Environmental Research & Technology, Vol. 2 (1), pp. 46-54, 2019

Turkish JournalPark ACADEMIC

Environmental Research & Technology

http://dergipark.gov.tr/ert

CONFERENCE PAPER

Integrated study of building information modeling (BIM) with green buildings for a sustainable environment

Aysu Hamzakadi[1], F. Ilter Turkdogan[1,*]

[1] Yildiz Technical University, Environmental Engineering Department, 34220 Esenler, Istanbul, TURKEY

ABSTRACT

This study emphasizes the necessity of sustainable buildings in order to protect environmental resources and reduce pollution by using technological developments. With the building information modeling, which is one of the contributions of developing technology, a three-dimensional simulation of a building project can be created. The annual energy and carbon emissions of the building can be calculated by means of analysis tools. Within the scope of the study, it is emphasized that the effects of carbon emissions on window thickness, window wall ratio, and window shades can be predicted by using Building Information Modeling analysis tools.

Keywords: Sustainability, building information modeling (BIM), green BIM, carbon emissions

1. INTRODUCTION

With the arrival of new technology, growing income The ideas that accompanied by the technological developments that started with the Industrial Revolution, after World War II, have been put into practice worldwide to meet the rising needs with rapid population growth and rapid economic development plans. This unplanned urbanization, which is not aimed at protecting the natural environment as a result of the industrialization, has led to the gradual decline of the green area, the increase in the per capita energy demand, the unconscious consumption of limited natural resources and the intensive use of oil resources. These environmental effects prevailed at the local level have reached global dimensions as a result of the imbalance between production and consumption.

The concept of "Sustainability" was first described in the Brundtland Report published by the United Nations Environment and Development Commission in 1989. Recent developments have emerged in many branches of the industry to support this concept. The application of environment and energy policies that support economic development that does not threaten natural life in the societies forces the state, institutions, foundation and business community, non-governmental organizations and other stakeholders to behave in this way. Therefore, as a result of its sustainable policies the construction sector, which is a part of new developments, has created a sustainable architecture, which is responsible for the pollution of natural resources and environmental pollution and at the same time environmentally friendly.

In this study, in order to reduce the effects of climate change caused by greenhouse gases, the effects of window thickness, window wall ratio and window shades on carbon emissions are investigated by subjecting the 3D simulation of a sample building project to energy analysis. In this way, it is aimed to reduce possible time losses and risks [1, 3].

2. MATERIALS AND METHOD

2.1. Sustainability

Sustainability in general; It is defined as maintaining the ability to be permanent while ensuring the continuity of diversity and productivity. In this context, the idea of sustainability should be implemented in all areas from global development

Corresponding Author: ilter@yildiz.edu.tr (F. Ilter Turkdogan)
Received 20 June 2018; Received in revised form 12 November 2018; Accepted 22 January 2019
Available Online 29 January 2019
Doi: ISSN: 2636-8498

This paper has been presented at EurAsia Waste Management Symposium 2018, Istanbul, Turkey

policy to the use of energy resources and from production planning to architectural designs.
In the consumer society, the adoption of sustainable development strategies is important for future investments aimed at economic solutions and caring about environmental management. From this perspective, it can be stated that sustainability has three main components: environmental, economic and societal. Between the environmental, economic and social components of sustainability, by creating a balanced synergy and by providing a strategic development these three components should be considered as integral parts of the whole [1, 4].

Environmental Sustainability: Environmental sustainability means protecting the world from destroying ecological equilibrium and natural systems in order to offer the world better conditions for future generations. The basic step of this protection situation is the delivery of natural resources without destruction. Therefore, while determining the level of use of natural resources; these sources need to be taken into account for the cleaning of these sources and for the removal of pollutants.

Environmental sustainability is sensitive to the following issues;

•Preservation of vitality and diversity in the world,

•Protection of life support systems,

•Sustainable use of renewable resources,

•Saving by using non-renewable resources,

•To minimize the harm to the environment and living things,

•Protection of cultural and historical environments [4]

Economic Sustainability: The strategy adopted by today's the modern economic development model is that the economic activities will increase in the market with the increase of the purchasing power of the individuals and thus the increase of the Gross National Product will contribute to society. This development model, targeting unlimited consumption, brings to the agenda environmental problems with the wastes that are generated at the end of the consumption madness. Economic sustainability aims to provide a steady flow of investment with the effective use and management of resources, taking ecological sensitivities into account.

Economic sustainability is sensitive to the following issues;

•Creation of new markets and trade opportunities

•Reducing energy and resource input in production, thus reducing costs with efficiency

•Providing added value [4]

Social Sustainability: Social sustainability focuses on some fundamental rights and freedoms of people. The most obvious of these fundamental rights and freedoms are equality and balance between generations. Sources are passed down to new generations to maintain their assets and ensure their assets.

Social sustainability is sensitive to the following issues;

•Ensuring that each individual has long-term basic needs such as work, health conditions, education and cultural activities

•Increasing the quality of life

•Rehabilitation of disabled groups

•Protecting the right to life of future generations [4]

2.1.1. Sustainable Development Strategies

Sustainable development strategies are based on nine basic principles, starting from the idea of "the increase in people's quality of life provided that the limited ecosystem remains within the bounds of transport capacity".

•Respect and attention to social life

•Increasing the quality of life of people

•Protection of vitality and diversity in the World

•Reduction of non-renewable resource consumption

•The carrying capacity of the earth should not exceeded

•Demonstrate change in individual behaviors and habits

•Respect for the environment by societies

•Establishing a national framework for integration between development and protection

•Establishing world-wide treaty on sustainability at global scale [2, 3]

2.1.2. Sustainability in the Construction Sector

It is known that the executive part of the construction sector is at the forefront while sustainable development strategies are being developed. Today, the construction sector has an important place both in the economy and employment. Besides the mines such as iron, cement and aluminum which are used during construction, and maintenance and repair of the building; such as water, natural gas and coal, which are used in the construction of the building, are the main sources of natural resources used in the construction sector. In addition, the sustainable construction sector is necessary for sustainable development, as there are many environmental problems during the destruction process.

As the human population in the constantly developing world increases, the number of buildings needed is also rising. As a result of this situation, energy and resource consumption in excess of the buildings caused a number of adverse effects on climate change and air and water quality in cities. In this context, air pollution is 23%, water pollution is 40%, solid pollution is 40% and the pollution caused by greenhouse gas production is 50% [5].

Sustainable Architecture: Sustainable architecture is defined as a group of activities that minimizes the harm to the environment, ensures the ecological balance and uses the required construction process. On the other hand, energy, water, and materials are the main sources of the main inputs for construction. The principles of sustainable architecture are based on the protection of these basic inputs [5].

Sustainable Construction: Sustainable construction is the implementation of all sustainable development principles, such as building life cycle, raw material production, construction material disposal, disposal, and waste management planning. The main purpose of sustainable construction is to establish the appropriate settlements for people and to ensure harmony between nature and environment by supporting economic equality. In addition to the construction process, large amounts of resources are required to be used during the disposal of the wastes that occur during both the service period and maintenance-repair activities. The controlled use of these resources is among the main objectives of sustainable construction.

In order to ensure sustainability in the pre-construction phase, the land should be used efficiently, sustainable-flexible building designs should be supported and effective material selection should be made. During the construction phase, efficient waste management should be adopted and energy efficient materials should be used to ensure sustainability. In the post-construction phase, existing structures should be adapted to new users and programs, building elements and materials should be reused, building components and materials should be recycled and land and existing infrastructure should be reused [4, 5].

2.2. Building Information Modeling (BIM)

Building Information Modeling is an information sharing process. Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. It is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure. Due to the dynamic system, a possible change between stakeholders can be updated immediately, resulting in better quality project outputs and possible risks being reduced in a shorter period of time. BIM not only provides technical advantages to the development process, but it also provides an innovative and integrated work platform for increasing productivity and sustainability throughout the project life cycle.

BIM supports social sustainability in two key areas. Firstly, it provides a better facility design for comfort of life in society and it allows the designers to review while they are still in the design phase and give feedback through the visulization of a three-dimensional building information mode. Secondly, it promotes the achievement of more absolute results by providing a better framework of cooperation that will strangthen the working relationship between project participants [3, 5].

2.2.1. Objectives of Building Information Modeling (BIM)

In the direction of the objectives determined by the building information modeling, it is necessary to make visualization, cost estimation, construction sequencing, conflict analysis and neutral analysis, facility management, prediction of environmental data, determination of life cycle data, faster and more efficient processes, better design possibilities and better customer service are presented [3, 5].

2.2.2. Uses of Building Information Modeling (BIM)

Usage areas of building information model; engineering, energy, static, lighting, mechanical, site, structural system analysis; phase planning (4B Modeling), programming, cost estimation - discovery (5B Modeling), sustainability assessment, digital manufacturing, 3D control and planning, visualization, design creation and development, 3D coordination, site use planning, construction system design-, building management and maintenance (7B Modeling), asset management, space planning and follow-up, disaster planning and planning of existing resources [3, 5].

2.2.3. Benefits of Building Information Modeling (BIM)

•By means of the improved construction documentation, drawing mistakes can be reduced during the design and construction phases.

•Numerous design alternatives can be created and tested.

•The project can be managed more effectively.

•Cost estimates and timing are continuously updated to yield more reliable results.

•Business and plant management data are transferred automatically.

•Having to real-time clash detection, coordination and knowledge management, site coordination during construction, steel design, detailing, manufacturing and assembly features simultaneously.

•Automatic numerical analysis can be calculated much more easily. Hence, the estimation process can be started at the early design stage.

•Enhance co-operation with key team members, contractors and consultants.

•Team members gain new team roles and skills [3, 5].

2.3. Supporting the Sustainability of Building Information Modeling (BIM) – Green BIM

Sustainable building designs require conscious technology as well as high level collaboration among stakeholders. Sustainable design is provided with the use of BIM as a technology and IPD as a delivery method. The key point in sustainable building designs is to minimize the disturbance to the environment and at the same time contribute to the development of local, regional and global ecosystems. The main issues addressed in sustainable buildings are energy efficiency, efficient use of materials, water saving and healthy interior quality. Effective design parameters in terms of maximum utilization of natural sources, minimum energy consumption and evaluation of important basic issues in sustainable buildings in order to provide climatic, visual and auditory comfort conditions: the location of the structure, the location and the distance of other constructs around it, the orientation and the form of it; physical properties affecting the heat transfer of the building shell, outdoor light level, physical properties of building interior volume, dimensions and structural properties of windows, walls and glass, properties of components constituting artificial lighting system and solar control and natural ventilation systems. It is possible that the main issues mentioned in sustainable structures can be assessed with the conscious analysis tools available in BIM. Thus, providing a sustainable design with predictable fixes of a building that is still in the design stage reduces both waste of time and possible risks. This supports the creation of more comfortable structures [3, 5-6].

2.3.1. Effective Energy Use in Buildings and Carbon Emissions Analysis Performed by Building Information Modeling Tools

A sample pilot study was conducted to measure carbon emissions from buildings by means of BIM tools. First of all, the location information was entered in order to know the climate data. This study is a building project and its location is determined as Gebze/Turkey. Revit Architecture, one of the BIM analysis tools, was used for early phase energy analysis with architectural modeling elements in the building. With the Green Building Studio analysis tool, which is coordinated with Revit Architecture, the carbon emissions were calculated based on the window/wall ratio, the glass thickness of the window and the window shade criteria for the north, south, east and west facades of the project. In line with the calculations made, a 3D virtual prototype of a building project which is still in the design phase has been created and optimum decisions have been taken based on carbon emissions. The exterior of the building designed for a family of 5 is shown in Fig 1 below [7].

Fig 1. The exterior of the building project

In early design phases, energy analysis with BIM tools can support sustainability with the following items.

•Foreseeing the energy consumption of the building to be built
•Building design and system optimization to achieve cost effective and more sustainable solutions
•The best decision on energy conservation measures implemented in the project can be made while still in the design phase
•Achieving LEED credit scores in LEED EA 1 "Optimized Credit Performance" [5]

3. RESULTS AND DISCUSSION

3.1. Findings Related to Carbon Emissions and Energy Modeling

The Energy Use Intensity and Life Cycle Energy Usage/Cost of the building project, which was determined as Gebze, was determined after the energy analysis in Revit Architecture. Fig 2 below shows the climate graph of Gebze province.

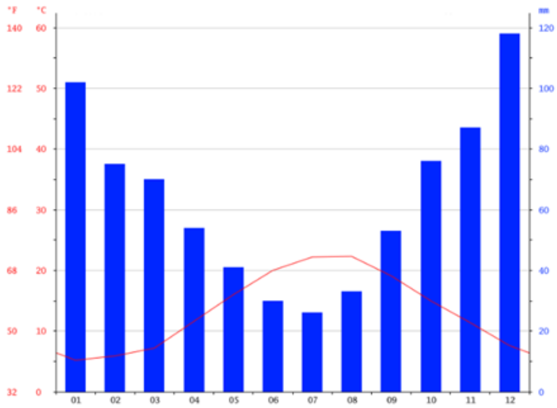

Fig. 2. Climate graph of Gebze

Table 1 below shows the numerical data of the Building Performance Factors performed by the intelligent measurement devices of the pilot study [7].

Table 1. Building performance factors

Location	Gebze/Turkey
Outdoor Temperature	Max:34°C/Min:-4°C
Floor Area	806 m^2
Exterior Wall Area	505 m^2
Average Lighting Power	9.69 w m^{-2}
People	5
Exterior Window Ratio	0.81
Electrical Cost	\$0.14 kWh^{-1}
Fuel Cost	\$1.44 $Therm^{-1}$

Energy analysis is based on Building Performance Factors and then Energy Usage Density and Life Cycle Energy Usage / Cost is calculated according to this information. Table 2 and 3 below shows the numerical information on Energy Use Density and Life Cycle Energy Use / Cost, respectively [7].

Table 2. Energy use intensity (EUI)

Elecricity EUI	181 kWh sm^{-1} yr^{-1}
Fuel EUI	485 MJ sm^{-1} yr^{-1}
Total EUI	1,137 MJ sm^{-1} yr^{-1}

Table 3. Life cycle energy use/cost

Life Cycle Electricty Use	4,321,263 kWh
Life Cycle Fuel Use	11,570,625 MJ
Life Cycle Energy Use	$344,578

*30-year life and 6.1% discount rate for costs

After the energy analysis in Revit Architecture, the energy and cost comparisons of the building project transferred to Green Building Studio were examined. Thanks to these tools, the effects of glass thickness, window wall ratio and window shades on carbon emissions were predicted. The following tables show the optimum results for carbon emissions by analyzing the Green Building Studio for the north, south, west and east fronts, respectively [8].

Table 4. Results of energy analysis and carbon emissions for northern fronts

Glass Thickness	Window Wall Rate	Window Shades	Energy Use Intensity (MJ m^{-2} $year^{-1}$)	Annual Electricity Usage (kWs)	Annual Fuel Usage (MJ)	Annual Electricity Cost ($)	Annual Fuel Cost ($)	Annual Total Energy Cost ($)	Annual Carbon Emissions (mg)
Single Clear	%95	-	1,341.2	151.787	520,003	21,098	7.115	28.214	25.9
Double Clear	%95	-	1,251.5	149,701	456,137	20,808	6,241	27,050	22.7
Double LoE	%95	-	1,211.6	149,398	425,499	20,766	5,822	26,589	21.2
Triple LoE	%95	-	1.137.1	144,208	384,997	20,045	5,268	25,313	19.2
Single Clear	%95	1/3	1.330.0	150,194	516,829	20,877	7,072	27,949	25.8
Double Clear	%95	1/3	1.241.6	148,347	453,162	20,620	6,201	26,821	22.6
Double LoE	%95	1/3	1,200.4	147,463	423,567	20,497	5,796	26,293	21.1
Triple LoE	%95	1/3	1,139.4	144,950	384,138	20,148	5,256	25,404	19.2
Single Clear	%95	2/3	1,325.0	148,997	517,159	20,711	7,076	27,787	25.8
Double Clear	%95	2/3	1,237.9	147,842	452,065	20,550	6,186	26,736	22.5
Double LoE	%95	2/3	,197.9	147,214	422,515	20,463	5,781	26,244	21.1
Triple LoE	%95	2/3	1,138.6	144,744	384,250	20,119	5,258	25,377	19.2
Single Clear	%65	-	1,269.0	149,028	472,493	20,715	6,465	27,180	23.6
Double Clear	%65	-	1,197.6	146,701	424,079	20,391	5,803	26,194	21.1
Double LoE	%65	-	1,165.4	145.806	401,755	20,267	5,497	25,764	20.0
Triple LoE	%65	-	1,118.2	142,717	375,304	19,838	5,135	24,973	18.7
Single Clear	%65	1/3	1,262.6	148,191	470,445	20,599	6,437	27,036	23.5
Double Clear	%65	1/3	1,192.4	145,910	422,798	20,282	5,785	26,067	21.1
Double LoE	%65	1/3	1,159.9	144,831	400,843	20,132	5,485	25,616	20.0
Triple LoE	%65	1/3	1,122.5	143,760	374,997	19,983	5,131	25,114	18.7
Single Clear	%65	2/3	1,259.5	147,556	470,259	20,510	6,435	26,945	23.5
Double Clear	%65	2/3	1,193.6	146,325	422,271	20,339	5,778	26,117	21.1
Double LoE	%65	2/3	1,161.0	145,179	400,447	20,180	5,479	25,659	20.0
Triple LoE	%65	2/3	1,122.8	143,846	374,879	19,995	5,130	25,124	18.7
Single Clear	%30	-	1,169.3	144,133	410,865	20,034	5,622	25,656	20.5
Double Clear	%30	-	1,128.5	142,309	385,006	19,781	5,268	25,049	19.2
Double LoE	%30	-	1,112.8	142,052	373,417	19,745	5,110	24,855	18.6
Triple LoE	%30	-	1,092.9	140,642	362,657	19,549	4,962	24,512	18.1
Single Clear	%30	1/3	1,170.2	144,501	410,227	20,086	5,613	25,699	20.5
Double Clear	%30	1/3	1,131.8	143,080	384,799	19,888	5,265	25,153	19.2
Double LoE	%30	1/3	1,112.8	142,127	373,167	19,756	5,106	24,862	18.6
Triple LoE	%30	1/3	1,094.3	141,018	362,433	19,601	4,959	24,561	18.1
Single Clear	%30	2/3	1,168.9	144,242	410,107	20,050	5,612	25,661	20.5
Double Clear	%30	2/3	1,131.9	143,121	384,751	19,894	5,265	25,158	19.2
Double LoE	%30	2/3	1,112.5	142,059	373,143	19,746	5,106	24,852	18.6
Triple LoE	%30	2/3	1,094.7	141,059	362,568	19,607	4,961	24,568	18.1

Table 5. Results of energy analysis and carbon emissions for southern fronts

Glass Thickness	Window Wall Rate	Window Shades	Energy Use Intensity (MJ m^{-2} $year^{-1}$)	Annual Electricity Usage (kWs)	Annual Fuel Usage (MJ)	Annual Electricity Cost ($)	Annual Fuel Cost ($)	Annual Total Energy Cost ($)	Annual Carbon Emissions (mg)
Single Clear	%95	-	1,479.4	179,281	530,861	24,920	7,264	32,184	26.5
Double Clear	%95	-	1,381.2	173,859	472,289	24,166	6,462	30,629	23.6
Double LoE	%95	-	1,374.3	177,508	453,682	24,674	6,208	30,881	22.6
Triple LoE	%95	-	1,176.2	152,713	385,427	21,227	5,274	26,501	19.2
Single Clear	%95	1/3	1,320.5	156,632	486,104	21,772	6,651	28,423	24.2
Double Clear	%95	1/3	1,241.7	154,199	432,152	21,434	5,913	27,347	21.6
Double LoE	%95	1/3	1,226.7	156,532	411,426	21,758	5,630	27,388	20.5
Triple LoE	%95	1/3	1,113.5	143,840	367,563	19,994	5,029	25,023	18.3
Single Clear	%95	2/3	1,250.9	146,591	466,883	20,376	6,388	26,765	23.3
Double Clear	%95	2/3	1,182.2	145,506	416,174	20,225	5,695	25,920	20.8
Double LoE	%95	2/3	1,159.6	146,937	393,050	20,424	5,378	25,802	19.6
Triple LoE	%95	2/3	1,091.2	139,797	364,381	19,432	4,986	24,418	18.2
Single Clear	%65	-	1,328.4	163,100	469,043	22,671	6,418	29,089	23.4
Double Clear	%65	-	1,250.1	158,422	423,628	22,021	5,797	27,817	21.1
Double LoE	%65	-	1,243.0	160,722	409,702	22,340	5,606	27,946	20.4
Triple LoE	%65	-	1,123.4	145,968	367,773	20,290	5,032	25,322	18.3
Single Clear	%65	1/3	1,237.0	150,236	442,715	20,883	6,058	26,941	22.1
Double Clear	%65	1/3	1,176.1	148,085	402,000	20,584	5,501	26,084	20.0
Double LoE	%65	1/3	1,163.3	149,637	386,238	20,800	5,285	26,085	19.3
Triple LoE	%65	1/3	1,091.7	140,839	360,992	19,577	4,940	24,516	18.0
Single Clear	%65	2/3	1,193.9	143,892	431,242	20,001	5,901	25,902	21.5
Double Clear	%65	2/3	1,141.1	142,785	393,252	19,847	5,381	25,228	19.6
Double LoE	%65	2/3	1,125.1	143,854	376,752	19,996	5,155	25,151	18.8
Triple LoE	%65	2/3	1,079.1	138,299	360,120	19,224	4,928	24,151	18.0
Single Clear	%30	-	1,157.2	146,133	394,000	20,312	5,391	25,704	19.6
Double Clear	%30	-	1,119.4	143,863	372,119	19,997	5,092	25,089	18.6
Double LoE	%30	-	1,113.5	144,770	364,200	20,123	4,983	25,106	18.2
Triple LoE	%30	-	1,074.3	138,858	354,372	19,301	4,848	24,149	17.7
Single Clear	%30	1/3	1,125.4	141,051	387,065	19,606	5,296	24,902	19.3
Double Clear	%30	1/3	1,098.1	139,952	369,268	19,453	5,053	24,506	18.4
Double LoE	%30	1/3	1,090.7	140,608	361,044	19,544	4,940	24,485	18.0
Triple LoE	%30	1/3	1,067.1	136,818	355,893	19,018	4,870	23,887	17.7
Single Clear	%30	2/3	1,115.3	138,927	386,682	19,311	5,291	24,602	19.3
Double Clear	%30	2/3	1,090.1	138,159	369,375	19,204	5,054	24,258	18.4
Double LoE	%30	2/3	1,081.8	138,676	360,910	19,276	4,938	24,214	18.0
Triple LoE	%30	2/3	1,064.9	135,944	357,347	18,896	4,890	23,786	17.8

Table 6. Results of energy analysis and carbon emissions for western fronts

Glass Thickness	Window Wall Rate	Window Shades	Energy Use Intensity (MJ m^{-2} $year^{-1}$)	Annual Electricity Usage (kWs)	Annual Fuel Usage (MJ)	Annual Electricity Cost ($)	Annual Fuel Cost ($)	Annual Total Energy Cost ($)	Annual Carbon Emissions (mg)
Single Clear	%95	-	1,544.1	184,723	562,740	25,676	7,700	33,377	28.1
Double Clear	%95	-	1,486.6	184,140	519,084	25,596	7,103	32,698	25.9
Double LoE	%95	-	1,489.1	188,526	505,305	26,205	6,914	33,119	25.2
Triple LoE	%95	-	1,262.5	162,562	418,636	22,596	5,728	28,324	20.97
Single Clear	%95	1/3	1,459.7	173,948	534,413	24,179	7,313	31,491	26.7
Double Clear	%95	1/3	1,405.0	173,481	492,597	24,114	6,740	30,854	24.6
Double LoE	%95	1/3	1,399.7	176,701	476,789	24,561	6,524	31,085	23.8
Triple LoE	%95	1/3	1,206.4	154,166	404,204	21,429	5,531	26,960	20.2
Single Clear	%95	2/3	1,398.1	165,393	516,261	22,990	7,064	30,054	25.7
Double Clear	%95	2/3	1,343.8	165,141	473,990	22,955	6,486	29,440	23.6
Double LoE	%95	2/3	1,338.2	168,286	458,196	23,392	6,270	29,661	22.9
Triple LoE	%95	2/3	1,170.4	149,199	393,522	20,739	5,385	26,123	19.6
Single Clear	%65	-	1,414.1	173,455	499,942	24,110	6,841	30,951	24.9
Double Clear	%65	-	1,354.7	170,848	462,115	23,748	6,323	30,071	23.0
Double LoE	%65	-	1,350.9	173,200	450,590	24,075	6,166	30,240	22.5
Triple LoE	%65	-	1,185.7	152,558	393,589	21,206	5,386	26,591	19.6
Single Clear	%65	1/3	1,350.3	164,713	480,657	22,895	6,577	29,472	24.0
Double Clear	%65	1/3	1,295.4	162,565	444,751	22,597	6,086	28,682	22.2
Double LoE	%65	1/3	1,287.7	164,357	432,163	22,846	5,913	28,759	21.6
Triple LoE	%65	1/3	1,153.2	148,074	383,832	20,582	5,252	25,834	19.1
Single Clear	%65	2/3	1,296.6	156,647	467,000	21,774	6,390	28,164	23.3
Double Clear	%65	2/3	1,244.8	154,972	431,876	21,541	5,909	27,451	21.5
Double LoE	%65	2/3	1,236.5	156,694	419,096	21,780	5,735	27,515	20.9
Triple LoE	%65	2/3	1,130.6	145,039	376,857	20,10	5,157	25,317	18.8
Single Clear	%30	-	1,212.1	151,708	417,592	21,087	5,714	26,801	20.8
Double Clear	%30	-	1,173.9	149,420	395,470	20,769	5,411	26,181	19.7
Double LoE	%30	-	1,169.7	150,503	388,272	20,920	5,313	26,233	19.4
Triple LoE	%30	-	1,106.5	142,922	365,304	19,866	4,999	24,865	18.2
Single Clear	%30	1/3	1,184.1	147,878	409,143	20,555	5,598	26,154	20.4
Double Clear	%30	1/3	1,150.5	146,212	388,453	20,323	5,315	25,639	19.4
Double LoE	%30	1/3	1,144.2	146,962	380,746	20,428	5,210	25,638	19.0
Triple LoE	%30	1/3	1,094.9	141,242	362,104	19,633	4,955	24,587	18.1
Single Clear	%30	2/3	1,165.8	145,384	403,536	20,208	5,522	25,730	20.1
Double Clear	%30	2/3	1,134.3	144,065	383,307	20,025	5,245	25,270	19.1
Double LoE	%30	2/3	1,127.4	144,625	375,748	20,103	5,141	25,244	18.7
Triple LoE	%30	2/3	1,086.7	139,972	360,174	19,456	4,928	24,385	18.0

Table 7. Results of energy analysis and carbon emissions for eastern fronts

Glass Thickness	Window Wall Rate	Window Shades	Energy Use Intensity (MJ m^{-2} $year^{-1}$)	Annual Electricity Usage (kWs)	Annual Fuel Usage (MJ)	Annual Electricity Cost ($)	Annual Fuel Cost ($)	Annual Total Energy Cost ($)	Annual Carbon Emissions (mg)
Single Clear	%95	-	1,446.5	169,200	541,056	23,519	7,403	30,922	27.0
Double Clear	%95	-	1,372.0	168,604	483,899	23,436	6,621	30,057	24.1
Double LoE	%95	-	1,375.0	173,330	469,301	24,093	6,422	30,515	23.4
Triple LoE	%95	-	1,154.6	148,679	382,813	20,666	5,238	25,905	19.1
Single Clear	%95	1/3	1,328.5	153,648	503,158	21,357	6,885	28,242	25.1
Double Clear	%95	1/3	1,258.0	153,102	449,074	21,281	6,145	27,426	22.4
Double LoE	%95	1/3	1,251.6	156,093	433,216	21,697	5,928	27,625	21.6
Triple LoE	%95	1/3	1,098.9	141,404	364,724	19,655	4,991	24,646	18.2
Single Clear	%95	2/3	1,257.0	144,942	477,687	20,147	6,536	26,683	23.8
Double Clear	%95	2/3	1,190.1	144,568	425,850	20,095	5,827	25,922	21.2
Double LoE	%95	2/3	1,177.7	146,637	408,524	20,383	5,590	25,972	20.4
Triple LoE	%95	2/3	1,062.7	136,404	353,916	18,960	4,843	23,803	17.7
Single Clear	%65	-	1,288.1	154,800	466,905	21,517	6,389	27,906	23.3
Double Clear	%65	-	1,218.7	152,127	421,380	21,146	5,766	26,912	21.0
Double LoE	%65	-	1,214.4	154,440	409,590	21,467	5,605	27,072	20.4
Triple LoE	%65	-	1,084.8	141,181	354,257	19,624	4,847	24,471	17.7
Single Clear	%65	1/3	1,218.9	146,549	441,56216.1	20,370	6,042	26,412	22.0
Double Clear	%65	1/3	1,155.7	144,524	398,630	20,089	5,455	25,543	19.9
Double LoE	%65	1/3	1,146.9	146,215	385,514	20,324	5,275	25,599	19.2
Triple LoE	%65	1/3	1,051.0	136,602	343,898	18,988	4,706	23,693	17.2
Single Clear	%65	2/3	1,170.1	140,134	425,915	19,479	5,828	25,307	21.2
Double Clear	%65	2/3	1,113.4	138,896	385,219	19,307	5,271	24,578	19.2
Double LoE	%65	2/3	1,101.8	140,206	371,294	19,489	5,081	24,569	18.5
Triple LoE	%65	2/3	1,029.7	133,491	338,143	18,555	4,627	23,182	16.9
Single Clear	%30	-	1,104.4	139,604	375,578	19,405	5,139	24,544	18.7
Double Clear	%30	-	1,066.7	137,846	351,911	19,161	4,185	23,976	17.6
Double LoE	%30	-	1,061.8	138,703	344,908	19,280	4,719	23,999	17.2
Triple LoE	%30	-	1,013.7	133,152	326,631	18,508	4,469	22,977	16.3
Single Clear	%30	1/3	1,076.9	135,805	367,348	18,877	5,027	23,903	18.3
Double Clear	%30	1/3	1,043.5	134,596	345,182	18,709	4,723	23,432	17.2
Double LoE	%30	1/3	1,036.6	135,160	337,637	18,787	4,620	23,407	16.8
Triple LoE	%30	1/3	1,005.4	131,786	325,017	18,318	4,447	22,766	16.2
Single Clear	%30	2/3	1,062.3	133,618	363,636	18,573	4,976	23,549	18.1
Double Clear	%30	2/3	1,032.4	132,843	342,671	18,465	4,689	23,154	17.1
Double LoE	%30	2/3	1,024.1	133,206	334,764	18,516	4,581	23,096	16.7
Triple LoE	%30	2/3	999.8	130,780	324,151	18,178	4,435	22,614	16.2

As a result of the data obtained from the above tables, the effects of the energy analysis on the carbon emissions of windows and walls are explained by 3 items.

1. As window thickness increases, carbon emissions decrease
2. As the window / wall ratio decreases, carbon emissions decrease
3. As the window canopy ratio increases, carbon emissions are decreasing [8]

4. CONCLUSIONS

The hypothesis advocated by the study; sustainable architectures, which need to be supported more for the sustainable environment, are subjected to an integrated work with building information modeling, and the analyzes made by means of tools within the structure can be seen, changed and obtained at the earliest design stage. This ensures that resources are preserved, less contamination is created, savings efficiency is increased and time loss and potential risks are reduced. Within the scope of the study, the effects of greenhouse gases from buildings which are one of the biggest reasons for climate change were pointed out. The effects of window glass thickness, window wall ratio and window shades rates on carbon emissions was supported by numerical data. Furthermore, the study encouraged the use of various technological tools to reduce greenhouse gases from buildings.

REFERENCES

[1]. H. Aladağ, G. Demirdögen and Z.Isık, "Building Information Modeling (BIM) Use in Turkish Construction Industry," *Procedia Engineering*, Vol. 161, pp. 174-179, 2016.

[2]. S. Azhar, W.A. Carlton, D. Olsen and I. Ahmad, "Building Information Modeling for Sustainable Design and LEED Rating Analysis," *Automation in Construction, Vol.* 20, pp. 217-224, 2011.

[3]. H.Y. Chong, C.Y. Lee and X. Wang and A Mixed, "Review of the Adoption of Building Information Modeling(BIM) for Sustainability," *Journal of Cleaner Production*, Vol. 142, pp. 4114-4126, 2017.

[4]. M. Yılmaz and A. Bakış, "Sustainability in Construction Sector," *Procedia-Social and Behavirol Sciences*, *World Conference on Technology, Innovation and Entrepreneurship*, Vol. 195, pp. 2253-2262, 2015.

[5]. G.D. Özperçin, "Integrated Project Delivery Method Using BIM to Support of Sustainable Design and Construction," MSc. thesis, Department of Architecture Program of Housing Production and Construction Management, Yildiz Technical University, İstanbul, Turkey 2016.

[6]. AUTODESK Sustainability Workshop website. [Online]. Available: https://sustainabilityworkshop.autodesk.com/building-design/concepts

[7]. AUTODESK Revit website. [Online]. Available: https://www.autodesk.com/products/revit-family/overview

[8]. AUTODESK Green Building Studio website. [Online]. Available: https://gbs.autodesk.com/GBS/Project