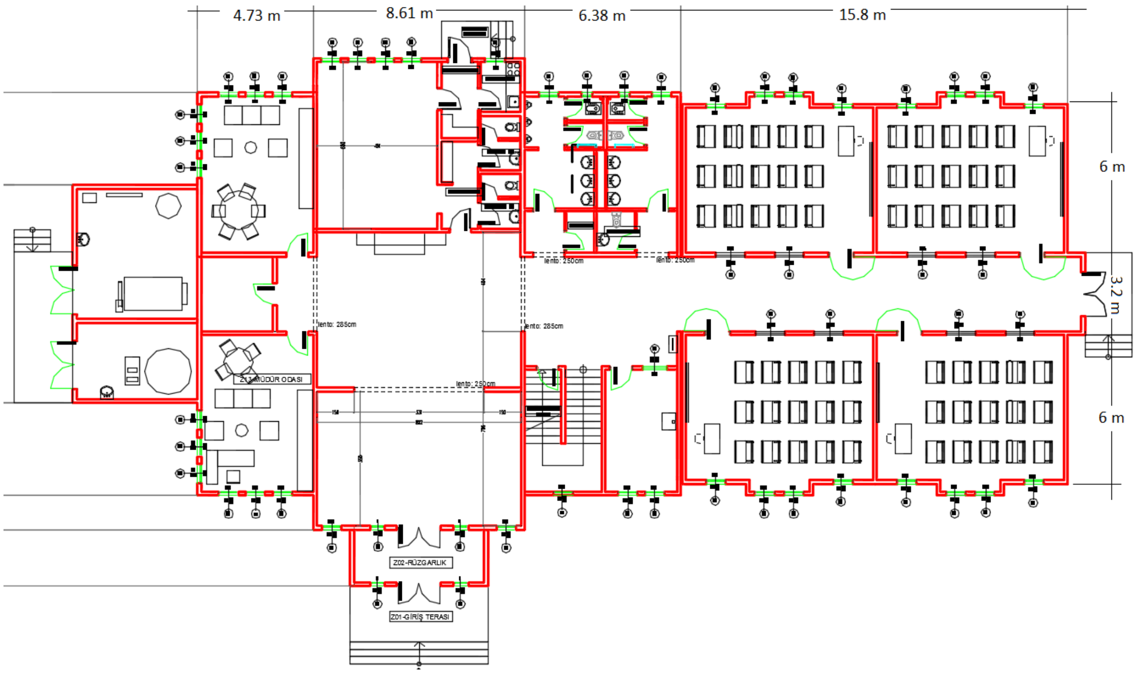
3D view   Cross Section

Figure 2. Cold formed steel building system

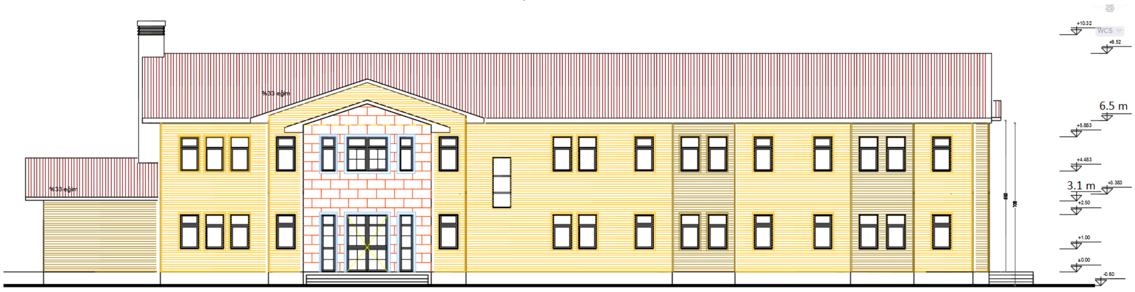
a.Before

b. After

Figure 2. Cold formed steel building system



a)Plan view



b)Front view

Figure 3. School plan and front view

3. Energy model simulation

In this study the effect of building system type on the annual energy consumptions of the case study school building were investigated. The first building system is a cold form steel building system, the second is a 3D panel building system the third is a reinforced concrete building system with and without insulation materials on its exterior walls. The wall cross section details of each building system is given in Figure 5. For each case the annual heating energy consumptions have been calculated according to TS825 standard (Turkish Standart for Thermal insulation requirements for buildings-May2008) by using appropriate code of Heat Water Sound and Fire Insulator Manufacturers' Association. Heating Energy Consumption Loads for educational buildings have been simulated monthly for Istanbul city of Turkey and outside temperature has been taken as -3°C regarding for the TS825. Only winter months loads have been considered for the annual total heating load values and monthly heating loads calculated by using degree-day values as given in TS825 and one of example page of resulting calculation has been given in Table 1.

4.Analysis results

The analysis results for each building system (i.e each type) is given in Tables 1,2,3,4 and Figure 6,7,8,9 given below. For comparison all the results are compared in Table 5.

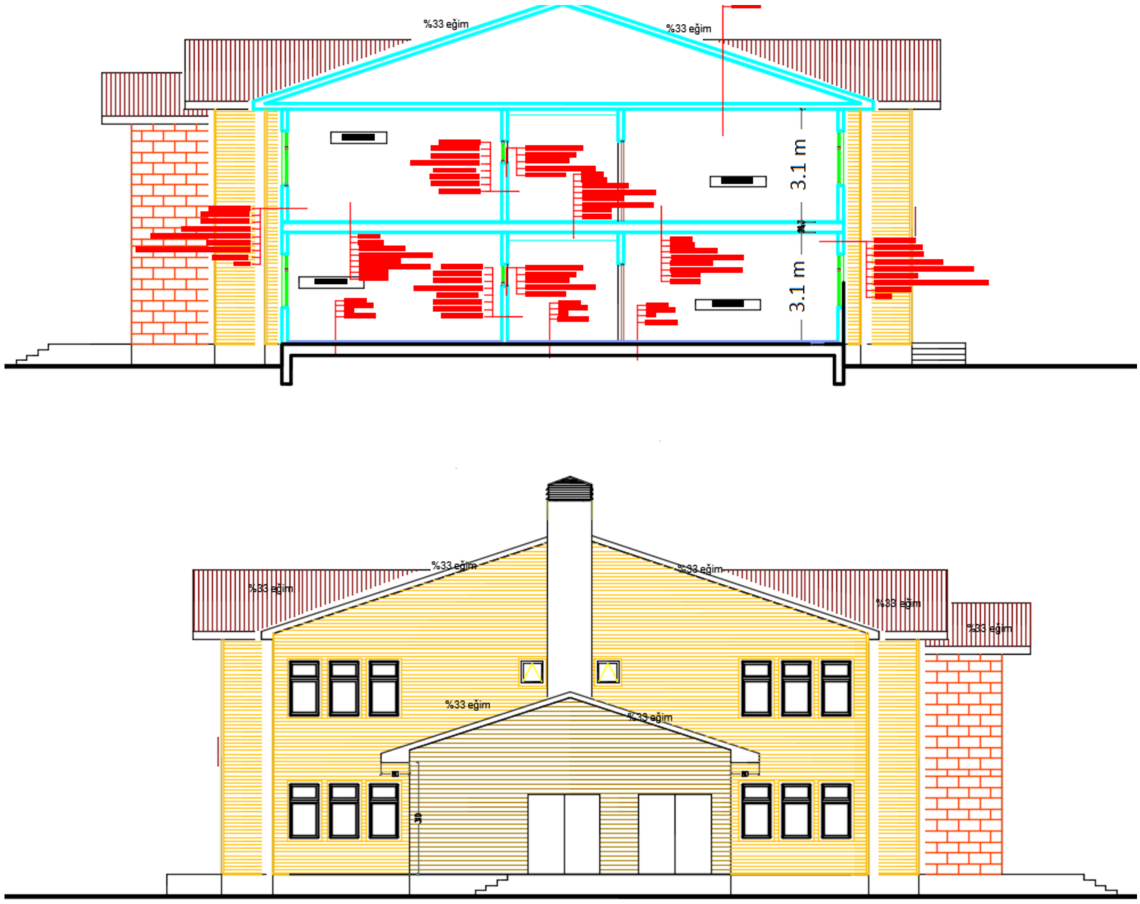


Figure 4. Side view and a cross section

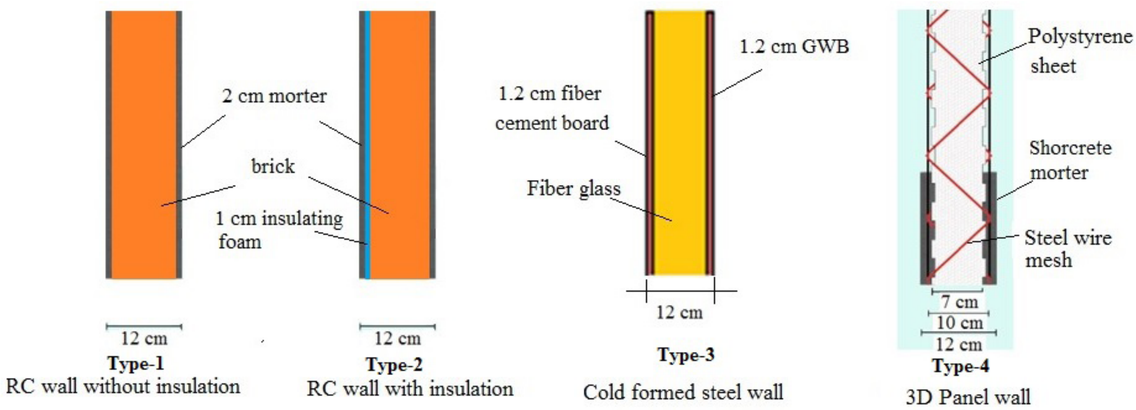


Figure 5. Cross sections of the external walls for different building systems

Table.1 Monthly and Annual Heating Load Values for Type-1 wall section

Monthly Heating Energy Consumptions for Type-1			
Months	Energy Consumption	Unit	Annual Percentage
January	62.683,67	kW	20,69%
February	56.087,44	kW	18,51%
March	43.625,61	kW	14,40%
April	21.187,32	kW	6,99%
May	2.770,89	kW	0,91%
June	-12,85	kW	
July	-12,64	kW	
August	-11,99	kW	
September	-9,43	kW	
October	17.159,43	kW	5,66%
November	40.203,12	kW	13,27%
December	59.291,61	kW	19,57%
Annual Heating Load	303.009,10	kW	100,00%
Annual Cooling Load	2.817,80	kW	

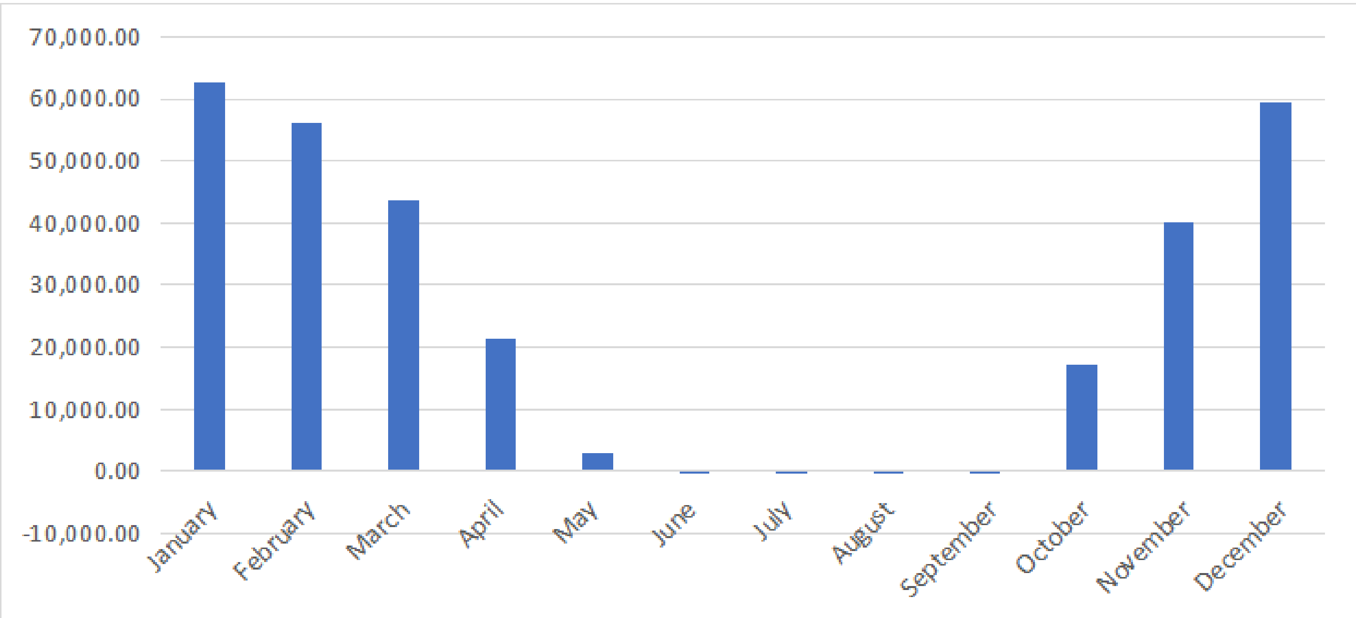


Figure 6. Monthly Heating Loads (kW) Graph for Type-1 wall section

Table 2. Monthly and Annual Heating Load Values for Type-2 wall section

Monthly Heating Energy Consumptions for Type-2			
Months	Energy Consumption	Unit	Annual Percentage
January	56.596,22	kW	19,14%
February	50.930,30	kW	17,22%
March	40.261,75	kW	13,62%
April	20.982,88	kW	7,10%
May	17.791,92	kW	6,02%
June	-6,62	kW	
July	-6,41	kW	
August	-5,74	kW	
September	-4,42	kW	
October	17.791,92	kW	6,02%
November	37.577,83	kW	12,71%
December	53.762,30	kW	18,18%
Annual Heating Load	295.695,12	kW	100,00%
Annual Cooling Load	17.815,10	kW	

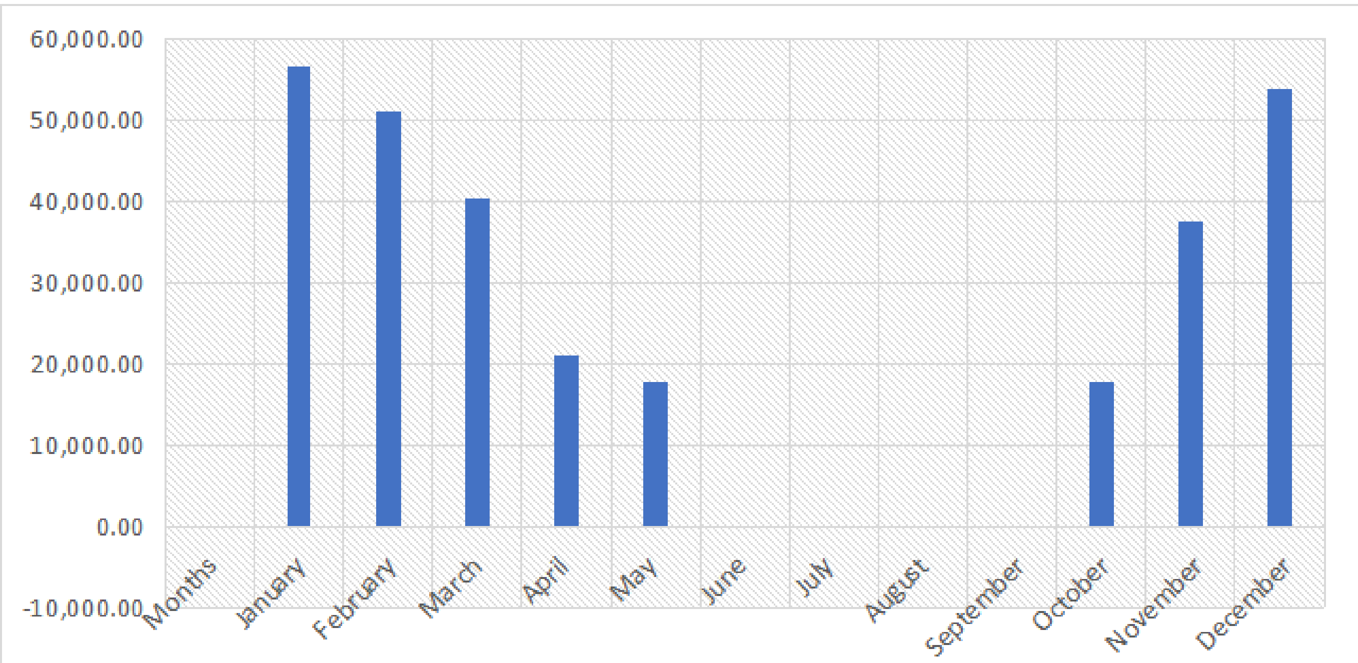


Figure 7. Monthly Heating Loads Graph for Type-2 wall section

Table 3. Monthly and Annual Heating Load Values for Type-3 wall section

Monthly Heating Energy Consumptions for Type-3			
Months	Energy Consumption	Unit	Annual Percentage
January	12.381,21	kW	23,05%
February	10.455,87	kW	19,46%
March	7.239,08	kW	13,47%
April	2.771,37	kW	5,16%
May	-12,43	kW	0,00%
June	-12,85	kW	0,00%
July	-12,64	kW	0,00%
August	-11,66	kW	0,00%
September	-9,43	kW	0,00%
October	2.211,65	kW	4,12%
November	7.021,07	kW	13,07%
December	11.643,80	kW	21,67%
Annual Heating Load	53.724,05	kW	100,00%
Annual Cooling Load	59,00	kW	

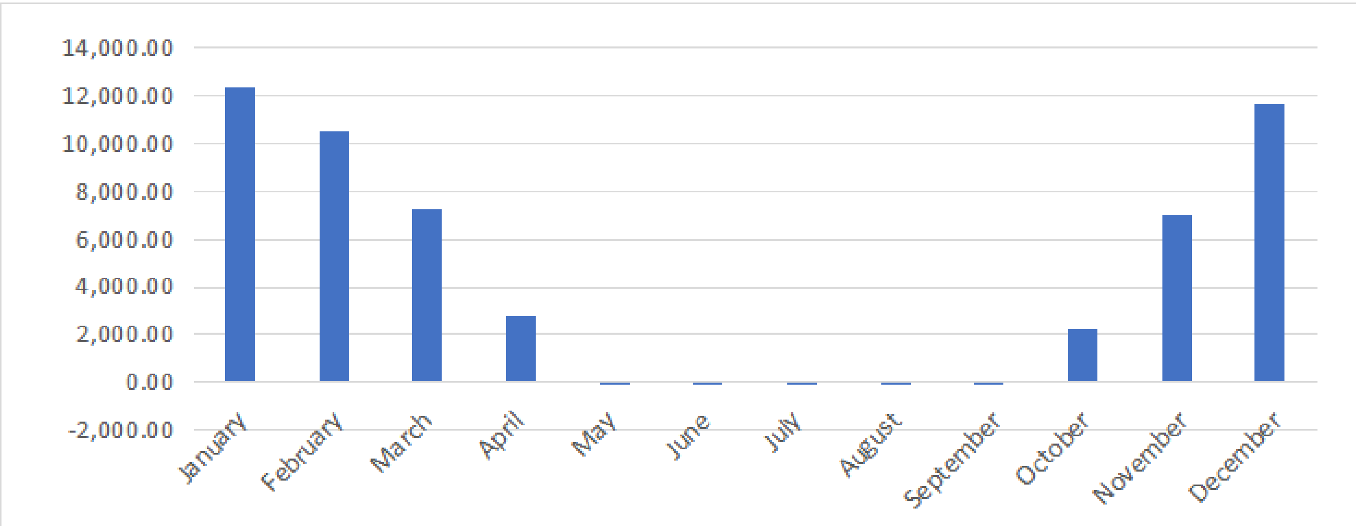


Figure 8. Monthly Heating Loads (kW) Graph for Type-3 wall section

Table 4. Monthly and Annual Heating Load Values for Type-4 wall section

Monthly Heating Energy Consumptions for Type-4			
Months	Energy Consumption	Unit	Annual Percentage
January	12.816,20	kW	23,03%
February	10.852,70	kW	19,50%
March	7.562,13	kW	13,59%
April	2.874,17	kW	5,17%
May	-12,43	kW	
June	-12,85	kW	
July	-12,64	kW	
August	-11,99	kW	
September	-10,65	kW	
October	2.293,84	kW	4,12%
November	7.191,85	kW	12,92%
December	12.055,88	kW	21,67%
Annual Heating Load	55.646,77	kW	
Annual Cooling Load	35,69	kW	

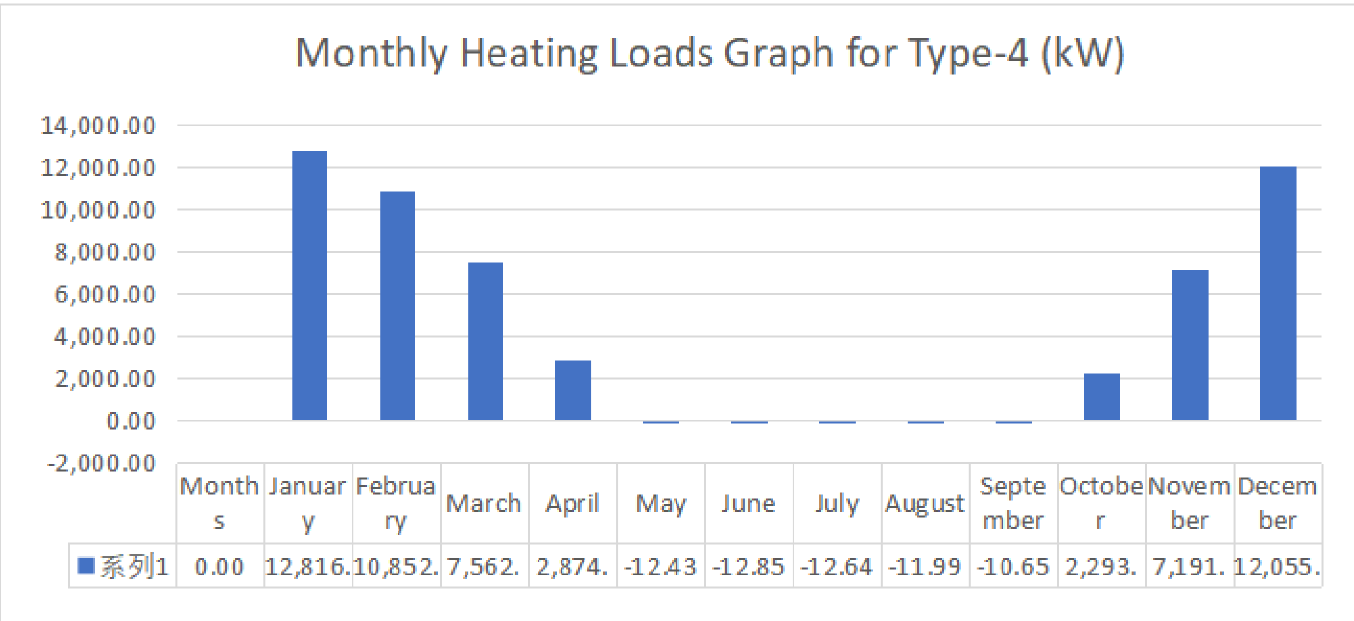


Figure 9. Monthly Heating Loads (kW) Graph for Type-4 wall section

Table 5. Comparison of Heating Load and Consumption Values for all Building types

	Type-1 Building	Type-2 Building	Type-3 Building	Type-4 Building
Energy Consumption (kWh)	303.249	281.418	53.767	55.691
Specific Energy Consumption (kWh/m3)	77,76	21.648	13,79	14,28
Annual Heating Load (kW)	303 009	295 695	53 724	55 647
Annual Cooling Load (kW)	2818	17815	59	36
Heating Load Saving Ratio (%)	100	93	17.33	18.4
Cooling Load Saving Ratio (%)	100	632	2.1	1.2

5 Conclusions

As it can be seen at Table 5; 3D panel and Cold Formed Steel wall type of buildings will be established with 59% and 36% less energy requirements with respect to non-insulated wall types of buildings. In future more research is needed to investigate the performance of each building type under different climate conditions.

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