Improving the Energy Performance of a Convention Center Building

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ABSTRACT

Energy-efficient design is becoming very important not only for the depletion rate of energy resources but also for the reduction of the carbon dioxide gas emission. To be able to obtain the highest efficiency with the lowest energy consumption several measures can be taken such as the improvements of envelope's thermal performance, ,and the use of active and passive systems.

In this study, improvement suggestions for the application of an energy-efficient conference center located in Soma, Manisa (in Turkey), a province with a semi-humid climate, have been examined. Different strategies have been presented by using passive and active solutions to meet the credentials of the "Net Zero Energy Building" or "Approximate Zero Energy Building." First, the three-dimensional energy model of the building was created through the eQUEST program by using the current plan and other building specifics. Buildings cause significant energy consumption during their life-span and consequently, environmental effects are integral. For the second stage of the study, the energy improvement method of the conference was achieved by proposing different layers in the building elements, whilst PV panels being mentioned as an active solution. In line with the strategies created, changes in energy performance were evaluated through the eQUEST program. According to the energy analysis results data of the "Current Situation" and "Improvement Scenarios" on the annual use of the Conference Center Building, total energy efficiency increases by 26%. This performance is achieved with an efficiency of 19% in electricity consumption and 38% in gas consumption, and an increase in energy performance is observed with a decrease in total energy consumption. In addition, it has been observed that a total of 223.1 MWh can be achieved

annually with 525 modules installed on the green roof using “PVsyst” program for photovoltaic panels, which are proposed to be integrated as renewable energy sources.

Keywords: Energy Efficient Building Design, Zero Energy Buildings, Energy Consumption, Convention Center, Whole Building Energy Simulation.

1. INTRODUCTION

Nowadays, it is possible to build sustainable structures with zero carbon emissions and achieving a minimum use of resources and waste production by developing qualified design and application principles without causing any increase in lifetime costs (Republic of Turkey Ministry of Energy and Natural Resources, 2016). In order to obtain a sustainable and environmentally friendly structure criterion, there have to be concrete steps towards reducing the use of fossil fuels, such as oil, natural gas. As a way to meet the standards of the concept of low-energy buildings (Passive, Approximate Zero Energy, Zero/Plus Energy Building), all phases including construction and demolition should be taken into consideration (Technical Assistance for Improving Energy Efficiency in Buildings, 2016).

Zero-energy building is defined as buildings that have significantly lower energy requirements and use renewable energy sources to meet this need (Hermelink, et al., 2013). Along with this, the amount of annual energy being less or equal to that of the supply of renewable energy, is also a definition of an energy-efficient building (The U.S. Department of Energy by The National Institute of Building Sciences, 2015).

This study aims to analyze the energy consumption of a selected Conference Center while developing strategies for energy efficiency with their environmental impacts. Within the scope of the study, to cover the heating and cooling consumption of the Convention Center, the whole year's energy performance was analyzed by utilizing the "eQuest" program. Afterward, certain strategies were determined, to reduce energy consumption. In the second stage, changes were made regarding the data proposed in the eQUEST program to evaluate the strategies. Finally, the performance analysis for the data received as a result of the application of the structure's current situation data and the proposed scenarios were compared.

Suggested strategies to reduce energy consumption and carbon footprint are:

1. Improvement on the thermal permeability coefficients (U value) by changing the layers in the building openings that cause the thermal bridge,

2. Improvement on the thermal permeability coefficients (U value) by changing the layers of the solid elements that enhanced the building envelope,

3. Integration of the photovoltaic system that generates electricity using solar energy, which could be the alternative energy source,

4. Combination of all strategies to evaluate energy performance.

It has been observed that improvement in energy performance could be achieved by making changes in building components and integrating renewable energy technologies into the design. Further, it is very critical to consider the carbon footprints and embodied energy of applied strategies.

2. LITERATURE REVIEW

In recent years, many national and international academic and scientific theses, publications and studies on "Building Energy Performance" and "Energy Efficiency in Buildings" have been made. Approaches taken within the scope of the studies conducted to evaluate the energy performance levels can be defined as;

- Examination of energy-saving applications,
- Evaluation of energy generating systems,
- Evaluation of both energy-saving methods and energy generating systems together

Including these three definitive approaches, some sources used in literature review and general approaches in studies including detailed master's theses, research reports and articles are detailed below. Although there are many studies within the scope of energy performance, some of the studies conducted to improve building energy performance are as follows;

In her master thesis, Çiğsem Yağmur Yüksel aims to increase the energy performance of buildings in the Adana region by comparing two buildings with the same heating and cooling demands but with different structural layers. In this study, the effect of applications such as increasing window transparency, improving glass type, adding shading elements, as well as green roof selection among passive design techniques about the house structure was analyzed with the "eQUEST" program. By developing five different energy models, the differentiation between the energy performance of each has been revealed. According to the obtained data, energy consumption was reduced by 40% in the reference structure, 6% reduction in heating loads was achieved with the effect of passive solar design, 6% in electricity consumption and 55% in gas consumption were achieved with the use of green roof. As a result, it is calculated that 48% energy saving will be achieved annually with the implementation of all improvement proposals (Yüksel, 2019).

In their study, Parasonis and others, examined the effect of architectural volumetric design solutions on reducing building energy consumption without the need for a structural or mechanical improvement in the building. The results show that structures with the same area but different shell properties have different energy consumption potentials and geometry is a very effective factor on the building's energy consumption overall (Parasonis et al., 2012).

Gazioğlu and others, aimed to reduce the need for building heating energy by changing certain variables during the design phase. By choosing a building that complies with the regulations, the heating energy consumption amount was calculated for the desired period with the simulation program. A comparison on the passive design variables, different building forms and different climatic zones have been made. Accordingly, a change up to 20% in heating energy consumption was achieved in areas where heating was desired by changing the passive design variables. Also, during the design phase, it turns out that variables such as building form and building envelope should be handled differently for each climate zone (Gazioğlu et al., 2013).

Sezer has examined and evaluated the performance criteria of various glass units for solar control, light transmittance, color and light reflection to ensure optimal comfort conditions (Sezer, 2005). Tzempelikos and others, compared high-performance glass and standard glass, which provide thermal and lighting comfort conditions. As a result, when using low permeability glass, the need for artificial lighting and heating load has risen (Tzempelikos et al., 2010).

Nurten Ceylan has evaluated the most commonly used thermal insulation applications and the environmental impact of the production process, resulting in the inception of the graduate thesis as a way to increase energy efficiency in the buildings of Turkey. XPS (Extruded Polystyrene Foam), EPS (Expanded Polystyrene) and rock wool (TSY) applications used in the thermal insulation studies of Istanbul, were analyzed with “SimaPro 7.1” simulation program based on the life cycle analysis approach. As a result of the study, when the production and construction processes of XPS, EPS, and TSY applications are compared, it is seen that the environmental impacts of production are more than ten times the impacts of the production process. Compared to the TSY application, it was found that the EPS application had 4% and XPS application had 22% less environmental impact (Ceylan, 2012).

In the master thesis, the potentials of a solar city in Manisa, which was developed by Ece Özmen, in connection with the support of renewable energy sources were evaluated. To test the benefits of the use of solar energy, three densities were selected according to their intensities, low dense, medium dense and very dense, and the roof area of each of the dwellings in these areas was calculated through "NETCAD" program. With the help of the "Pvsyst" program, annual electricity generation potentials can be obtained with solar energy systems, which are compatible with any roof structure of houses, were calculated. As a result of the simulations, it is envisaged that the annual electricity demand of the less dense island will be met by photovoltaic systems. While it is expected that 88% of the annual energy need will be met by solar energy in the medium-dense building island, it is seen that it is possible to meet 45% of the very dense building island (Özmen, 2018).

“Improving Energy Efficiency through the Design of the Building Envelope" by Hatice Sözer is an article that scrutinizes the improvement plans of a hotel's overall energy performance, with the implementations of the passive solar design techniques. In this research, the "eQuest" software, one of the energy analysis programs, was used to model the hotel building in İzmir. A model based on the assumptions was developed for the comparative evaluation phase. A 21-story lightweight hotel building (based on an existing hotel built in Izmir in 1992) was created to assess the energy performance (Sözer, 2010).The comparative strategies are:1) Addition or improvement of exterior wall insulation and improvement of the glass system, 2) Reducing the percentage of exterior windows on the facades,3) The addition of shading elements.

The building envelope determines the energy exchange between the outdoor and living spaces and therefore affects the overall energy performance of the building due to heat transfer. This study demonstrates the importance of building shell design in terms of energy efficiency for a large building. Proper thermal insulation, glass-type, and shading elements are proved throughout the study to have the ability to reduce heat loss from the building envelope, 86% reduction for heating, 60% reduction for cooling and total building energy showing a 40% reduction in success (Yüksel, 2019).

Utkucu and Sözer, made a comparison with the contemporary architectural elements by examining the basic state energy performance of the traditional house selected according to its energy performance through the use of the “eQuest” software. As a result, they came to the conclusion that, the traditional stone house has a better energy performance compared to the concrete and wooden house, which is one of the architectural elements of today (Utkucu, Sözer, 2019).

Dikmen and Savcı, aimed to discuss the role of green roofs on the scale of the city and building and to eliminate the problems that may be encountered in practice. By explaining the benefits of green roofs in the study, they support the implementation of the green roof samples carried out in Turkey and in the world. The research shows that energy consumption will decrease by 24-50%,

CO_2 emission by 33-39%, water consumption by 40% and waste by 70% if using structures according to environmentally friendly definitives (Dikmen, Savcı, 2015).

Aksamija, based on extensive energy modeling and simulations, has examined many design issues such as material selection, improvements in building envelope, strengthening HVAC and lighting systems, occupancy loads and the application of renewable energy sources. Using an existing commercial building, it is aimed to explore how the building can maximize energy savings by using renewable energy sources for its energy needs and how to achieve net zero energy targets. Research results show that the commercial building can meet net zero energy use after the use of appropriate design variables and multiple renewable energy sources (Aksamija, 2016).

Cooperman and others, have examined strategies for strengthening the building shell, an important step in improving the energy performance of existing commercial buildings (Cooperman et al., 2011).

Erkmen has investigated the variations for building cooling, which increases in importance with global warming and causes energy expenditures. He compared the cooling loads of a sample structure with different methods in hot humid and hot dry climatic regions. As a result of the research carried out in Antalya and Diyarbakır provinces, it observed the effect of relative humidity factor on temperature increase and thermal comfort. In the study, it is stated that there is a need for more cooling load in the hot humid climate zone compared to the hot dry climate zone (Erkmen, 2005).

Zoroğlu and others, argue that providing thermal comfort conditions and reducing energy consumption are closely related to design decisions such as orientation and building shell components. He determined that energy consumption was reduced by improving the U value of the building envelope components and changing the mechanical system. However, in order to provide energy efficient building design, it states that it is important to consider the transparency rates of buildings, their orientation with respect to the sun, and the holistic handling of noise control (Zoroğlu et al. 2018).

In the literature scanning process, it was seen that interventions to the building envelope and building components and the use of active and passive systems were applied in the buildings in line with the zero-energy approach. The following; energy performance of buildings with different structural layers, the materials used in manufacturing and the respective production process, environmental impact of the use of renewable energy sources and photovoltaic panels in a likewise location (Manisa, Turkey), utilization of energy analysis program and design phases, establishing the improvement scenario, improving glass systems and changing transparency ratios, the effects of green roofs, the effect of building orientation and geometry on energy consumption potentials, mechanical systems, different climatic zones, commercial buildings where conference centers are included, as well as energy performance analysis in buildings with different functions, were investigated. In the study, different strategies that will be evaluated by using and suggested to be used in energy performance evaluation and improvement studies are included. Further research and experimentation are required with practical case studies on the energy efficiency improvement applications of the commercial building. In this study, considering the literature reviews given, energy efficient improvement strategies have been implemented for the existing Conference Center building. Energy consumption reduction targets were tried to be achieved through diverse and holistic applications.

3. METHODOLOGY

Methodology has been developed to examine the current energy performance of the Conference Center in Soma-Manisa and to offer suggestions for improvements based on the data obtained. Improvement suggestions are not only limited to layer changes, but all components are completely replaced. Accordingly, the study also emphasizes the importance of building energy analysis in the early design phase of a building. The total primary energy consumption of the building was calculated through the "eQuest" energy simulation program. Improvements in energy-efficient design were presented by considering the architectural features and usage profile of the building. Strategies to reduce annual energy consumption were determined accordingly. The main objective is to evaluate the energy performance of the applied strategies. In the early design process, it is important to determine the impacts of the building on the environment in advance.

The steps taken to analyze the building energy performance is as follows:

- Identification of the environmental data
- Identification of the current building data
- Defining variables related to the improvement scenarios
    - Reducing thermal transmittance coefficients (U-value) in building openings (windows and doors),
    - Reducing the U value in building envelope components (floor, roof and walls),
- Integration of photovoltaic systems (active systems).
- Evaluating the effects of strategies developed within the framework of "improving energy efficiency" on building energy performance.

The working process, including the given steps, is shown in detail in Figure 1.

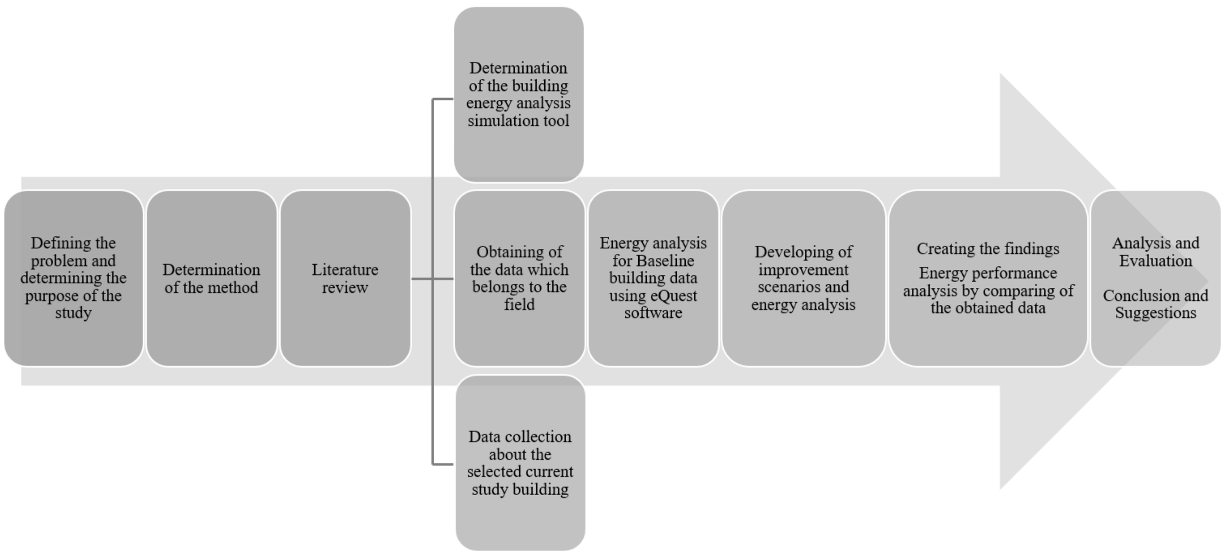


Figure 1. Process steps

3.1. Identification of the Environmental Data

3.1.1. Geography

Soma district is located between 27° 36' east longitude and 39° 11' north latitude. More than 50% of the land in Soma is mountainous, surrounded by mountains from the south, east, north and northeast. Because the mountains around the plains are not high enough to cut off the sea effect and their vertical position, the effect of the sea is felt to a decreasing extent from west to east (Municipality of Soma, 2019). The location of Soma, situated in the Aegean Region of Turkey, the aerial views of the study case and the district are shown in Figure 2.

Figure 2. Soma, Manisa's location; Aerial view of the district and the location of the study building; Aerial view of the study building (Google Earth, 2020).

The physical environment in Soma has been altered by the effect of the thermal power plant operating near the city center. This altercation has caused many environmental problems such as deforestation, loss of productivity in agricultural soil, surface and underground water pollution and air pollution, in and around the city (Karadağ, 2006).

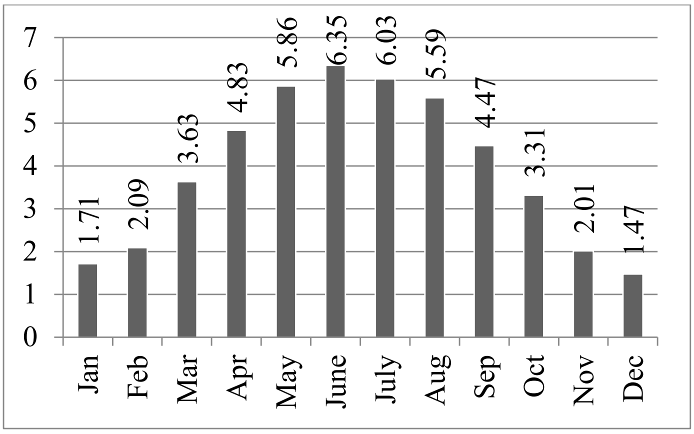
3.1.2. Climate Data

The climatic data of Soma, a district of Manisa, was used as the study area for the conference building proposal. The information was investigated for both the initial design process and the evaluation of the improvement stages.

Soma and its Surroundings: According to the methodic studies of researchers such as Koppen, De Mortann and Erinç, the climate classifications of Turkey define Soma as a "semi-humid Mediterranean climate type". In this region, the winters are the rainiest, and the summer is almost rainless. The average temperature of the region, which has its hottest days in July, is around 23-24 °C, and in winter it is often much lower as it is often exposed to cold air currents from the Balkans. The coldest month is January and the average temperature is 3-5 °C. In winter, there is much more rainfall than in summer. Frequent frost incidents are observed (Municipality of Soma, 2019).

3.1.3. Solar Power in Soma, Manisa

The sunshine times are an important factor to determine the solar energy potential of a given area. Our country is one of the leading countries in Europe with an annual energy potential of 380 billion kWh (Demir, 2012). Figure 3 shows the high sunshine potential, global radiation values and average sunshine duration of Soma, a district of Manisa, every month (Turkish Solar Power Atlas (GEPA), 2019).



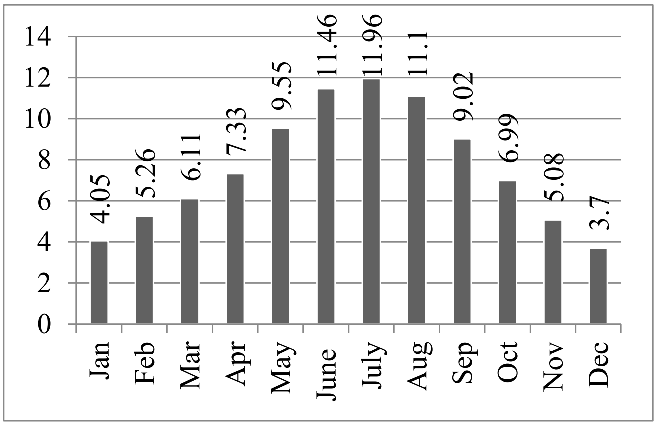


Figure 3. Soma Global Radiation Values (kWh/m^2-day); Soma's Values of Sunshine Duration (hour).

The sun is also the energy source of many passive-active energy systems that we provide energy to. Taking into account the annual energy potential of our country from the sun, by taking advantage of this opportunity arising from geographical features, both savings can be achieved and the impact of environmental pollution can be reduced thanks to this unlimited and environmentally friendly renewable energy source (Aksungur, Kurban, Filik, 2013).

3.1.4. Building Orientation

Building orientation is one of the criteria of architectural planning that affects the heat and energy performance of buildings. The daylight situation depends not only on the latitude but also on the orientation of a building, with every facade or material of the building requires a different design significance. Therefore, daylight and architectural design strategies are inseparable (Capeluto, 2003). In this respect, examining traditional architecture and successful natural lighting designs strategies from the past is concerned in our study to understand climate-balanced building design.

3.2. Identification of Data during the Initial Building Design

3.2.1. Building Type and Space Organization

The building has a 4837 m^2 usable area, which includes the Convention and Meeting Center, Lobbies (Main Entry and Assembly), Dining Area, Corridor, Kitchen, and Food Preparation Spaces, Restrooms, Theater (Motion Picture) and related building services. The ground floor plan of the existing conference center building used in the study and the condition of the rooms determined by the "eQuest" program has been shown in Figure 4.

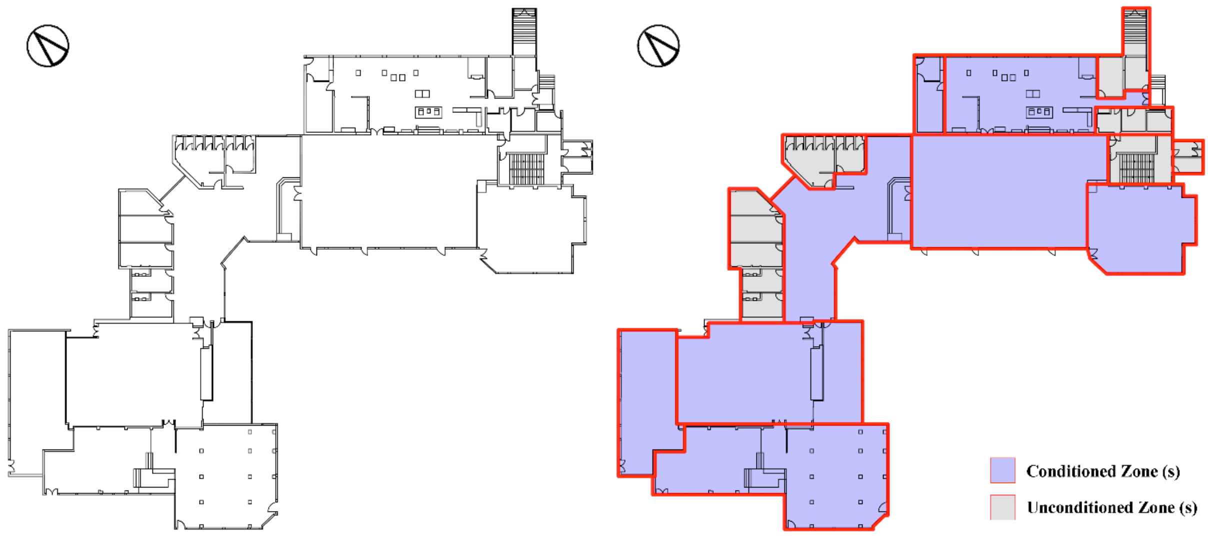


Figure 4. Schematic plan of the Working Conference Center Building;
Air conditioned and non-air conditioned areas identified in the "eQuest" software.

Conference centers are categorized as a commercial building. In the architectural design of commercial buildings, considering the zoning and block/plot situation, heat, natural ventilation, and lighting needs should be kept to a minimum and natural heating, ventilation, and lighting facilities should be utilized as much as possible, taking into account the effect of the wind and sun. In the orientation of the interior spaces, undesirable heat gains and losses should be prevented with the architectural solutions created by considering the meteorological elements such as sun, humidity, wind, rain, and snow in the climate zone where the structure is located. When organizing living spaces, spaces that are used for a long time should be placed in such a way that they get sufficient efficiency from the sun's heat and light along with benefiting from the natural conditions (Özüpak, 2008).

The high energy efficiency indicators depend on improperly designed projects and construction. At this stage, the total heat transfer coefficients (W/m^2 K), as well as insulation standards such as the location, form and physical characteristics of the facade, should be determined to provide optimum energy performance concerning the temperature zones (TS 825, 2008).

3.2.2. Conference Center User Profile

A building's user profile is an important factor for building energy performance analysis. To calculate the energy performance of a building in the most accurate way, it is important to determine the occupancy rates for each building by separating the buildings according to their functions. Since the user profile, occupancy times and operating conditions of each building are different, their energy-saving potentials also vary (Aksakal, 2011). As a result of these studies, user profiles of a conference hall were determined as shown below (Figure 5).

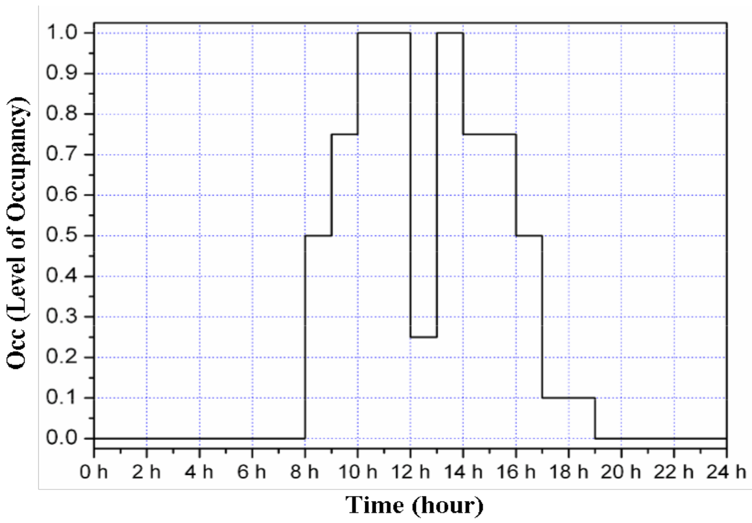


Figure 5. User Profile of the Conference Hall (TS EN 15232, 2008).

Working hours should be known when evaluating the conference rooms and specific functions should be designed for the system to be used. As stated above, conference hours generally reach maximum occupancy around 10 AM and 2 PM, the occupancy rate decreases considerably since there is a break between 12 AM and 2 PM (TS EN 15232, 2008). Considering the function of the studied Conference Center Building, the occupancy period was defined between 08:00 and 22:00 during the whole week (Monday through Sunday). Accordingly, in terms of user comfort, ventilation and air conditioning (HVAC) systems start working 1 hour before use (07:00) and continue to work 2 hours (00:00) after closure. Considering the factors such as age, gender, clothing status, a large spectrum constitutes to the building's user profile.

3.2.3. Building Components of the Existing Building

The materials and properties of the existing building components are shown in Table 1.

Table 1. Building Component Materials and Properties for the Convention Center

Building Components	Name	Unit weight (kN/m^3)	Area (m^2)	Volume (m^3)	Material Mass (kg)	U values (W/m^{2}K)
Convention Center-Interior Doors	Wood Door Panel	6.87	185	3.47	2430.85	-
Convention Center-Exterior Doors	Glass	23.7	31	0.05	120.83	1.8
	Wood Door Panel	6.87	16	0.16	112.09	
Convention Center-Windows	Glass	23.7	164	1.03	2489.19	1.8
	Wood Door Panel	6.87	137	1.52	1064.81	
Convention Center-Ground Floor	Ceramic Tile	11.767936	4837	12.09	14501.83	0.57
	Concrete - Sand/Cement Screed	18.632566	4837	12.09	22961.23	
	EIFS - Exterior Insulation and Finish System	0.000077	4837	241.84	1.90	
	Concrete	23.607104	4837	2152.41	5178277.17	
Convention Center-Wall	Paint	0.076973	3929	8.93	70.07	0.57
	Plaster	0.000077	3896	75.88	0.60	
	EPS	0.490331	2117	108.14	5404.19	
	Concrete	23.607104	1975	335.41	807404.45	
Convention Center-Roof	Roofing - Tile	19.122897	2532	75.96	148037.42	0.38
	Insulation- Wool	1.961323	2532	50.64	10122.22	
	Wood	0.076973	2532	126.60	993.13	
	Air Barrier - Air Infiltration Barrier	0.000077	10128	1012.84	159158.72	

3.2.4. Energy Model with the use of “eQuest”

3D geometric modeling of the building was made with the "e-Quest 3-64" program, one of the energy simulation tools with a user-friendly interface with ease of use and quality results. The model was created using a more detailed and data-intensive "Development (DD) Wizard" in the program, which uses three different levels of input data: the schematic design wizard, the design development wizard, and the detailed (DOE-2) interface.

The simulation input data in the program defined for the initial phase is as in the Table 2.

Table 2. Input Summary Design Model Characteristics

General	
Location	Soma, Manisa in Turkey
Simulation Weather File	Custom weather file GBS_06M12_18_073262.bin
Modeling Software	eQuest 3.64
Building Area	4837 m^2 (Conditioned+Unconditioned)
Hours of Operation	Monday to Sunday: 8.00am to 10.00pm
Envelope Performance	
Overall Roof U-value	0.38 W/m^2K
Overall Wall U-value	0.57 W/m^2K
Overall Glass U-value including frame	1.8 W/m^2K
Mechanical Systems	
Indoor Design Temperature for Conditioned Areas	Occupied: 70°F heating, 76°F cooling Unoccupied: 64°F heating, 82°F cooling
Maximum Heating Supply Air Temperature	Heating: 95°F
Minimum Cooling Supply Air Temperature	Cooling: 55°F

From the conceptual analysis stage to the final stage of the design, energy simulation and comparative calculations were used to obtain energy consumption data for the building through “eQuest,” a program that can be used throughout the entire stages of the design process. The three-dimensional model of the structure created with the “eQuest” software using the current definitive features has been shown in Figure 6.

Figure 6. The “eQuest” 3D model obtained using “Baseline” data.

Figure 7 and Table 3 show the monthly and annual electricity consumption, Figure 8 and Table 4 show the energy consumption data for monthly and annual general space heating. Table 5 summarizes the energy

consumption per year and per m^2 obtained from the energy analysis.

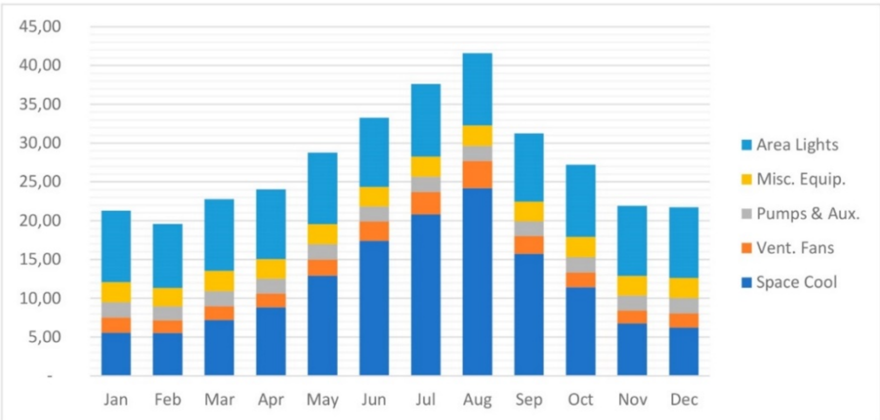


Figure 7. Electric Consumption (kWh) (x000)

Table 3. Electric Consumption (kWh) (x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/1 year
Space Cool	5,57	5,54	7,21	8,86	12,92	17,41	20,83	24,19	15,75	11,42	6,76	6,23	142,7
Vent. Fans	1,96	1,65	1,75	1,74	2,08	2,5	2,86	3,49	2,28	1,91	1,69	1,83	25,73
Pumps & Aux.	1,98	1,79	1,98	1,92	1,98	1,92	1,98	1,98	1,92	1,98	1,92	1,98	23,35
Misc. Equip.	2,59	2,34	2,59	2,52	2,59	2,51	2,6	2,6	2,5	2,6	2,52	2,58	30,54
Area Lights	9,2	8,27	9,24	9	9,2	8,93	9,34	9,34	8,79	9,31	9,03	9,1	108,73
kWh/1 year	21,31	19,59	22,78	24,04	28,79	33,27	41,6	41,6	31,24	27,22	21,91	21,72	**331,04**

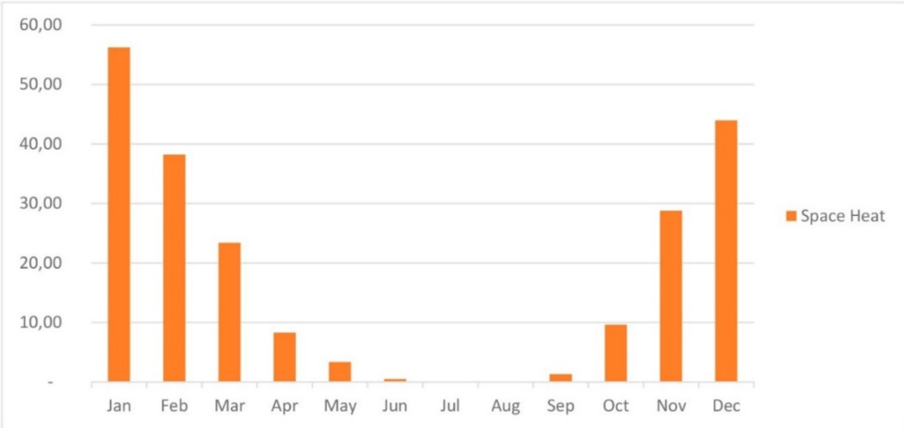


Figure 8. Gas Consumption (kWh) (x000)

Table 4. Gas Consumption (kWh) (x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/1 year
Space Heat	56,2	38,19	23,38	8,28	3,35	0,5	-	-	1,33	9,6	28,79	43,96	213,63
kWh/1 year	56,2	38,19	23,38	8,28	3,35	0,5	-	-	1,33	9,6	28,79	43,96	**213,63**

Table 5. "Baseline" Energy Consumption Data Achieved by the use of the "eQuest" Program (kWh)

Energy consumption (kWh)/1 year		**Energy consumption (kWh)/m².1 year**	
Electricity	Heating	Electricity	Heating
331.040	213.631	68,44	44,17
Total energy consumption (kWh)/1 year		**Total energy consumption (kWh)/m².1 year**	
544.671		112,61	

According to the energy performance analysis made for the existing building, the annual total energy consumption of the building was 544671 kWh and the energy consumption per m^2 was 112.61 kWh. The data obtained is an initial output for the design. Strategies for energy-efficient improvement have been developed and it is aimed to approach the zero-energy building concept by reducing energy consumption.

3.3. Definition of Variables Related to the Improvement Scenarios

By taking into account the amount of energy consumption and location obtained for the Conference Center, they defined different variables in the building structural components and the "PV Panel" application was proposed as a way to prioritize solar energy as an alternative energy source. By increasing the thermal resistance of the walls, floors, and roof structure elements, along with separating the internal environment of the building from the external environment, the aim to minimize the heat transfer between the outdoor air and living spaces, as a way to reduce the energy consumption of the building by gaining energy from the sun, was set at the main goal.

The total heat transfer coefficients which will be accepted as the highest value according to the regions for the existing buildings are as in Table 6.

Table 6. Turkey's U Value (Total Thermal Transmittance) Coefficients by Regions (TS 825, 2013).

	U_D W/m^2K	U_T W/m^2K	U_t W/m^2K	U_P W/m^2K
1st zone	0.66	0.43	0.66	1.8
2nd zone	0.57	0.38	0.57	1.8
3rd zone	0.48	0.28	0.43	1.8
4th zone	0.38	0.23	0.38	1.8
5th zone	0.36	0.21	0.36	1.8

U_D: Thermal conductivity of outer wall [W/m^2 K],

U_T: Coefficient of heat permeability of the ceiling [W/m^2 K],

U_t: Number of thermal conductivity of floor/slab [W/m^2 K],

U_P: Thermal conductivity of window [W/m^2 K].

According to TS 825, climatic conditions affect the U values of the structural elements and the climate data for simulation. TS 825 standards were examined and 2^{nd} Region data was taken into consideration as degree day zone for Manisa. Necessary calculations and applications have been made regarding standards.

Considering the last stage of the study, it is possible to say that the energy consumption for the operations can be reduced and the energy performance can be increased by changing the values of the design variables related to the building through simulation tools in the early design phase. In this context, alternative variables in the strategies proposed for the “energy efficient improvement” of the building are described and detailed in the following sections.

3.3.1. Windows and Outdoor Doors

In the first stage, the use of qualified glass was proposed to increase the energy performance of windows and doors with a thermal permeability coefficient of 1,8 W/m^2K and the use of flat glass and wood frames was proposed and the thermal permeability coefficients were reduced to 1,425 W/m^2K. At the same time, the window rates on the facades were reduced by 50%.

Wood as a material is a renewable resource and does not harm the environment due to the low primary energy consumed in its production. It is seen that the window frame produced from high-quality wood has a 50-year lifespan under appropriate conditions (Berge, 2001). The thermal conductivity coefficient (U value) of the wooden frame is very low and resistant to thermal effects. U value varies depending on the thickness and type of wood, distance between glasses and the glass/frame ratio (Şahinoğlu, 2012).

The performance of an insulated glass unit can be further improved by the addition of Low-E coatings and by filling inert gases such as argon into the space between the glass. Argon is denser than air and reduces the amount of heat transfer through the insulated glass unit. If 90% argon gas filling is used instead of air, the insulation value of the glass can be increased up by 16% (Sezer Cam&Alüminyum, 2020).

It is recommended to use Argon infused Triple Insulating Glass Synergy (Double Low-E) for windows and exterior door glasses along with the use of wood for frames. The thermal conductivity coefficient of the proposed glass is 0.7 W / m^2K. Unit thicknesses are 4 + 12 + 4 + 12 + 4. The properties of the glass used in the improvement scenarios are shown in Table 7.

Table 7. Double Glazed Application Characteristics (Dilek Cam, 2019).

Product	Unit Thickness (mm)	Daylight		Solar Energy					Thermal Conductivity Coefficient U value W/m²K (EN 673)
		Permeability %	Projection %	Projection %	Absorption %	Direct Permeability %	Total Permeability	Shading Coefficient	Argon
Triple Insulating Glass Synergy (Double Low-E)	36	69	14	28	33	39	0,48	0,55	0,7

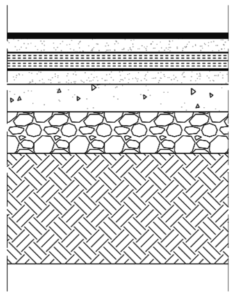
3.3.2. Floor, Roof, and Walls

The aim is to increase the thermal resistance of the walls, floor, and roof structure elements separating the internal environment of the building from the external environment and to minimize the heat transfer between the outdoor and indoor spaces.

3.3.2.1. Ground Floor

In today's world, where energy resources are limited, the importance of insulation in buildings and minimizing heat transfers should be given importance to reduce energy consumption for thermal comfort purposes. In this study, thermal resistance was increased by decreasing the thermal permeability coefficient by 0.57 W / m^2K, obtained within the first layer, (Ceramic Tile, Concrete - Sand/Cement Screed, EIFS - Exterior Insulation and Finish System) defined in the first stage to minimize the targeted heat transfer. Ground floor layers recommended in improvement scenarios are shown in Table 8.

Table 8. Details for the Proposed Ground Floor in Contact with Soil

Building Component	Stratification	Thickness (cm)	Details	U value (W/m² K)
Ground Floor	Epoxy	2		0,347
	Screed	5		
	Thermal Insulation - XPS	6		
	2 Layers Waterproofing	0,6		
	Leveling Screed	5		
	Lean Concrete	10		
	Blockage	15		
	Compressed Soil	40		

3.3.2.2. Roof

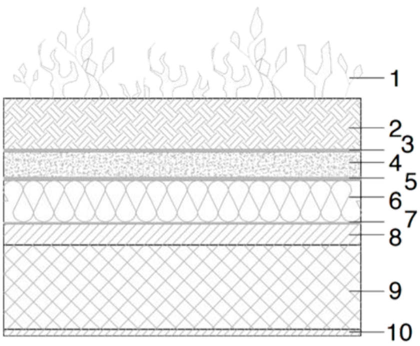
By selecting the green roof type as the roof covering as opposed to the terraced roof proposed in the "Baseline" for the building, the energy consumption of the building is expected to outperform the current situation. All existing layers of the roof (Roofing - Tile, Insulation - Wool, Wood, Air Barrier - Air Infiltration Barrier) have been changed and transformed into a green roof.

Benefits of green roof; reduced drainage density, improved air quality due to converting rainwater into green cover, providing equivalent heat insulation value to dry rock wool, reducing heat input by 85%, reducing heat loss by 70%, reducing noise by absorbing sound, reducing electromagnetic radiation, retention of metals and water, being recyclable materials, providing the recovery of lost vital soil, protection of the structure from ultraviolet rays, protection of the roof and carrier construction from mechanical damage, prolonging the life of the roof and structure, and being fire resistant. In addition, green grass roof covers; the vapor permeability feature allows the structure to breathe and remove moisture in the structure. This improves the quality of life of the people in the structure and positively affects the sensing threshold of heat (GeoGreen, 2020).

Green roofs are divided into extensively planted and densely planted systems (Bianchini et al., 2011; Ceylan, 2012). In this study, instead of densely planted green roof type, sparse planting system has been chosen for the reasons of; soil depth, having less vegetation than densely green roofs (Weiler and Katrin, 2009: 8), having less vegetation or no vegetation containing natural vegetation (Erkul, 2012: 24), as oppose to the intensive planting system lighter and more efficient stormwater management and less maintenance requirements (Bianchini et al., 2011; Ceylan, 2012). At the same time, sparsely planted green roofs provide a balance between the indoor and outdoor environments at thermal loads with reduced plant layers. "*These systems, with the heat storage feature of the green roof, reduced thermal load, due to the reduction of the vegetated layer, has less transfer to the interior spaces in the summer season. In the winter season, it prevents the flow of heat from the indoor environment to the outdoor environment and saves cooling and heating energy* (Liu and Baskaran, 2003). "

The features of the green roof system proposed for the improvement scenarios are shown in the table below (Table 9).

Table 9. Details for the Proposed Densely Planted Green Roof Systems

Building Component	Stratification	Thickness (mm)	Details	U value (W/m² K)
Green Roof	1. Vegetation layer (extensive green roof)	-		0,19
	2. Soil bed	150		
	3. Stab-Filter layer, Polypropylene fiber	1		
	4. Water Drainage/Storage Element, DAKU FSD20	1250x100x80		
	5. Anti-Root&Rot waterproofing membrane	4		
	6. Expanded Polystyrene insulation	50		
	7. Bitumen layer	4		
	8-9. Slopping screed - Concrete ribbed slab	300		
	10. Ceiling plaster	10		

3.3.2.3. Walls

For the existing wall as a building envelope component, only the material has been changed, considering that the thermal insulation made on the outer surface of the wall, as in the current layer layouts, prevents the problems such as thermal bridges, cracking and condensation by ensuring that the materials forming the building envelope remain on the inside (on the hot side). The thermal insulation layer is left as by as a likewise procedure used for the wall surface. The application of thermal insulation materials to the outer side of the outer walls is effective in terms of structural physics.

In wall component improvement scenarios, ventilated systems are recommended from applications to the outer surface of the wall. Ventilated systems; These are the systems formed by mounting the thermal insulation materials in sheets on the outer surface of the wall body and placing the outer wall covering material transported to the carrier system elements by leaving at least a 5 cm gap. In this system, the steam escapes from the interior of the building reaching up to the air gap and exiting from there, providing the building has a long life in terms of structure physics (İzocam, 2002). The following figure shows a ventilated system, according to the Thermal Insulation Regulation (Figure 9).

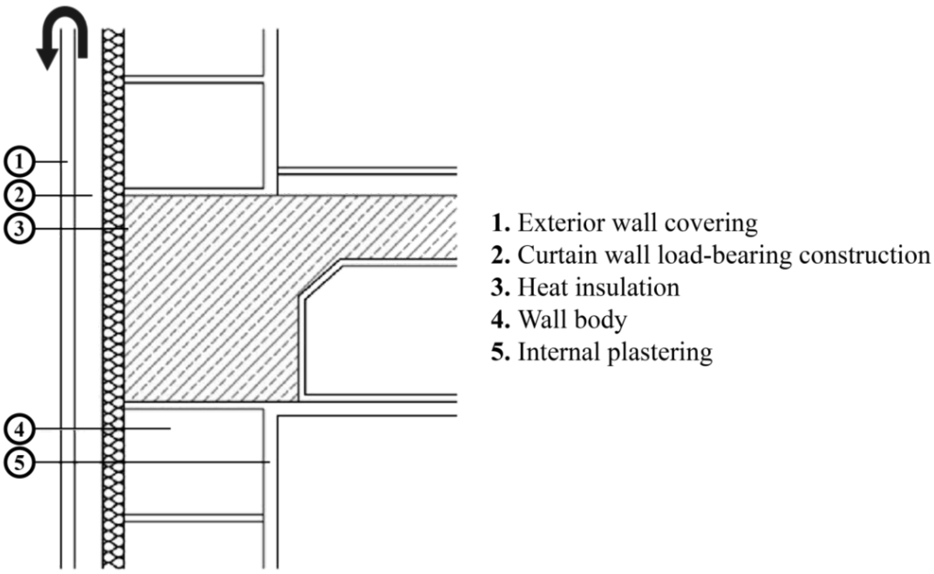


Figure 9. Ventilated Exterior Wall Thermal Insulation Application (TSE 825, 2008).

It is recommended to use a ventilated wall system that is recyclable as the outer wall cladding and to use clay brick as a sustainable building material. With the development of building technologies, the massive use of brick building material has been replaced by easier and more aesthetic systems. These systems provide high performance to buildings in terms of heat, sound, fire and static, and better thermal, auditory values for the users, maximizing comfort conditions (Yıldırım, 2018). The proposed wall building component properties for improvement scenarios are shown in Table 10.

Table 10. Recommended Details for the Components of the Wall Construction.

Building Component	Stratification	Thickness (mm)	Details	U value (W/m² K)
Wall	Plaster	13	Concrete with a density of 350 kg / m^3 covered by TS 825 (7.3.2).	0,4
	Gas Concrete (TS825 0,11W/mK)	100		
	Glass mineral wool	50		
	Clay bricks (λ: 0,5 W/mK)	105		

3.3.3. PV Panels

Solar energy, which can be used by the building as a renewable energy source, was used as a means of electricity production. The maximum number of panels that can be placed on the building roof, which is the

most suitable place for panel placement, was determined. Improvements have been made by taking into consideration the costs of the proposal. It is aimed to reach the "Zero Energy Building Concept" with the electricity production obtained from solar energy. The properties of the Photovoltaic Panel, proposed to be integrated, are shown in Table 11.

Table 11. Characteristics of Photovoltaic Panels (Tera Solar, 2020).

Electrical & Mechanical Characteristics	
Brand Name	Tera Solar
Model Number	TRP-300B
Maximum Power (Pmax)	300W
Open Circuit Voltage (Voc)	45.20V
Maximum Power Voltage (Vmp)	36.38 V
Short Circuit Current (lsc)	8.67A
Maximum Power Current (lmp)	8.24A
Operating Temperature	from -40°C to +85°C
Maximum System Voltage	1000VDC
Series Fuse Rating	10A
Linear Performance Warranty	10 Years, Over %90, 25 Years Over %80
Power Tolerance	0~+3%
Dimensions of the Module (WxHxD) (mm)	1960x990x35
Solar Cells	Poly
Solar Size	156x156
No of Solar Cells and Matrix	72(6x12)
Junction Box	IP65, 3 Diodes, 900mm Cable
Connector Type	MC4
Weight	22.5 kg
Front Glass	3.2mm Low Ironed Tempered Solar Glass
Frame	Frame Anodized Aluminum Alloy

STC: Irradance 1000 W/m². module temperature 25°C, AM=1.5

Photovoltaic systems are preferred in terms of energy efficiency because electrical energy is supplied from these systems; it does not leave harmful waste to the environment, it does not cause air pollution, it does not consume primary energy sources and tries to prevent climate change by using direct sunlight as a source of fuel. Contrary to the belief, photovoltaic panels are low cost both in operating and maintenance aspects (Özkılıç Keleş, 2008). Photovoltaic panels, other than providing electricity for constructions provide; thermal insulation, sound insulation, shading, and protection against harsh weather conditions (Güneş, 2019).

Designing high-performance energy-efficient buildings is essential to avoid irreversible environmental problems. Buildings with on-site renewable energy generation and better design can consume zero energy and generate additional energy (U.S. Department of Energy, 2009).

3.4. Evaluation of the Effects of Strategies Developed in the Framework of "Improving Energy Efficiency" on the Energy Performance of the Building

In this study, "eQUEST" energy analysis program was used both in building energy performance evaluation and implementation of energy efficient improvement strategies.

Input data for the proposed variables to minimize energy consumption at the initial stage are summarized in the table below (Table 12).

Table 12. Input Data for Proposed Variables.

Convention Center - Building Components	Name	U values (W/m²K)
Windows	Triple Insulating Glass Synergy (Double Low-E) Wood Window Frame	**1,425**
Exterior Doors	Triple Insulating Glass Synergy (Double Low-E) Wood Door Frame	**1,425**
Ground Floor	Epoxy Screed Thermal Insulation - XPS 2 Layers Waterproofing Leveling Screed Lean Concrete Blockage Compressed Soil	**0,347**
Wall	Plaster Gazbeton (TS825 0,11 W/mK) Glass mineral wool Clay bricks (λ: 0,5 W/mK)	**0,4**
Roof	Vegetation layer (extensive green roof) Soil bed Stab-Filter layer, Polypropylene fiber Water Drainage/Storage Element, DAKU FSD20 Anti-Root&Rot waterproofing membrane Expanded Polystyrene insulation Bitumen layer Slopping screed - Concrete ribbed slab Ceiling plaster	**0,19**
	Polikristal PV Panel - Tera Solar	
	Baseline + Scenarios	

The energy consumption amount in the "eQuest" program, for the defined structure, was completed with the initial data. For the following process the structural component layers of windows, exterior doors, walls, roofs, and floors were changed. PV panels were added and additionally, window ratios were reduced by half.

3.5. Analysis and Evaluation of the Results

In the second stage of the study, the different alternatives proposed were simulated with the 'eQuest' energy analysis program, by the assistance of the current status data. The proposed improvement scenario variables and current status data are shown in Table 13.

Table 13. Variables in structure components from the “Baseline Scenario” to the “Improvement Scenario”

Convention Center - Building Components	Material Names of Baseline Scenario	U values (W/m^2K)	Material Names of Improvement Scenarios	U values (W/m^2K)
Windows	Glass Wood Door Panel	**1,8**	Triple Insulating Glass Synergy (Double Low-E) Wood Window Frame	**1,425**
Exterior Doors	Glass Wood Door Panel	**1,8**	Triple Insulating Glass Synergy (Double Low-E) Wood Door Frame	**1,425**
Ground Floor	Ceramic Tile Concrete - Sand/Cement Screed EIFS - Exterior Insulation and Finish System Concrete	**0,57**	Epoxy Screed Thermal Insulation - XPS 2 Layers Waterproofing Leveling Screed Lean Concrete Blockage Compressed Soil	**0,347**
Wall	Paint Plaster EPS Concrete	**0,57**	Plaster Gas Concrete (TS825 0,11 W/mK) Glass mineral wool Clay bricks (λ: 0,5 W/mK)	**0,4**
Roof	Roofing - Tile Insulation - Wool Wood Door Panel Air Barrier - Air Infiltration Barrier	**0,38**	Vegetation layer (extensive green roof) Soil bed Stab-Filter layer, Polypropylene fiber Water Drainage/Storage Element, DAKU FSD20 Anti-Root&Rot waterproofing membrane Expanded Polystyrene insulation Bitumen layer Slopping screed - Concrete ribbed slab Ceiling plaster	**0,19**

The energy performance analysis results of the renewed building elements integrated into the "Baseline" scenario data are as follows. (Figure 10 – 11 and Table 14 – 15).

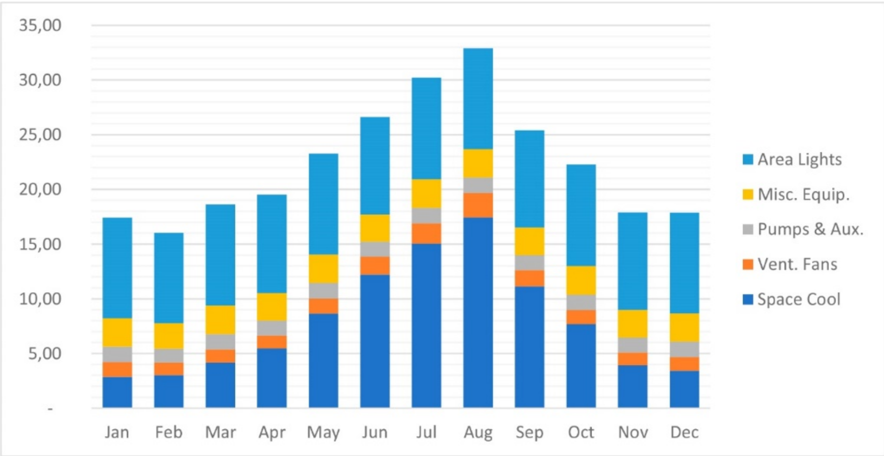


Figure 10. Electric Consumption (kWh) (x000)

Table 14. Electric Consumption (kWh) (x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/1 year
Space Cool	2,87	3,02	4,16	5,46	8,65	12,23	15,05	17,45	11,13	7,68	3,93	3,42	95,05
Vent. Fans	1,34	1,13	1,2	1,17	1,37	1,61	1,85	2,23	1,5	1,28	1,16	1,25	17,1
Pumps & Aux.	1,42	1,28	1,42	1,37	1,42	1,37	1,42	1,42	1,37	1,42	1,37	1,42	16,73
Misc. Equip.	2,59	2,34	2,59	2,52	2,59	2,51	2,6	2,59	2,51	2,6	2,51	2,59	30,54
Area Lights	9,2	8,27	9,24	9	9,23	8,9	9,31	9,23	8,9	9,31	8,92	9,2	108,73
kWh/1 year	17,43	16,05	18,61	19,52	23,27	26,61	30,23	32,92	25,42	22,29	17,9	17,89	**268,14**

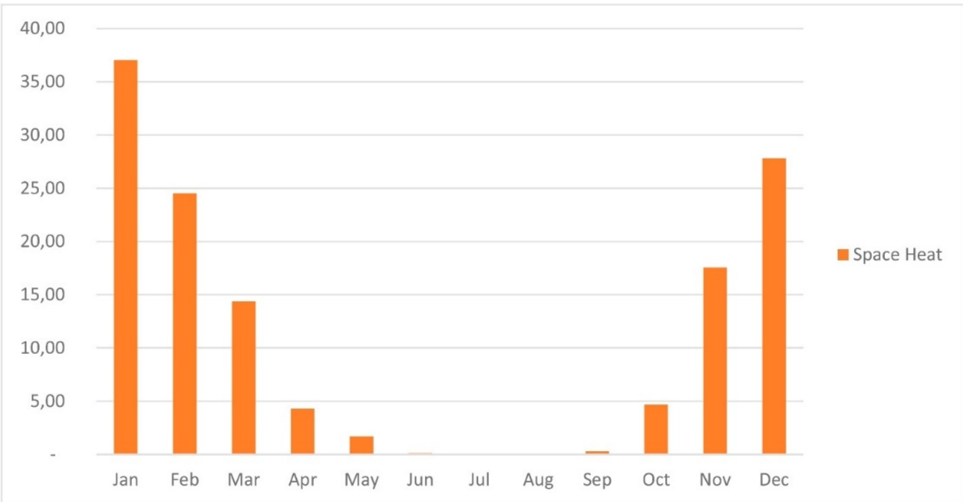


Figure 11. Gas Consumption (kWh) (x000)

Table 15. Gas Consumption (kWh) (x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/1 year
Space Heat	37,04	24,52	14,37	4,3	1,68	0,11	-	-	0,28	4,67	17,57	27,81	132,35
kWh/1 year	37,04	24,52	14,37	4,3	1,68	0,11	-	-	0,28	4,67	17,57	27,81	**132,35**

In the first stage, the use of qualified glass was proposed to increase the energy performance of windows and doors with a thermal permeability coefficient of 1.8 W/m^2K and the use of glass and wood frames was proposed with the thermal permeability coefficients reduced to 1,425 W/m^2K. At the same time, the window proportions in the façades were reduced by 50% considering the suitability of the building's main function.

The data obtained by integrating the imrpovement suggestions are made in line with the increase of thermal resistance of the walls, flooring and roof elements, working as elements that seperate the exterior from the interior, by minimizing the heat transfer from the outdoor and indoor spaces, is shown above.

Epoxy floor coverings are long-lasting and do not require frequent floor application, repair, and modification. It is preferred as a way to prevent abrasion, wear and tear at spaces with extensive human use and continuous cleaning methods. Due to the gradual and sequential application of flooring products and applications, with craftsmanship being a prominent element, epoxy flooring activities are a bit more costly and long-term, but they are very useful in terms of their advantages compared to their prices (Sanat Zemin ve Yapı, 2020).

In the improvement scenario according to "Baseline," an evaluation is made by considering that there will be no energy consumption during the operation phase for flooring, where carbon dioxide emission and cumulative energy demand increase in production and construction. It has been evaluated whether the targeted state can be achieved as a result of the improvement practices aimed at minimizing heat transfer, so as to reduce energy consumption for thermal comfort. As a result of the energy analysis conducted, a decrease is observed in the total energy consumption of the building, as well as an increase in energy performance. Factors such as reducing repair, modification and renewal in the building life cycle and increasing thermal protection in operation will also affect the energy performance positively.

When the performance of the green roof application in taken into consideration, opposing the traditional terrace roof application, one can come in terms with the many benefits. With an area of 4837 m^2, the proposal works as an urban heat island, reducing noise and air pollution. This can be verified by the data showing that heat loss is reduced by 70%, all the while increasing the heat inlet to 85%. Along with these, the improvement of air quality, rainwater management, support of biodiversity, reduction of electromagnetic radiation, usage of recyclable materials, filtration of heavy metals from precipitation and the extension of the roof/structure's life cycle can be listed as the continuation of the benefits. A performance assessment for the green roof application, which provides the balance between the indoor and outdoor environment at thermal load, has not been made numerically. Although, it can be said that green roof application will regain more of the energy consumed by considering the life span of the building.

The reduced thermal permeability coefficients for the outer walls, which are planned to be installed by mounting the thermal insulation material on the outer surface of the wall body in plates to prevent problems such as thermal bridges, cracking and condensation, and placing the outer wall covering (with construction) material by leaving a 5 cm air gap, are defined in the program.

As a result of the evaluation made with the "PVsyst V6.43" program for the photovoltaic panels that are planned to be integrated into the building in order to benefit from solar energy, the amount of energy produced with 525 modules has been found to be 223.1 MWh / year, and the positive effect it will provide on electrical energy consumption should be considered.

4. CONCLUSIONS AND SUGGESTIONS

In this study, the evaluation on whether the expected performance can be achieved with the improvement works that can be done to make a Conference Center Building, located in Manisa-Soma, more energy efficient has been made. The scenarios proposed in the study suggests an integration of a new component rather than changing the entirety building component layer. This phenomenon is supported by energy performance simulations and emphasizes the importance of energy performance analysis in the early design phase. For the building, changes were made to the thermal comfort conditions of the building envelope elements and alternative energy sources were implemented. With the application of these variables, the energy performances that have changed during the year for operation have been analyzed. In addition, the structure baseline energy performance data and the data obtained after the improvements were compared as follows;

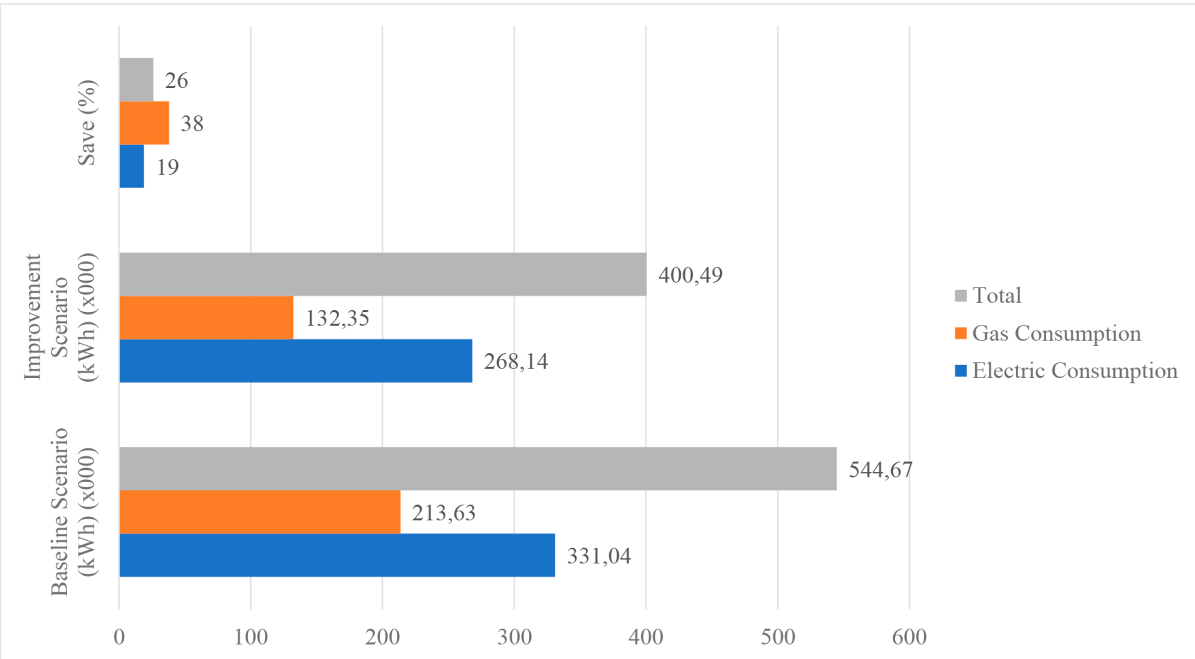


Figure 12. Comparison of “Baseline” and Improved Scenario Energy Consumption Data

(As a result of the evaluation made with the "PVsyst V6.43" program, the amount of energy produced by 525 module applications was found to be 223.1 MWh / year.)

According to the data of electricity and gas consumption, which is constructed upon an annual use of the building, when “Baseline” and improvement scenarios are compared, an increase in energy performance is observed with a decrease in energy consumption. In line with the improvements in electricity consumption, 19% efficiency was achieved, while 38% efficiency was achieved in the gas consumption used for heating. Along with this, total energy efficiency increased by 26%. In addition to the data obtained through the program, factors such as the useful life of the recommended materials, frequency of maintenance/repair, recycling, and positive effects on energy gain should also be taken into consideration during the interpretation phase. The cost of using active system PV panels, integrated into “eQUEST” data through a different program, should be evaluated according to the energy performance efficiency it will bring to the project.

As a result, the determination of basic energy use at the beginning of a study helps to identify feasible targets to improve the design in the early design stage and to develop appropriate strategies to achieve these objectives. All design parameters should be considered as a whole and buildings should be evaluated throughout their life-cycle.

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