Energy Saving and architecture in association with climatic factors

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Abstract

The current research investigates energy saving and architecture in association with climatic factors. The research is descriptive and analytical through library resources. One of the most important effective factors in energy saving is climatic factors. Things like the design and the materials are less important. This distinguishes those who believe in passive design from those who believe in an active one. How to know the climate is the first question before us. For a long time, two groups of factors have helped us identify the climate, one geographical location in terms of longitude, latitude, and altitude, and the other climatic elements such as temperature, radiation, humidity, airflow, and atmospheric precipitation. The results showed that there are three ways to save energy in buildings. All three methods complement each other and the first way, using pre-controlled building factors, is reasonably of priority. These factors include proper design, location, proper orientation, and factors that allow maximum use of natural light during building exploitation. The second method of saving is associated with simultaneous control factors, such as using energy-saving lamps, changing the type of heating and cooling devices, and having the power to control them. The third method is to change the culture of consumption. Education is the root of the right culture. It is possible through economic and environmental channels.

Keywords: energy consumption, building architecture, climatic factors, renewable energy
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Introduction

Demographic studies and the human economy indicate that the consequence of excessive population increase is poverty and hunger in a large part of the globe and the accumulation of wealth in another part. Rich countries are somewhat satisfied with this situation and even fuel the problem. Population control planning and conservation of resources at any cost should be the priority for the authorities of any country. Although the increase in population in non-developed countries, which is increasing daily, increases the energy demand rate. If the per capita consumption of energy increases, the people of these countries will have to use all their available fossil fuel sources for survival. The use of fossil fuels has caused the emission of greenhouse gases, which create alarming changes in the climate. It seems that control of the population is necessary. Otherwise, the planet will not be habitable in the future, and the next generations will experience a suffering life associated with numerous diseases. There is also the concern about the decay of moral questions. Those who appear to be human rights promoters, by promoting egoism, intend to provide foundations for amoral actions in the future. Do not pay the slightest attention. Today's politicians seek to alienate people at any cost so they cannot think and do not provide means of disturbance [1].

In general, without proper measures, in 2050, we will witness misery for at least 50% of the eleven billion people on the planet. In 2020, about a one-third increase in the world population. Most of this population will live in underdeveloped countries. Therefore, the population that suffers from insufficient economic income will increase unbelievably. Unfortunately, half of the current population of the world is deprived of the usual energy resources. With the increase in population, there is no hope for solving the

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problem by improving technology. Although the population share of third-world countries is increasing daily, the share of using their resources and facilities is decreasing daily [2].

A variable called the extent of countries is not a positive or negative factor, but the relationship between population distribution and wealth distribution is important and worthy of sufficient attention. A reasonable expectation that the theory of gradual development of demand has recorded in its goals is in complete contradiction with the population growth we are witnessing today. The only way to deal with the population increase is to raise literacy and cultural and social awareness. Although this is expensive, it will produce permanent stability for one or two decades. Taking the above issues seriously will be helpful in Macro-Planning and all fields.

Energy sources

Energy comes from three important sources. First, the sun's radiation as the essential source; second, the central heat of the earth - through the temperature inside it - and third, the water sources and sea waves. Theoretically, the energy flow in the earth is about 174000 x 10^{12} watts, 1600 watts per capita, considering the world's population of six billion. We know very well that this amount is not the same for everyone in different parts of the world and even in different parts of the same country. Some energy sources, such as fossil sources, are not renewable, but others are irreplaceable. This group includes solar energy, wind energy, and sea wave energy. [3]

1. Solar energy

In power plant use, solar energy is converted into electrical energy using parabolic mirrors or tower receivers (central receivers using heliostat mirrors). In non-power plants, solar thermal energy produces energy using photovoltaic systems, cells, and water heaters. The efficient use of solar collectors started in 1990. The prediction was that in 2010, about 2000 megawatts of energy would be supplied through these collectors. [4]

Another way to use solar energy is to benefit from solar cells, a technology developing day by day worldwide (Figure 1). Solar cells have widespread uses and are applicable in different ways, from the finest to space stations. There are many reasons for using solar energy with solar cells. This is a healthy system; their carbon dioxide production is nearly zero. As for the use of solar cells, the share of third-world countries is nothing, and in the most optimistic forecasts, it is about one-fiftieth of the global energy production [5].

Among other technologies, harnessing solar energy is the solar energy concentrating system, which collects sunlight through a large mirror, concentrates it and turns it into a concentrated heat source. In 2001 in the European continent, about 755 million residential houses were not connected to the national electrical grid and used the local grid. Public use of the national grid is completely uneconomical. Local production easily meets local demands in the heat, cold, and light fields. Such a distribution has many social and environmental benefits, creating healthy competition for healthy consumption.

Figure 1: Solar panels on the roof

2. Wind energy

Severe and planned exploitation of this energy source did not exist anywhere in the world until thirty years ago. With proper planning, wind energy significantly affects using less fossil energy. It is expectable to produce 10^7 megawatts of electrical energy through wind energy. When solar radiation reaches the uneven surface of the earth unevenly, it causes changes in temperature and pressure, and consequently, wind occurs. On the other hand, the flow of warm air moves from the equator to the north and south poles, and this movement creates wind. Ocean currents do a similar action. The wind is one of the different forms of solar energy [6].

With the beginning of the energy crisis in 1973, a new approach to using wind energy became popular. This problem has caused the slope of the wind power curve to rise sharply in recent years.

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The global wind map shows that 27% of the land area of the earth is exposed to winds of more than 5.1 meters per second. If one square kilometer of this land is prepared for installing wind turbines, it will have a production capacity of 8 megawatts. Thus, 24 x 10^4 gigawatts of electricity will be producible every year. If only 5% of it is realized, then there will be no electric energy problem until 2300. On the other hand, the emission of carbon dioxide gas from a wind turbine is one-tenth of the emission from a similar coal-fired system. Normally, with similar energy production, the carbon dioxide gas of fossil fuels is fifty times more than the carbon dioxide gas of wind energy.

The negative aspects of using wind turbines are not negligible. The noise of the turbines, telecommunication interference from electromagnetic waves in the environment, the loss of birds due to collision with the turbines, the useful life of fewer than 20 years of each turbine, and the high construction cost are among these negative aspects. Such issues cause limited use of wind energy [7].

We should note that with global projects underway, turbines will become familiar and affordable shortly (Figure 2). Another difficulty is the high cost of preparing the wind atlas, which must be revised carefully every few years. This problem has reduced the global share of wind energy in global energy production. The growth trend of global electricity production through wind energy shows the lack of use of such an expensive system. We have to wait for new and cheap technology.

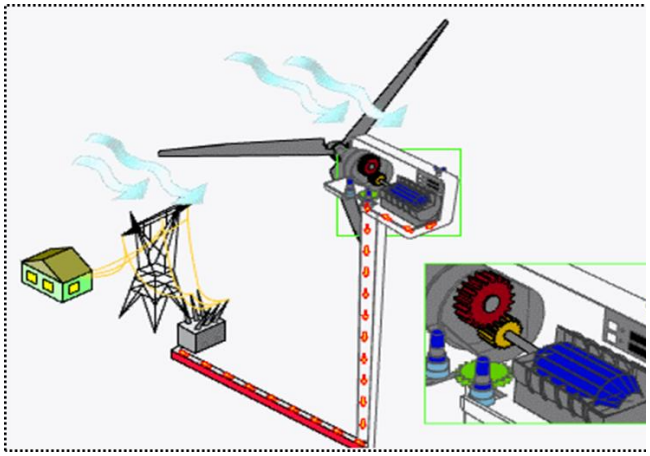

Figure 2: Wind turbine mechanism

3. Hydropower

It is possible to use the waves of the seas and oceans to produce energy in large parts of the planet. The emergence of tides and the wave movements of seawater also make it possible to use coastal energy production sites. China, Japan, Norway, and Scotland use optimally energy production systems - of the sea waves. The low amount of greenhouse gas production and the significant amount of wave energy production makes this production method very important. The high cost of equipment and repairs, as well as the possibility of rising seawater and total destruction of facilities, warn us to use this type of energy cautiously. Although producing such energy has faced environmental and marine problems, it is generally cheap, efficient, and useful with a long history. In 2000, more than 40% of the global production was for hydroelectricity, among renewable energies.

4. Geothermal energy

Geothermal energy results from the temperature taken from the depths of the earth due to the natural temperature flow of the earth. The Latin adjective is a derivative of two words (*geo* meaning earth) and (*thermal* meaning heat). Geothermal is the only type of renewable energy whose actual source is within the inhabited earth. Using steam and hot water produced by the heat of the earth's center is perhaps one of the best and easiest ways to produce the energy needed at regional levels. The first attempt to use the earth's heating occurred in 1904 to generate electricity in Italy. [8]

The results of the forecasts show that the global capacity for energy production in this way reached about 120 gigawatts in 2010. In terms of global use, it ranks third among other renewable energies. Investigations of the geothermal power plant in Meshkinshahr (Iran) are underway. So far, three wells have been drilled at an average depth of 3000 meters in the site, which shows good potential for generating electricity through this method.

Energy planning

Consumption is much more important than production in energy planning. To save energy, we must have enough information about energy-consuming sectors and separate their share from the total and annual national consumption. It is a precise and important task to formulate a program and to obtain accurate statistics for each department's energy consumption and needs. Depending on the needs of each population, determining the minimum level of consumption is also variable. In developing countries, like Iran, which do not have stable costs and have a variable and upward inflation growth with a steep

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slope, it is very difficult to predict the needs and is under the influence of factors beyond the need for energy. [9]

Accordingly, it is necessary to emphasize that determining the per capita basis for the gross national product plays a fundamental role in determining the energy consumption limits of different sectors. It is also acceptable that lowering per capita consumption by keeping or increasing the gross national product is an essential issue in the economy of any country. Another point in the energy consumption of different sectors is the problem of the minimum level of consumption, as we repeated several times. Its minimum level is a level of consumption that, if we can reduce again, we will have to spend more money to compensate for its losses. In such a situation, the strong recommendation is the non-reduction of the minimum level. Nowadays, the first global requirement is to determine such a level. All standards and laws focus on finding such a lost. [10]

Iran's obstacles to increasing efficiency and determining the minimum level of energy

In Iran, three groups of obstacles disrupt energy efficiency and the determination of the minimum level of consumption. The first group is institutional obstacles. The most important are a lack of information and sufficient experience, a weak relationship between executive bodies, non-respect of intellectual property rights, and negligence of public promotion of energy saving. An extensive and destructive obstacle is the lack of relationship between institutions, ministries, and various decision-making bodies in the energy production sector on the one hand and the energy-consuming devices and people on the other. In short, there is no proper communication between these two prominent and essential sides of the energy line. Middle officials have not perceived this significant challenge correctly. Consumers consume as much as they want, and producers produce as much as they need. Both excessive is the consumption, and false is the need. The low price of energy, the payment of wandering, and aimless subsidies caused such a crisis. An expectation is that the executive and legislative powers will be diligent and decisive in this field by formulating the right laws and fully implementing them. The many energy crises that appeared in the years after 1970 involved the widespread attention of Western countries to energy planning, production, and consumption so that they removed such obstacles from their way with the sufficient education. Such needs appeared in a country like Iran with a delay of about thirty years, but no severe plan was thought to dominate them. The lack of energy consumption standards and insufficient information through mass media have made the problem more acute. [11]

The next group of obstacles is ignorance regarding the construction and use of new equipment, which with the help of new technology, have increased efficiency and realized the minimum level of consumption. The new equipment is essential, produced domestically or not. Although realizing this goal requires an initial investment, its result will be a return on the investment. Unfortunately, universities have been indifferent in this case.

Environment and Climate

In underdeveloped countries, energy consumption in the building sector is increasing. Unfortunately, there is no specific strategy to reduce consumption in most of these countries. Without a direct relationship between consumption and well-being, there would be a more profound opportunity for saving. Although there are different statistics on the amount of energy consumption in the building sector, everyone believes that more than one-third of the energy of any country is consumed in various buildings. The lowest value is around 35%, while some countries have reported statistics exceeding 50%. What is essential for us is that the consumption of energy in the building sector is high, and we must use severe strategies to reduce consumption.

One of the most important effective factors in saving energy is climatic factors. Things like the design of the building and the use of materials are under study in the following steps. This distinguishes those who believe in passive design from those who believe in active design. The first question before us is how to know the climate. For a long time, two groups of factors, one geographical location in terms of latitude, longitude, and altitude, and the other climatic elements, such as temperature, radiation, humidity, airflow, and amount of atmospheric precipitation, have assisted in identifying the climate [12].

In an area with specific geographical features, we can classify physical factors with the help of known climatic factors and call each class a type

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of weather with its conditions. Thus, time is the primary determinant of climate characteristics. Time in weather represents a wide range of different climates in a region.

Climate is attributed to the weather conditions of a geographical area, such as temperature, humidity, atmospheric pressure, wind, precipitation, and other meteorological characteristics over a relatively long period. In meteorology, the current weather conditions are usually under study, while in climatology, the long-term characteristics of the weather are essential. The climate is the intermediate state of the quantities that characterize the weather regardless of the moment of their occurrence; in other words, the climate depends on the place without any dependence on the time. According to the international meteorological lexicon, whenever we mention the climate of a region, it means a set of weather conditions in the region; change in the weather conditions of each region, along with time changes, constitutes the climate of that region. [13]

Climate division is the first step and the foundation of any building energy design or audit. Any architecture or urban planning that deals with energy saving must pay enough attention to the climatic foundation. Depending on their regional climate, from drinking water to lighting, heating, and ventilation. In a research by Dr. Shahin Heydari earlier, the amount of water consumed per person in a hot and dry climate is about 3.2 times higher than in a hot and humid climate, with equal weight, height, gender, and age. In Iran's hot and cold climates, the ratio of electric lighting is 2.2 to 7. Therefore, in the first step, we propose division and explain it according to the special conditions of Iran.

It is also worth noting that we should not propose the complexities of climatic divisions in works like agriculture in construction works. It seems that such a division is necessarily different from the specific climate divisions in Iran.

Climatic divisions in Iran

Undoubtedly, the two points in a mountainous country like Iran are never similar in climate. However, the principles of couponing are a basis for determining the climatic zones of the country. Therefore, the four divisions of Iran proposed by Dr. Hassan Ganji are not applicable. He has accepted the coupon division with a little change and according to the geographical complications of the country as follows.

A) Mild and humid climate (southern shores of the Caspian Sea),

b) Hot and humid climate (southern coasts),

c) Hot and dry climate (central plateau),

d) Cold climate (western mountains).

Besides the climatic division, the building usage division is also important. Each building requires a different amount of energy. Thus, similar recommendations are not very effective and practical. How can we make suggestions for saving electricity for a hospital building that the same suggestions are effective in military buildings, for example. Mentioning this point does not mean rejecting standard working procedures in building construction, but dealing with the type of usage in determining the minimum level of consumption has a significant effect. Buildings with intermittent use and buildings with permanent use have different energy-saving solutions during construction and exploitation. Another critical step is to determine comfort conditions accurately. Thermal comfort conditions vary from person to person and from region to region. A person who lives in Tabriz has more cold tolerance than a person who lives in Yazd, just as a Yazdi person has more heat tolerance. Regional differences have a significant impact on energy consumption. If buildings in Yazd are supposed to be heated up to 25 degrees in winter, 20 degrees is enough in Tabriz, and we know that every one-degree change in heating or cooling systems allows us to save energy by about seven percent [14].

Adaptive reform, structural reform, and changing existing laws in the construction sector are among the other issues we deal with. All the mentioned things are helpful when we promote the improvement of the quality level of energy consumption.

Thermal comfort

Besides the thermodynamic laws governing the human body, an internal self-control system is responsible for keeping the body's internal temperature constant and adapting to external environmental conditions. We pay attention to the internal and external temperature and their interaction to explain the question. The fuel of consumed food produces internal body heat with the help of oxygen. This heat depends directly on the type and amount of food and is associated with the individual's activity. If the amount of consumed food energy is more than the total

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temperature energy produced in the body, it goes to the external parts around the body with the help of blood flow. [15]

Two external environmental sources of the body also cause heat absorption. One is the heat of radiant energy, and the other is the heat of shell transfer. The human task is to maintain the internal temperature of the body in a limited range between 36.5-37.5 degrees Celsius, but this temperature is not constant throughout the body. If the measurement occurs in the ear area (closer to the blood flow in the brain), the temperature in the throat area is closer to the core body temperature. The assumption is that the body temperature is constant and stable, but the temperature on the skin is supposedly a variable temperature with different sizes according to special conditions. Among the most critical factors affecting skin temperature are environmental temperature change, change of clothing rate, change of measurement location on the body, and possible change of internal temperature.

The presence of clothing reduces its cooling power because sweat first wets the clothing and then evaporates through the surface of the clothing. Therefore, we should accept that the type and material of clothing have a direct effect on the amount and speed of evaporation. Besides the loss through evaporation, heat loss through radiation is also significant. When sitting next to a cold surface, such as a window, the temperature is regularly taken from the body by radiation, but when we are next to a warm surface, the body absorbs the temperature by radiation. Since people are usually in environments where the temperature of their surfaces is not precisely equal to the body temperature, they are constantly exposed to losing or gaining temperature through radiation. If the body temperature and the surrounding surfaces are the same, then the energy flow through radiation will be zero. On the other hand, radiation loss per unit of the body surface is also necessary for thermal calculations, but it is not accurate and close to reality. Factors such as the physical form of the body and thermal and particle differences of the surrounding surfaces reduce the accuracy of the calculation. The wind variable should be examined after the two variables of evaporation and radiation. We are surrounded by air. If the air temperature is lower than the average temperature of the body's skin, then the body slowly gives its temperature to the air, consequently getting a warm layer around it. This hot air is removed from the body through the fluid flow of the air or by the airflow of the surrounding environment; the cold air surrounds the body again, and this process continues until the temperature balance between the surrounding environment and the human body. [16]

The principle of survival of a person's thermal balance results from a balance between the lost temperature and achieved temperature within the permissible limit, but different body parts react differently to the conditions. The brain is more stable than the hands and feet. When we feel cold, our feet and hands are colder than the rest of the body because the amount of blood on the surface of the skin in these areas is less, and consequently, they lose less heat. Changes in blood flow and the thermal resistance of internal organs are associated with the skin. Certainly, climatic and specific factors alone do not determine comfort conditions. Regional, cultural, psychological, and economic factors influence thermal comfort.

Ashrae considers thermal comfort a mental condition expressing people's satisfaction with the ambient temperature. The expression "mental condition" in Ashrae's definition refers to the fusion of psychological and physiological conditions in a feeling called thermal comfort. This definition is incomplete, as Ashrae did not provide a clear explanation. A wide range of conditions can supposedly create a state that is not included in this definition. Thermal comfort is not subjective. Because subjective categories are not measurable, and countless factors replace them. Despite such criticisms, we cannot reject Ashrae's definition because many environmental and specific factors create comfortable conditions. The mind differentiates and absorbs these factors as the main element. Another definition sees thermal comfort as a state in which a person does not take any behavioral action to change the thermal conditions of the environment. This definition is much more objective than Ashrae's standard definition. Olgi stated a range for thermal comfort based on which he defines the range of thermal comfort. According to him, thermal comfort is a condition where the minimum energy consumption creates a favorable environment. The main difference between the previous definitions and Olgi's definition is that the existence of human behaviors and specific factors are the criteria of

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those definitions, but Olgi looks at the energy consumption as a criterion. The reader realizes that many situations without energy consumption can create comfortable conditions for most people living in the environment. [17]

One of the other essential issues in the discussion of thermal comfort is people getting used to the environment. A person who lives in a cold region tolerates cold more quickly than one in a warm region. On the other hand, people in the cold season have a lower neutral temperature than in the hot season. This leads us to the question of whether neutral conditions are dependent on external conditions. Is there a logical connection between comfort conditions and external conditions? In 1978, Humphreys showed the relationship between comfort temperature and outside temperature. He proved that this relationship was real and varied from point to point. The important thing is that the relationship is natural for each place and differs from one point to another.

Moreover, for each place, this relationship must be obtained through field research. Before continuing the discussion of the relationship between external conditions and comfortable temperature, we will mention the variables affecting thermal comfort due to their effect on climate separation. Four essential variables directly affect human responses to thermal environmental conditions: air temperature, radiant temperature, humidity, and airflow. If we add activity and clothing rates to these four variables, we have enumerated six essential and effective variables in thermal comfort. Other factors, such as the quality of a person's placement, behavior, gender, age, culture, economy, etc., are also influential.

At the molecular level, the temperature is the average thermal kinetic energy in the body. If thermal energy gets out of the body, then the temperature of the body decreases, and if the thermal energy of the body is transferred, it increases. Body temperature is the most critical indicator of thermal diagnosis, heat, or cold stress. Humidity is the following influencing variable. Evaporation occurs when the human body heats liquid water or sweat. The evaporation steam moves to the environment, and the body slowly cools down. The quality of such a state is associated directly with the amount of humidity in the environment as a fundamental variable. Perceiving the environmental humidity and measuring it is of particular importance. The airflow around the body also creates heat flow from or towards the body. Therefore, body temperature changes under the influence of airflow [18].

Visual comfort (lighting)

The health of vision often depends on the presence of proper light. In low-light environments, things are complex, and there is no proper care in doing them despite efforts. Therefore, the designer's goal is to minimize the use of artificial light without disturbing visual comfort. Such a design is admirable and an essential step towards saving. We can observe that in building design, the designer chooses artificial light design from between two sources natural light and artificial light. The ignorance of engineers in applying lighting principles causes this wrong choice. Architects are more interested in using all kinds of lamps and chandeliers aesthetically; there is nothing wrong with this, but the architect should consider the lighting and its consumption. On the other hand, there is an essential difference between estimating the amount of illumination for the day and that for the night. The illumination at night is uniform and predetermined due to artificial light. In using natural light, it is not the case. In the calculations of natural lighting, minimum conditions should be kept in mind so that the size and dimensions of the window are adequate in critical times. This is in accordance with the goals of saving. [19]

Energy consumption in the building

The maximum energy consumption in the building and city sector should not exceed 25% of the total annual consumption of a country. Some countries, like England, have set a goal of reaching 20% in 2020. It means that we can or should be able to reduce up to 25% of the country's energy consumption in the building and city sectors. If we get it, we will increase the national budget and contribute to the health of the environment. The number of consumers and the consumption amount of each one is different from one building to another due to the various usages.

Table 1: GPA value of energy consumption by revised usage for the conditions of Iran

	Lighting	Heating & hot water	Cooling	Ventilation	Equipment	Other

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Commercial buildings	55%	15%	16%	3%	11%	0
Educational buildings	22%	31%	13%	7%	23%	4%
Healthy buildings	20%	23%	21%	9%	24%	3%
Office buildings	15%	36%	35%	5.4%	8%	1.5%
Residential buildings	27%	30%	27%	5%	9%	2%
Hotels and restaurants	31%	31%	25%	7%	5%	1%
GPA	28.3%	27.7%	22.8%	6%	13.3%	1.9%

Conclusion

Climate change is real and seriously threatens human, animal, and plant life. The emission of greenhouse gases is the biggest problem in the world today. These gases have caused abnormal climate changes during the last hundred years. This reduces the emission of greenhouse gases. The required energy production should be at the top of the plans through renewable sources. Thus, the consumption of fossil energy will decrease. Different governments must commit to international agreements and have the necessary plans to fulfill them; also, planning energy consumption and production is necessary for every country, so it requires special attention [20].

The world resources of three non-renewable energy sources, i.e., oil, gas, and coal, are limited, and it seems that we do not have a long time to run out of these reserves. On the other hand, using non-renewable energy sources causes environmental pollution. Of the above three sources, natural gas is the least harmful, and coal is the most harmful for polluting the Earth's atmosphere and, ultimately, climate change. If we use non-renewable energy optimally, the environmental damage will decrease. Iran has significant reserves have privileged its position globally, although it has suffered politically from special losses and problems. We also talked about the importance of renewable energy and its production. We have proven that developing countries, including Iran, are very slow and weak in this regard and are still fond of non-renewable energy sources. The current trend is not acceptable. In addition to these two groups of energy sources, the use and production of nuclear energy are necessary. [21]

There are three ways to save energy in buildings. All three methods are complementary, and it makes sense to use them together.

The first way to save is to appeal to pre-controlled construction factors. These factors comprehend the proper design, location, orientation, and factors that allow maximum use of natural light during building exploitation. Here the building designer has the leading role. However, the role of urban planners in achieving a positive result is not ignorable. This means that the architect may consider all aspects of the design, but the presence of high buildings in a part of the building will make all his goals sterile. Here the user does not have much involvement, and saving is possible only by the architect and urban planner. Residents also have no choice but to use the required energy in the prepared space.

The second method of saving for building users is through simultaneous control factors, such as using energy-saving lamps, changing the type of heating and cooling devices, and having the power to control them. The third method is to change the culture of consumption. Education is the root of the right culture. It is possible through economic and environmental channels. Time is of considerable importance in such a process. The use of mass media, teaching at different levels of education and eliminating some possibilities of gradually cutting off energy subsidies help the authorities achieve this goal.

Undoubtedly, it is necessary to examine each mentioned case appropriately, especially since they are interrelated. The study of cultural barriers is of particular importance. This does not mean that its role in energy planning is ignorable, but it means that the scope of the subject and the numerous involved factors exclude a brief examination of the problem and require more profound and more detailed research that goes far beyond the author's literacy.

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