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Low Carbon Technologies in Green Buildings

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Abstract: Increasing population, industry, and developing technology, rising energy need, running out of fossil fuels, and limited existing energy resources have made it necessary to work on the efficient use of energy. In this context, energy efficient building design approaches have found an important place in interdisciplinary studies in recent years. Green building systems are nano-technology building automation control systems that facilitate home life and provide security. By integrating living spaces with developing technologies, it transforms it into a more comfortable, safer, and more enjoyable way of life. Green buildings enable building owners, building managers, and users to achieve their goals in cost, energy management, comfort, convenience, security, long-term flexibility, and visuality. Low carbon technologies, also known as green technology, are defined as the development and implementation of systems that are used to protect the natural environment, resources, and minimize the negative effects of human activities. The main objectives of low carbon technologies are; to control global warming, reduce greenhouse gas emissions, and develop innovative inventions that do not affect natural resources. In general, the necessity of low carbon technologies is related to reducing risks to the environment and protecting natural resources. At the same time, low carbon technologies enable the use of clean and renewable energy sources to prevent the complete depletion of other non-renewable resources. It is very important to use low-carbon technologies for the effective use of energy in buildings and not to pollute the environment. In this study, green buildings and low carbon technologies that can be used in these buildings are researched and suggestions are made.

Keywords: Technology, Green building, Low carbon.

1. INTRODUCTION

Many gases are produced as a result of the use of fossil resources. Most of these gases constitute greenhouse gases. Many gases such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), ozone (O_3), nitrogen oxides (NO_x), chlorofluorocarbons (CFC) and hydrofluorocarbons (HCFC) are greenhouse gases. These gases provide the required temperature for the world. Normally, some of the rays coming from the sun to the earth are reflected by the atmosphere, while the other part creates a greenhouse effect with greenhouse gases. The greenhouse effect provides the temperatures required for life on Earth. The average temperature of the earth is +15 degrees Celsius. However, if these gases did not exist, the temperature would be -18 degrees Celsius (Guliyev, 2022). Although this phenomenon is a natural phenomenon, today the excessive use of fossil resources increases the amount of these gases in the atmosphere. The more intense greenhouse effect that occurs as a result of this causes global warming by hiding more sunlight and causing the world temperature to increase. Global warming also raises the problem of climate change (Güzel & Alp, 2020).

CO_2 gas (9%-26%), which contributes the most to the world's greenhouse effect after water vapor (36%-70%), is responsible for 3/4 of global warming. Other greenhouse gases make up the remaining part. Total greenhouse gas emissions are given in Figure 1. Greenhouse gas emission units are CO_2 eq. (CO_2 emission equivalent) and metric tons of CO_2. When greenhouse gas emissions are compared, it is seen that CO_2 has a much stronger greenhouse effect potential than other greenhouse gases (Roston et al., 2021).

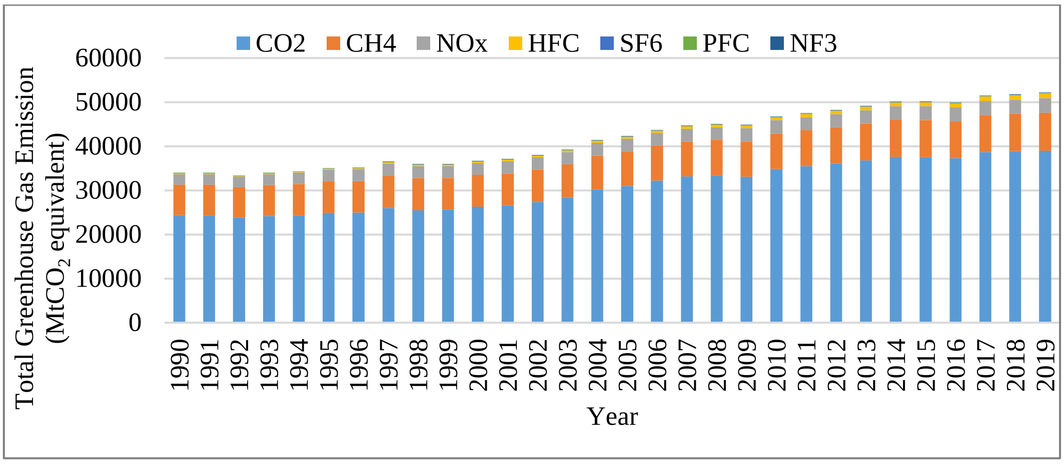

Figure 1. Change in total greenhouse gas emissions in the world.

Due to Covid-19, CO_2 emission values decreased in 2020 compared to previous years. As seen in Figure 2, carbon emissions resulting from energy use in 2020 decreased by 6.3%, falling to the lowest level since 2012. The year 2020 was recorded as the largest decrease in the amount of CO_2 emissions in primary energy consumption since the Second World War (BP Statistical, 2021).

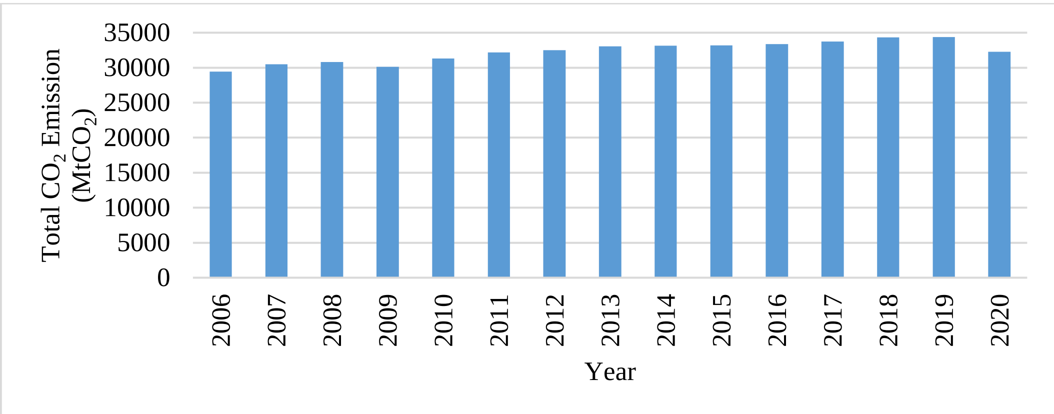

Figure 2. Change in total CO_2 emissions in the world.

2. GREEN BUILDINGS

The term green building was first used in the USA in the early 80s when information technologies were rapidly spreading. Green buildings are also called sustainable buildings, ecological buildings, and energy efficient buildings in the literature, where energy is used efficiently and at a minimum level. Green buildings start from the land selection of the building. Then, they are sustainable buildings designed with an understanding of environmental responsibility, suitable for climate data and local conditions, consuming as much as needed, oriented towards renewable energy sources, using natural, and waste-free materials, encouraging participation, sensitive to ecosystems (Kayın, 2019).

Green buildings are also structures that are designed, constructed, renovated and operated in a way that uses natural resources efficiently, and they are built to protect the health of the people living in them, increase the productivity of employees, use water, energy, and other resources more efficiently and to minimize the negative effects that may occur. There are several major benefits of green buildings. These include reducing carbon dioxide emissions, ensuring the use and development of renewable energy, utilizing natural light, providing energy savings, reducing heating and cooling costs with insulation systems, increasing the value of the building, and providing a healthier environment for users. Research on green buildings shows that if buildings are designed and operated in this way, there can be a 24% to 50%

reduction in energy use compared to buildings designed with traditional methods. Green buildings also show that CO_2 emissions can be reduced by 33% to 39% (Kılıç & Erikli, 2021).

Green building energy modeling is the creation of an abstract model of a building design in the required detail in a computer environment and testing it under the conditions that will occur during its use. The model to be created can be created from scratch by an energy modeling expert or can be derived from existing models. As seen in Figure 3, the main goals of green building are (Khosla & Singh, 2014):

- Building design that is flexible and can adapt to changing conditions and has a long lifespan,
- Efficient use of energy,
- Effective use of resources,
- Reducing waste,
- Protection of clean water resources,
- Avoiding harmful and dangerous substances,
- Minimizing health and safety risks,
- Ensuring healthy indoor air quality
- Preservation of biological diversity

Figure 3. Green building design concept.

Applying building energy modeling brings many benefits. These are determining the optimum building layout by examining the land-sun relationship, evaluating approaches such as natural ventilation or night cooling by examining the prevailing winds, evaluating innovative air conditioning systems suitable for the building usage profile, determining the amount of energy production with the use of renewable resources, evaluating passive architectural measures and shading approaches on a seasonal basis, reducing the electrical energy required for lighting by optimizing the use of daylight. Energy modeling can be applied in new buildings as well as in operational decisions or renovations of existing buildings. As seen in Figure 4, energy modeling studies require a labor-intensive process that involves defining the building's current data regarding energy consumption (Energy, 2019).

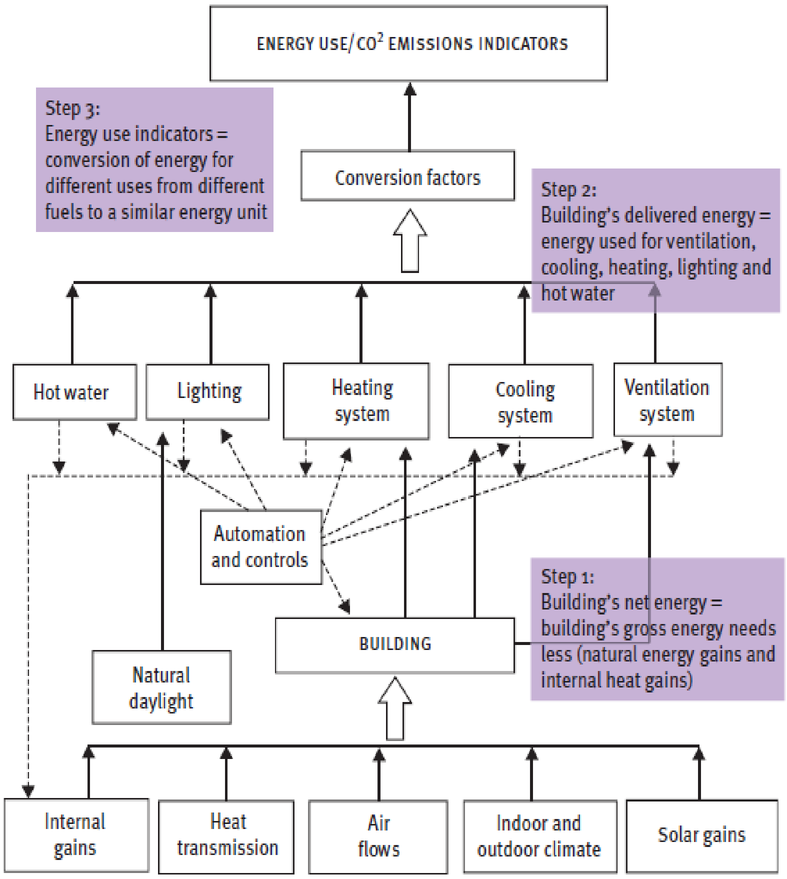

Figure 4. Energy modeling in green buildings.

3. LOW CARBON TECHNOLOGIES

Energy needs can be reduced by using renewable energy sources in buildings. On-site production from renewable energy sources and the use of the produced energy in the building can help reduce or completely eliminate the building's dependence on energy networks. The main active systems that produce energy in green buildings and affect energy efficiency, reducing the energy needs of buildings, are as follows; photovoltaic systems, wind systems, and hybrid systems (Zhou et al., 2012).

3.1. Photovoltaic Systems

Solar panels, which are in the distributed electricity generation system category, consist of modular photovoltaic systems that can produce electricity. These systems, which are generally installed on the roofs of buildings, meet the energy needs of the building with the electricity they produce. At the same time, since they function as a small-scale energy production plant working in parallel with the electricity grid, they can transmit this electricity to the nearest point of need. If excess energy remains in the system in the building where the system is installed, the energy produced can be sent to the grid to meet the energy needs of other buildings. While these systems operate with zero CO_2 emissions, they also prevent almost 40% of energy losses resulting from transmission. In addition, other advantages provided by the system are (Küçükgil, 2021);

- The system can be installed and operated without a license
- Installation can be achieved quickly
- It saves space by being installed on empty roofs.
- Since they are installed instead of the roof systems in the building, they do not require another roof element

- In this system, choosing distributed generation points instead of providing energy from central points contributes to the emergence of a more durable and less risky energy system
- These systems can provide the support energy services that energy networks need
- As seen in Figure 5 and Figure 6, these systems can be applied as desired, both on-grid and off-grid (Nur & Buğutekin, 2017).

Figure 5. On-grid residential photovoltaic systems.

Figure 6. Off–grid residential photovoltaic systems.

3.2. Wind Systems

Wind systems are the main structural elements of wind power plants and are machines that convert the kinetic energy of the moving air first into mechanical energy and then into electrical energy. Although wind energy has been widely used since the 90s, its use in buildings has become more prevalent in recent years. The need for clean and renewable energy has made the use of wind energy in buildings mandatory. Wind systems can be used wherever electricity is needed, such as (Yılmaz, 2006);

- Buildings
- Businesses
- Park, garden, and street lighting
- Signaling systems
- Irrigation systems
- Caravan, boat, and mobile stations

Wind systems, like photovoltaic systems, can be divided into two groups: independent from the grid and dependent on the grid. The types of wind turbines used in buildings are used independently of the building, as in Figure 7, or connected to the building, as in Figure 8 (Bektaş, 2013).

Figure 7. Halifax marina market, Canada.

Figure 8. The green building, England.

3.3. Hybrid Systems

Hybrid systems are systems that produce energy by combining at least two energy sources. Wind systems and photovoltaic systems are used as a hybrid system and these systems are very efficient. In this system, wind turbines and solar panels are used together. In this type of system, when the wind blows, electricity is produced from the wind and the energy stored by the solar panel during the day is accumulated in the battery system. When weather conditions are not sufficient (for example, when the wind is not blowing or the weather is cloudy), it is used by supplementing it with either stored energy or energy taken from the grid. Generally, the wind-solar hybrid system includes a wind turbine, solar module, regulation unit, generator, and battery system. Moreover, such systems can be easily mounted and used on the roof in homes and industrial facilities. Figure 9 shows the use of a photovoltaic-wind hybrid system (Bektaş, 2013).

Figure 9. Yıldız Technical University, Türkiye.

4. CONCLUSION

Green buildings are designed and operated to minimize the negative effects of the built environment on human health and the natural environment. It ensures the effective use of energy, and other resources, protecting the health of users and increasing the productivity of employees. It also means reducing waste, pollution and environmental degradation. Using low carbon technologies in homes is the first step to be taken individually in reducing carbon footprint. The cost of these technologies used to benefit from renewable energy sources is decreasing day by day. Low carbon technologies should be disseminated by producers, distributors and consumers, and renewable energy storage systems should be developed. Current energy policies in the electricity sector should be updated again and focused on low carbon technologies. All these studies will make great and important contributions to achieving national and international targets in both ensuring energy efficiency and reducing greenhouse gas emissions produced by buildings.

In Türkiye, within the framework of the harmonization process with the European Union, various legal regulations, standards, and regulations on the use of renewable energy sources have begun to be implemented regarding the effective and efficient use of energy in buildings. Studies have been carried out within the framework of the activities of the public, private sector and local governments to raise sufficient awareness about energy efficiency in buildings and to draw attention to reducing carbon emissions in buildings. Suggestions that will be useful are as:

- Developing energy and carbon policies at the national level and strengthening this framework's institutional and legal structure
- Increasing the energy performance of buildings and reducing carbon emissions
- Expanding the use of renewable energy sources in buildings
- Revision of relevant standards in buildings
- Developing energy performance and carbon emission calculation programs
- Strengthening relevant control and audit mechanisms
- Raising public awareness and training about energy consumption and carbon emissions

- More active involvement of energy and carbon emission consultancy services in buildings

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