A low cost plus energy building in Istanbul


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Introduction

Building industry is certainly one of the most important industrial and economic sectors that affect the life quality and environmental issues, since it has a strong effect on user comfort and energy consumption. It is known that 1/3 of greenhouse emissions in the world is from buildings due to their high energy consumption. All because of those, in every country in the world, regulations came into force to decrease the emissions from the buildings. Energy Performance Directive for Buildings (EPBD) has described the rules to increase energy performance of existing and new buildings. In the framework of EPBD, in Turkey "Building Energy Performance Regulation" has been published in 2008 and the rules for emission reduction from buildings have been described in this regulation. In the meantime, EPBD recast has been prepared to consider cost optimality together with energy efficiency. Recast EPBD directs to define cost optimal level of energy efficiency considering investment, maintenance and energy cost of buildings. However, in Turkey there is a prejudice that the energy efficient building is expensive building considering investment cost. In fact, if the required studies have been carried out during the design stage to improve energy efficiency through energy modeling and feasibility studies, it is possible not to increase the initial cost of building for higher energy performance. In this study, a PlusEnergy building in Istanbul is introduced. This building has been designed to decrease the energy need to the possible minimum level and this need has been met by solar thermal and solar power systems integrated to its roof. Monitoring results of the past year showed that the building has only used the 40% of this self-produced energy.

Figure 1. Steelife-EcoHouse South Façade.

Plus energy building in Istanbul

The name of the Building is Steelife-EcoHouse and it is the first sample and prototype in Turkey which aims to produce energy from building integrated renewables to achieve zero carbon objectives during operation period.

Architectural Design

All design decisions have been made according to the detailed dynamic simulation results, to achieve low energy consumption and zero carbon emission through renewables. As a result of this design process, Steelife-EcoHouse has exceeded its first aim and it has become a PlusEnergy house that provides more energy than it requires. Steelife-EcoHouse offers healthy life conditions to its occupants. Energy efficiency has been considered in three headlines;

- to reduce energy demands in heating, cooling and lighting
- to meet the energy need through efficient systems
- to provide energy through clean energy sources

The South facade of the house is shown in **Figure 1**.

In the design process of this prototype, detailed dynamic simulations have been performed to ensure thermal, visual, and acoustical comfort of the building occupants at the maximum level and to minimize the heating, cooling, ventilation and lighting energy demand to provide these comfort conditions. All design details including insulation thicknesses and thermal bridge insulations are determined according to these simulation results. The windows have been predicted to have three glass layers and the size of the overhang shading has been defined through detailed simulations. Moreover, to determine the position of the building, shading analyzes of the surrounding buildings have been performed during the design process. **Figure 2** shows examples for simulation model and shading analyzes.

The energy performance level of the building has been compared with National Reference Building which is described in Turkish National Building Energy Performance Calculation Method (BEP-TR). The annual heating and cooling energy demands of the reference building for Steelife-EcoHouse are shown in **Figure 3**. As it mentioned before insulation, window type, daylight and natural ventilation strategies, etc. have been determined in accordance with detailed dynamic simulations and the annual heating and cooling energy demand results of the proposed design is also shown in **Figure 3**. The simulation results in **Figure 3** shows that the energy demands of the proposed design have been reduced 70% and almost 50% in comparison to the reference building, respectively for cooling and heating, and the total energy demand from 84 to 44 kWh/m². In all of the energy efficiency strategies also maximum benefit from daylight has been aimed and therefore, lighting energy demand has been reduced as much as possible. Window frames have been selected as PVC having three glass layers with Passive House certificate and the U-value of the window is 0.9 W/m²K.

Roof slope was desired to be only in one direction by architect and it has been planned with the optimum angle to get maximum benefit from solar radiation for solar power (PV) and thermal solar systems. As shown in **Figure 1**, PV panels for electricity production and solar collectors for domestic hot water production have been located on the roof. To be able to provide enough daylight and minimize the heating and cooling energy demands at the same time, the dimension of the roof overhang has been determined by making shading and energy analyzes. **Figure 5** shows the interior of Steelife-EcoHouse.

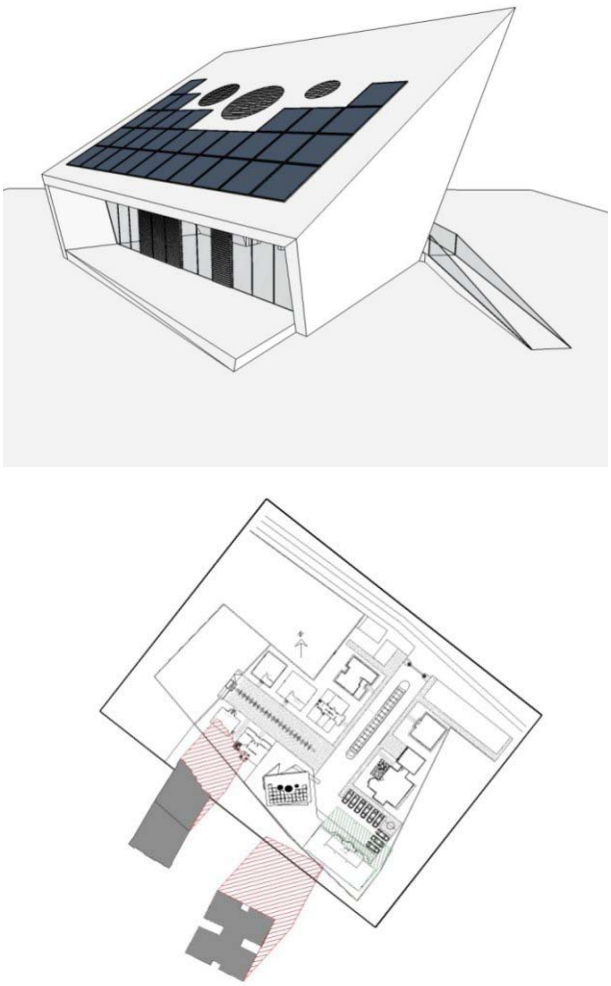

Figure 2. Examples for the Simulation Model and Shading Effect Analyzes of Surrounding Buildings.

Technical Equipment

The technical systems that have been used to provide clean energy and energy efficiency in the house are as below:

- PV Panels and Solar Collectors
- Air Source Heat Pump
- Under-floor Heating/Cooling System
- Controlled Ventilation System/Heat Recovery Unit
- Rain Water Storage System
- Gray Water Treatment System
- Waste Water System
- Water Efficient Fixtures
- Central Vacuum System
- Led Lighting
- Control Panel

Air source heat pump with COP of 3.5 - 4 has been used in order to supply the under-floor heating system to meet the minimized heating and cooling energy demands of the Steelife-EcoHouse. Moreover, since the system has been applied to a wider surface, it can work with low water temperature. The minimum water temperature that is used in under-floor heating system is around 42°C in a standard insulated building in Istanbul weather conditions. However, it should be remarked that the water temperature for under-floor heating system in Steelife-EcoHouse is around 33°C since the heating energy demand is minimized through architectural design. Therefore it requires less energy in comparison to other heating/cooling terminal units. The electricity that is required by the heat pump has been easily provided from the PV panels located on the roof, therefore no fossil fuels has been used for heating and cooling. The building is self-sufficient without any need from natural gas or others.

Whenever the outdoor air quality is appropriate for comfort conditions, fresh air is provided from roof and façade windows through natural ventilation. When the outdoor air temperature and humidity are not appropriate, controlled ventilation system starts to operate.

Rain water storage system and gray water treatment system are used for garden irrigation and/or in reservoirs. The reservoir that is used in the building has dual functions with the 2.5- 4 liters or 3- 6 liters options, therefore it provides almost 70%water saving. In addition, water consumption is reduced using the efficient fixtures in lavatory and bath.

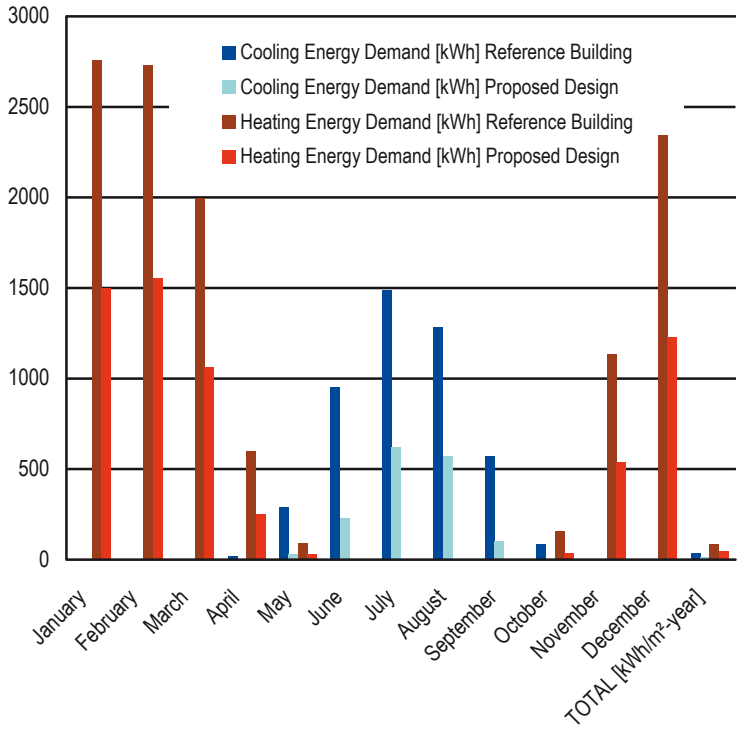

Figure 3. Monthly cooling and heating energy demand of the reference building and proposed design in kWh/month. Annual heating energy demand was reduced from 34 to 11 kWh/m² and cooling energy from 84 to 44 kWh/m².

Figure 5. Steelife-EcoHouse Interior and System Control Panels.

Led luminaires have been used for all lighting systems in the building. These luminaries can work until 100,000 hours and have 10 W Led lamps instead of 75 W lamps. These lamps produce 25 times less heat than the standard lamps and therefore prevent the loss of energy as heat and therefore they have positive effect on cooling loads.

The control panel which is located in the living area as it is shown in **Figure 4** to control all of the technical systems. The production of PV panels has also been continuously monitored.

It has been defined that only 40% of the electricity produced by 28 unit of PV panels located on the roof can meet the total electricity required by all technical systems of Steelife-EcoHouse. The excess electricity production is providing electricity demand of the neighborhood buildings.

Thus, Steelife-EcoHouse is PlusEnergy building operating with zero carbon emission and providing comfortable indoor environment to the occupants without any energy bill. ■