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Review Article

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Integration of Renewable Energy Sources in Public Buildings (Hospitals): One Step to Overcome Addiction to Using Fossil Energies

Kamu Binalarında (Hastaneler) Yenilenebilir Enerji Kaynaklarının Entegrasyonu: Fosil Enerjiler Kullanımı bağımlılığından kurtulmak Adına Bir Adım

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ABSTRACT:

The issue of renewable energy and the need of humans to use it has been the subject of discussion and research by many investigators. In all medical centers, providing a suitable environment for general treatment is considered a fundamental goal but in specific diseases that require organ transplantation, the planning of its environment is very important, since this type of treatment requires a specific environment with careful planning, along with a perfectly systematic design. Therefore, it should be a pure and clean building, located in an environment free from any pollution, including pollution that caused by the energy consumption of the building. With regard to the scarcity of fossil fuels, it should be remembered that hospitals have the highest energy consumption among public buildings due to their cyclical. In this regard the need to free user buildings from renewable energy may not seem urgent. However, the needs of the buildings and a clean environment may also require the switch to clean energy. This study aims to investigate and explore the innovative use of renewable energy systems by accessing books and scientific websites to discover the required energies for these types of building. The building itself can open new ways to meet its own energy needs through the use of modern technology. In this regard, with the help of the example models presented, the aim is to use renewable energy sources in public buildings and especially in hospitals in the near future, so that these buildings can provide their energy needs in a healthy and economical way and the treatments of people can be carried out in a clean and healthy environment.

KEYWORDS: *Renewable energy, Geothermal, Photovoltaic, Public building*

ÖZ:

Yenilenebilir enerjiler ve insanların bu kaynakların kullanım biçimi, üzün süredir birçok araştırmacının tartışma ve çalışma konusu haline gelmiştir. Tüm tıp merkezlerinde, genel tedavi için uygun şartlar sağlamak temel bir hedef olarak kabul edilir, ancak organ nakli gerektiren belirli hastalıklarda, bu şartların planlanması için çok daha dikkat gereklidir, çünkü bu tür bir tedavi sürecinde, standart bir planlama ile belirli bir ortamın olmasının yanı sıra mükemmel bir sistematik tasarım planının olması zorunludur. Bu durumda, sağlık binalarının planlanması ve tasarımı, uygulanan tedavi türleriyle farklı açışlardan doğrudan ilişkilidir. Bu nedenle, sağlık binaları ve onların çalışabilmesi için kullanılan enerjiler her türlü kirlilikten uzak tutulmalıdır, ayrıca sağlık kurumları, orada çalışan ve hizmet gören insanlar temiz bir ortam ve sağlıklı yapılara sahip olmalıdırlar. Diğer yandan Dünya çapında fosil enerji kıtlığı ile ilgili olarak, kamu binaları arasında en fazla enerjiyi tüketen binaların başında hastanelerin olduğu unutulmamalıdır. Bu

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bağlamda, kullanıcı odaklı binaları yenilenebilir enerjilerden arındırma ihtiyacı acil bir ihtiyaç gibi görünmeyebilir, fakat bazı özel binaların ihtiyaçlarına göre temiz ve yenilebilir enerjiler geçişi önemlidir. Bu çalışmada, kamu binalarında kullanılabilecek gerekli enerjileri keşfetmek adına kitaplar, bilimsel çalışmalar ve web sitelerine erişerek yenilenebilir enerji sistemlerinin modern kullanımını mercek altına alınmıştır. Bu doğrultuda, bu binalar modern teknolojinin kullanımı vasıtasıyla kendi enerji ihtiyaçlarını karşılamaları adına, fotovoltaik ve jeotermal sistemlerin geçmişi ve kullanımı ayrıntılı bir şekilde incelenmiştir. Bu araştırmanın sonucunda sunulan örnek modeller yardımıyla, yakın gelecekte kamu binalarında ve özellikle hastanelerde yenilebilir enerji kaynaklarından faydalanması hedefleniyor, böylece bu binaların enerji ihtiyacını sağlıklı ve ekonomik bir biçimde sağlamakla birlikte, insanlara yönelik uygulanan tedaviler temiz ve sağlıklı ortamlarda yapılacaktır.

Anahtar Kelimeler: *Yenilenebilir enerji, Geo-termal, Fotovoltaik, Kamu binaları*

INTRODUCTİON:

With the increase of the world population, countries have been confronted with the problem of energy consumption. The crises that threaten countries and human societies are the limited resources of non-renewable (fossil) energy and the increasing pollution caused by the excessive consumption of fossil fuels, which makes it necessary and important to pay attention to the use of renewable energy sources. The close link between economic and environmental issues has led to the emergence of new approaches in the field of international environmental law, of which the green economy is one of the most important. Developing countries' access to all types of new energy sources is essential for their economic development. Recent research has shown that there is a direct link between a country's level of development and its energy consumption.

Since the beginning of human life, therapeutic spaces have been one of the main principles and needs in the health and treatment of society. Desirable architectural designs for any purpose can be completely useful only if different spaces are designed based on the needs of users in order to improve and accelerate various activities. Because some of the standards of sustainable design such as the use of the hospital wastewater disposal and treatment system and its full use for the irrigation of the hospital's green space, the proper management of hospital waste is important but unfortunately, until now, in the discussion of hospital construction in the country, sufficient attention has not been paid to the use of renewable energy.

1. Material and Method

In this research, which takes into account the geographical location of Iran and the city of Tabriz, as well as the climate of this area, two categories of energy production—from geothermal energy to sunlight—have been studied and researched, so that perhaps at least small percentage of the energy needs of public buildings can be achieved in these ways.

2. Energy Systems

2.1. Geo-Thermal Systems

From ancient times, people made use of the geothermal water that flowed freely to the surface as hot springs. Early modern efforts in Laredo, Italy in 1904 worked towards the production of electricity from geothermal energy and since then, there has been much activity and research in geothermal energy around the world. Currently, geothermal energy is widely used in many parts of the world and in many different forms. Benefits of geothermal energy as a potential energy source are that the sources are deep underground, is independent of weather conditions and has the ability to meet current and future needs of human beings (D'Amico, Juárez , & Morales, 2016).

Utilization of geothermal energy is divided into the following two methods:

- Indirect or power
- Direct or non-power

Use of indirect methods or Power:

1- Geothermal power with a two-phase liquid (vapor-liquid)
2- Geothermal power with single-phase fluid (liquid)

Methods of direct or non-power use:

1- Hot water pools

In this method, hot geothermal water can be combined with conventional cold water and relatively warm water used for purposes such as tourism centres and water treatment facilities (Figure 1). If the geothermal hot water is free of harmful materials to human

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body, it can be used for water treatment purposes; otherwise, once can transfer its heat to ordinary water by using a heat exchanger, and tap water with warm temperatures in the pools used (Agarwal & Shah, 2017).

Figure 1. Geothermal swimming pool

Source: https://www.husafell.com/

2- Greenhouse Centres

The utilization of hot geothermal water in the cultivation of plants and fruits within greenhouses has garnered significant attention and interest in both academic and industrial sectors. This approach offers the necessary temperature range of 80 to 120 degrees Celsius for optimal plant growth and development. In order to enhance production capacity, our company is delighted to introduce a state-of-the-art Ceres greenhouse, strategically located adjacent to the Atlas High Tunnel. The Ceres greenhouse incorporates an advanced ground-to-air heat transfer system (GAHTTM) to regulate temperature. The GAHT system employs a network of perforated heat exchange tubes that are installed beneath the greenhouse surface. This system leverages the thermal properties of the soil, acting as a heat buffer to effectively cool and warm the greenhouse throughout the day and night. High-volume circulating fans, similar to those found in residential central HVAC systems, facilitate the process. The unique design of this greenhouse enables the cultivation of crops year-round, including during the challenging winter months typically experienced in highland regions. The implementation of GAHT as an alternative to conventional greenhouse heating systems significantly reduces reliance on fossil fuels such as propane. In conclusion, the introduction of hot geothermal water and the GAHT system in our modern Ceres greenhouse presents a promising solution for sustainable and efficient plant cultivation, offering a favorable climate for year-round crop growth while reducing environmental impact (Figure 2) (URL-10).

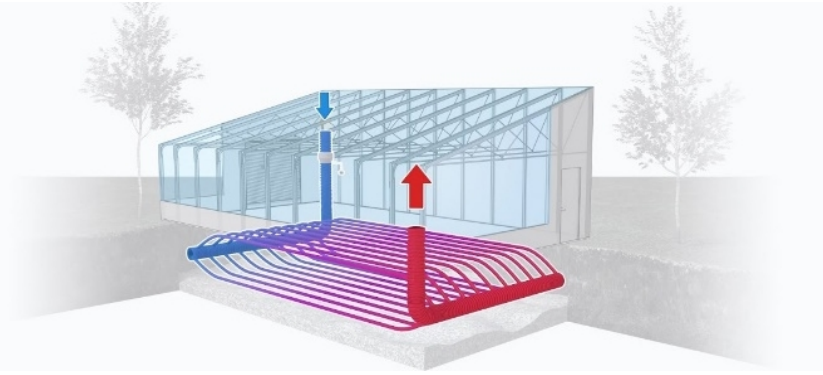

Figure 2. Geothermal greenhouse

Source: https://ceresgs.com/

3- Home heating

With the help of special radiators, plumbing or heating systems, Geothermal hot water can be transferred into the environment of homes, hospitals and can use the heat of the water to provide environmental heating. For home heating, geothermal water temperature should be about 50 to 100 degrees Celsius (Figure 3) (Eicker, Pesch, Dalibard, & Thumm, 2011).

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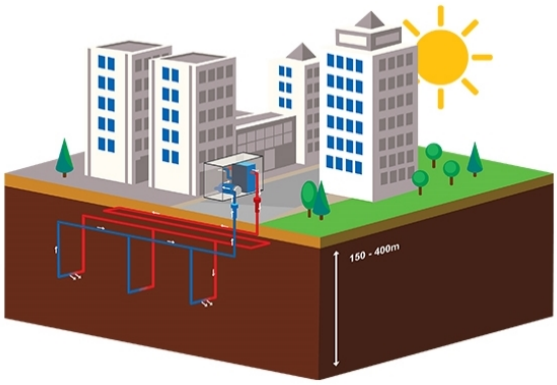

Figure 3. Heating buildings by geothermal energy

Source: https://www.engie.com/en/

A. Geothermal energy for buildings involves harnessing energy located at relatively shallow depths, typically a few tens of meters, to provide heating for smaller structures using heat pumps. This energy source can be effectively utilized within individual buildings or integrated into eco-friendly neighborhoods.

B. In the context of medium temperature heat networks, thermal energy is harnessed from depths ranging a few hundred meters, typically between 30°C and 90°C. Geothermal heating networks possess the capability to provide heating and cooling services to urban districts, industrial zones, and even entire cities.

C. Deep geothermal, also known as high-temperature geothermal, involves the extraction of energy from depths ranging between 2,000 to 3,000 meters, where temperatures surpass 150°C. This underground heat is subsequently harnessed and converted into electricity.

4- Pisciculture pond

The heat content of matter is the result of the energy of the motions of atoms and molecules. A thermometer responds to the average kinetic energy of the molecules in a substance. When sunlight passes through water, the energy of the light is transferred to the water molecules and increases their heat content, causing the water to heat up and its temperature to rise. For potential aquaculture applications, warm geothermal water can provide the conditions necessary for the growth of certain fish (Figure 4).

Figure 4. Using warm water for Pisciculture

Source: https://www.globalseafood.org/

5- Melting snow and preventing ice conditions on the road

The utilization of geothermal water for snow melting purposes has witnessed an increase over the past two decades, leading to the incorporation of snow melting systems in the majority of newly constructed parking lots. Geothermal water, derived from space

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heating applications, is reintroduced at a temperature of approximately 35°C and commonly employed for de-icing walkways. The annual energy consumption varies depending on weather conditions, with an average estimated value of 430 kWh/m2. The overall geothermal energy consumption attributed to snowmelt is estimated to reach 1,420 TJ per year. Notably, around two-thirds of this energy is sourced from the return water of space heating systems. By employing a pipeline that can be laid on roads, geothermal energy can be utilized to introduce heated water into paved roads and the surfaces of roads or sidewalks during the cold season, effectively melting the snow present on these surfaces (Figure 5) (Seo & Mitchell, 2011).

Figure 5. Melting snow and preventing ice conditions on the road by geothermal energy

Source: https://nea.is/

6- Heat Pump

Heat pumps can be used for cooling in summer and heating in winter (Figure 6).

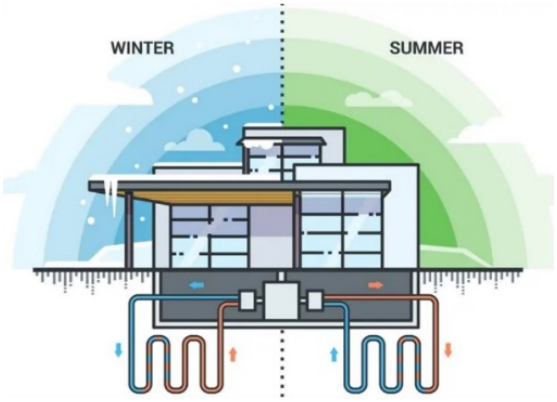

Figure 6. Heat Pump

Source: https://www.environmentbuddy.com/

2.2. Ground-Source Heat Pumps

Heat pump technology is based on this principle that at a depth of 2 to 3 meters from the ground, the temperature is constant and in winter it is cooler than the outside air and in summer, warmer than the ambient air. This system collects heat from underground using electrical energy, and the fluid runs from the pipes through the installed units and is transferred inside the building. The fluid in the pipes absorbs heat from the unit with using compression, intensifies and increases the heat, and it leads to the optimal temperature for heating buildings. It is the reverse in the summer, where hot air is pulled from inside the building via a suction device (Rao Martand , Kawuwa Sani, & Amis, 2019).

Heating and cooling systems with heat pump consists of three basic parts:

- Ground loop
- Heat pump

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- Heat distribution system

These systems can be classified as follows:

1- Open system

In this system the groundwater system acts as a heat carrier and is transferred directly to the heat pump. This system does not have a kind of buffer between the soil and ground water heat pump evaporator.

2- Closed system

In this system, the heat exchanger is located in the ground horizontally, vertically or diagonally and an intermediate heat carrier will circulate, and transfer heat from the earth and back to the heat pump.

3- Other systems (Figure 7).

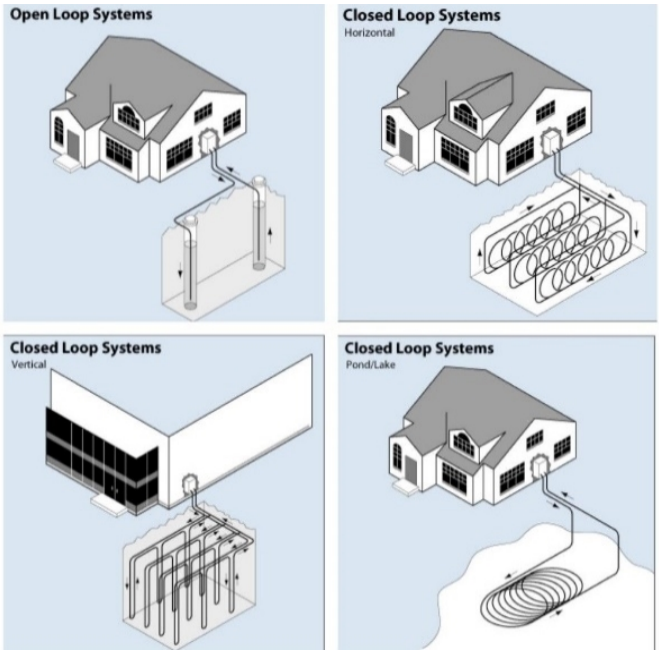

Figure 7. Types of heat pump systems

Source: https://tr.pinterest.com/

Closed-loop geothermal systems:

Within this system, a heat exchanger is integrated into the ground. During colder periods outside, the water undergoes cooling at the lower section of the pipeline. Conversely, on warmer days, the fluid descends through the pipe, effectively utilizing the lower temperature of the ground.

Vertical loops:

Due to the necessity of deep placement in the ground, vertical slings incur higher installation costs compared to horizontal loops.

Horizontal loops:

The installation cost of the recirculating system is comparatively lower than that of vertical circuits. Furthermore, horizontal circuits necessitate the use of smaller pipes, resulting in a higher number of ground holes that need to be drilled during the installation process.

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Slinky loops:

The slinky loop system bears greater resemblance to the horizontal loop system; however, it typically encompasses a tube positioned directly beneath the floor level.

Pond loops:

Pond bypass systems are commonly employed in situations where there is a nearby body of water. Due to their close proximity to the heat source, these systems are known to generate higher temperatures.

2.3. Photovoltaic Systems

Power generation is one of the foundations of a country's economic strength, so the increase in electricity production in recent decades has been considered. The sun is the only source of energy on the earth that when issued beside various forms of energy, meets the energy needs of a community and uses both fossil fuels and renewable sources. This becomes more important in conversion systems when we consider the sun's energy using photovoltaic systems, where sunlight is directly converted into electrical energy, and ease of access to electricity from solar power is one of the applications. Production of solar cells and modules has been increasing in recent years and in the current year has reached more than 2,500 MW at peak (Abou Jieb & Hossain, 2022).

2.3.1 Definition of solar electric systems (Photovoltaics)

This phenomenon has the effect of, without the use of mechanical mechanisms, converting radiant energy into electrical energy, and is called photovoltaic effect. This phenomenon is based on the hypothesis that an atom of radiant energy. Each system that also uses these properties is called a photovoltaic system.

Photovoltaic systems are composed of three main parts:

1- Modules or solar panels:

These modules convert solar energy into electrical energy. The photovoltaic modules are exposed to sunlight, including the photovoltaic cells. The main elements of the solar cells are formed from thin film and semiconductor material such as silicon. When the light hits the material, the semiconductor material absorbs a certain part of the light, releasing the electromagnetic energy. All PV cells have one or more electric fields that force the electrons released by the light absorption to flow in a certain direction. When energy is added to pure silicon (e.g., heat), it can cause the bonds of some electrons to be broken and leave their atoms, creating a hole in each. The electrons are then randomly scattered throughout the crystalline network, seeking other cavities into which they can fall. These electrons are called free carriers and can travel electric currents (Figure 8) (Shah , 2020).

Electric fields cause the movement of excited electrons by radiation, so when the cell is connected to an electrical charge, it creates a flow path and voltage and current respectively is DC, the output of the photovoltaic cells is connected in series or parallel circuits to produce higher voltages or currents (Geoff & Neill, 2021).

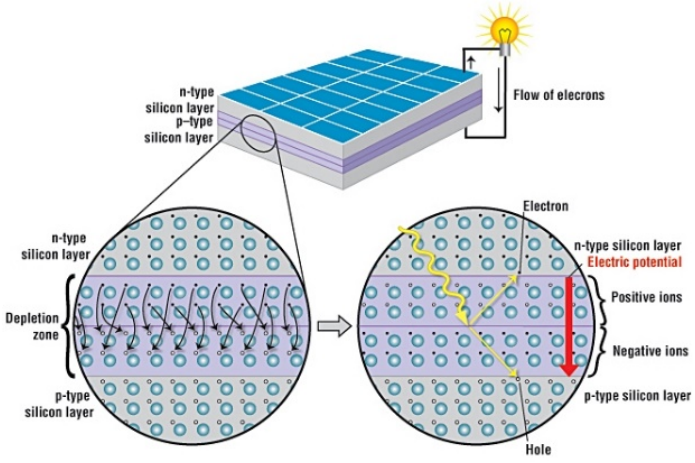

Figure 8. Structure of producing silicon PV cells

Source: https://www.powersystemscoach.com/

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2- Intermediate part or desirable section

The electrical energy produced by photovoltaic systems is carried out according to consumer needs and is managed and installed. This equipment primarily is made based upon consumer needs and includes a storage and backup system, charge controller and inverter.

2-1- Charge Control

Charge control is a device in the solar system that controls the charging, discharging, and voltage regulation of the batteries and prevents damage to the batteries and keeps them functional for life. It is a characteristic of solar modules that when the weather is cloudy or the direction of the sun changes, the output voltage of the solar module changes. Therefore, output voltage stabilization is a crucial point of solar power system, which is set in charge control.

2-2-Invertor

A subject of industrial electronics is turning a DC voltage into AC voltage. The system that can do this conversion is called an inverter. Inverters have a different range of applications, where use in solar electricity systems (PV) applications is one of them.

2-3- Battery

Battery power for use at night or when the sun does not provide the necessary power is supplied to the consumer.

2-4- Consumer or charge:

All electrical consumers such as: Spending AC and DC is included as consumption.

How the system works (Figure 9);

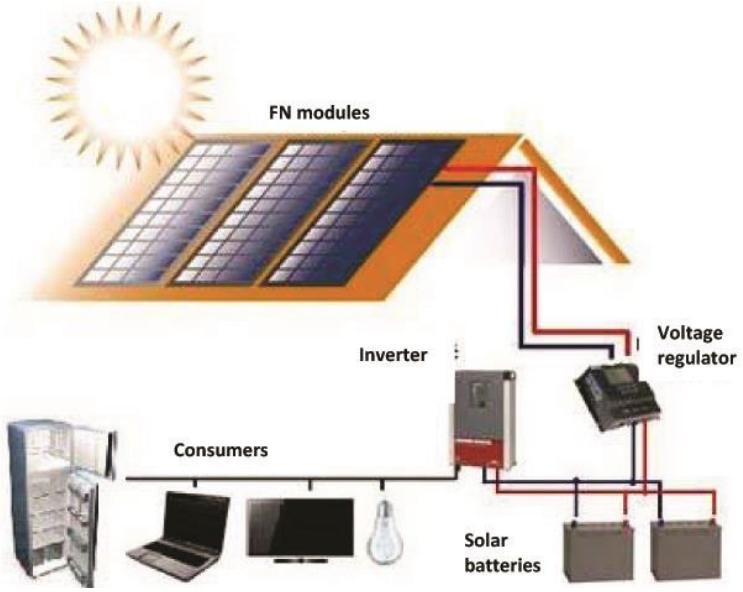

Figure 9. How the performance of photovoltaic systems works.

Source: http://solarserdar.blogspot.com/

3. Results and Discussion

During this research, by examining the systems that worked with renewable energy and summarizing the information obtained, two examples of these natural energy generators were selected to use of these systems in public buildings. Selected systems in line with the use of clean energy (Figure 10):

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- Geothermal system
- Photovoltaic system

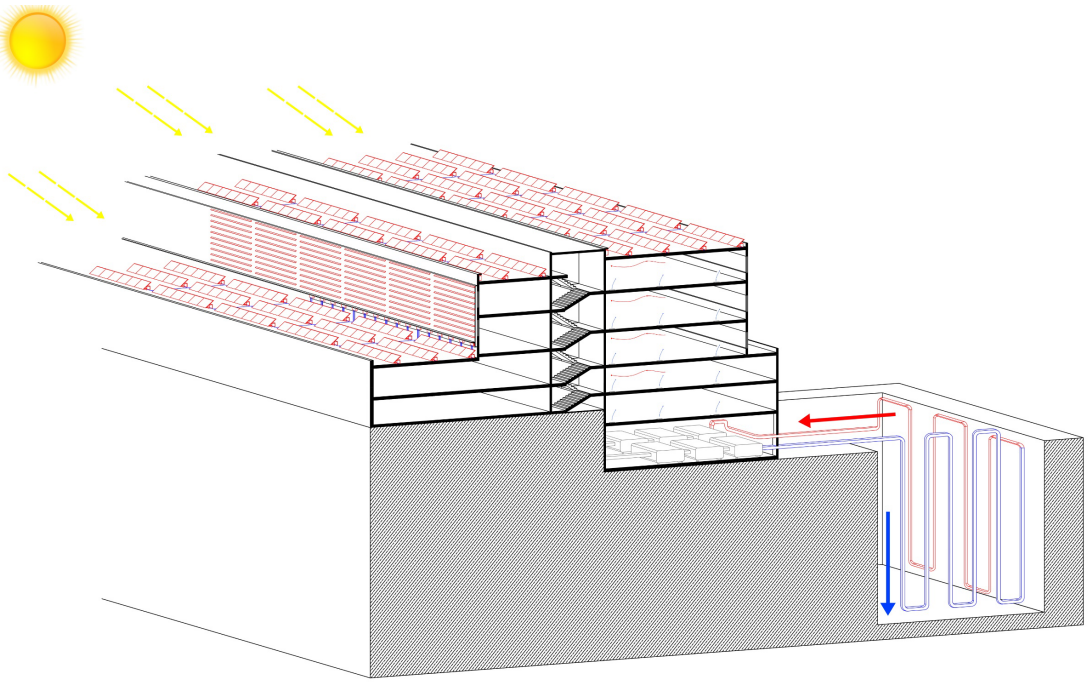

Figure 10. Overview of the system

Source: Drawn by the author

3.1. Geothermal System

In designing this system, air embedded through the duct in the inner wall unit is driven to the pipes leading to the heat pump in winter. Then, air is moved by heat pumps through pipes embedded by pressure in depths of 20 meters underground. The air moving within the tube on the way back to the surface is heated because of high temperatures deep underground, and on the way back to the building is transferred to the floors by heat pumps and is warmed through the ducts embedded in the floor. In summer the system works in reverse. The work of the system is shown in the picture below (Figure 11, 12, 13) (Author).

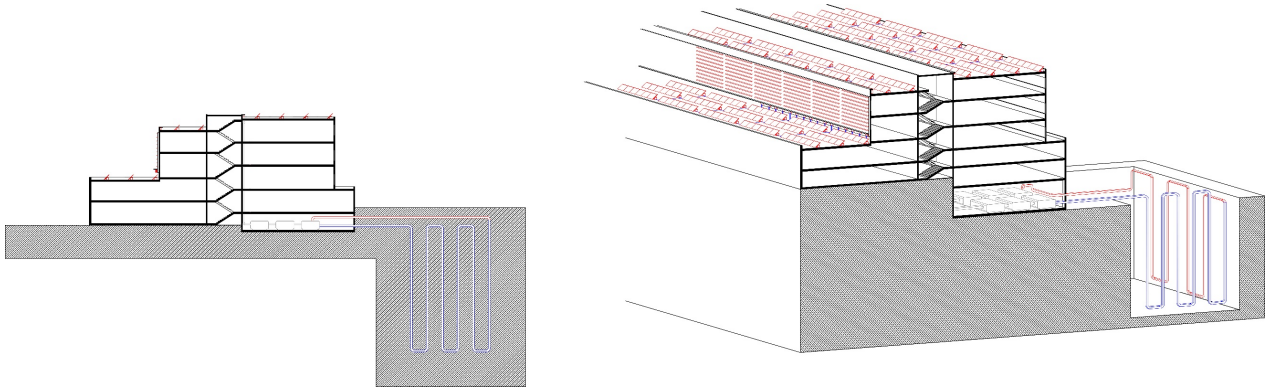

Figure 11. Overview of the geothermal system

Source: Drawn by the author

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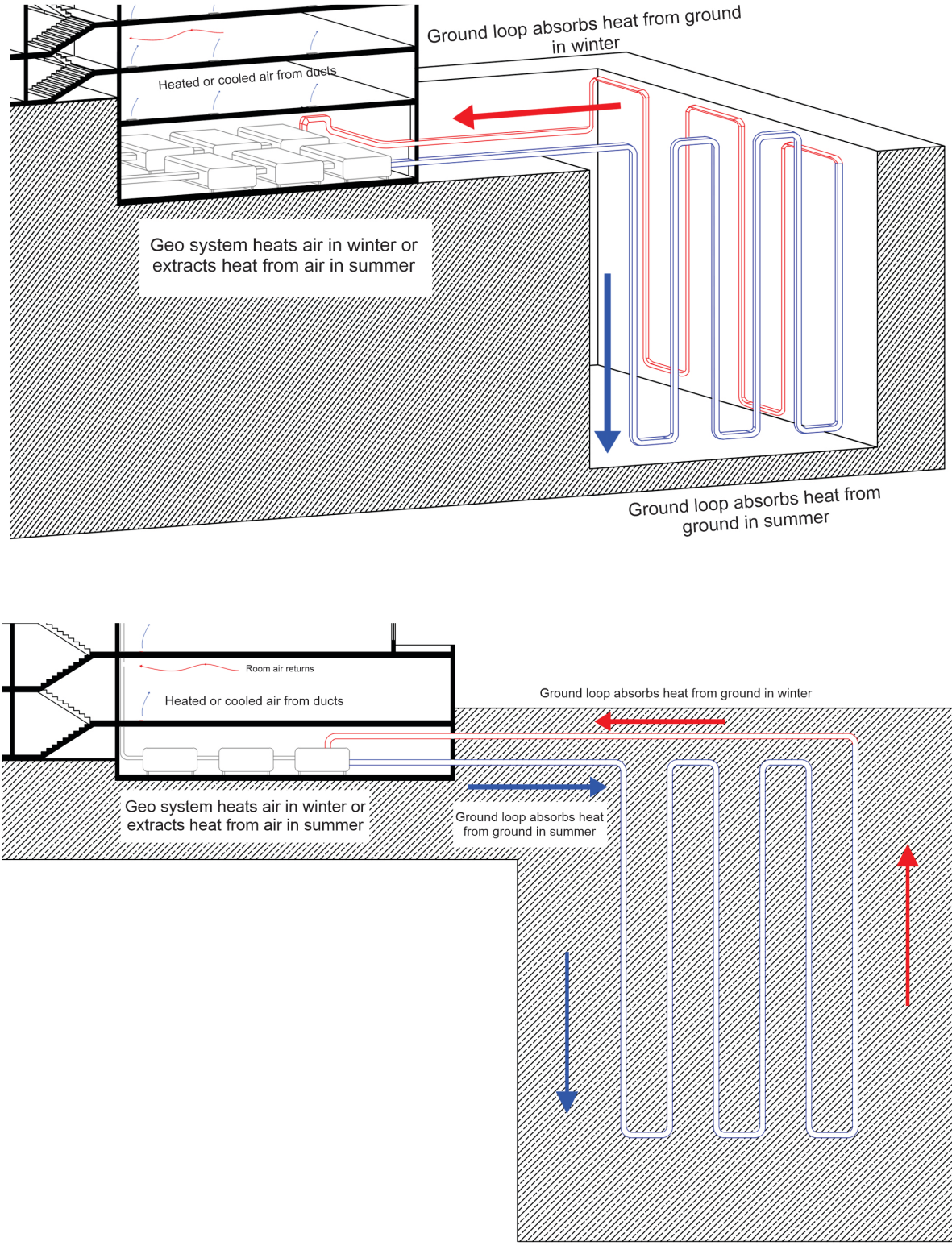

Figure 12. Powerhouse and Heat Pumps of System

Source: Drawn by the author

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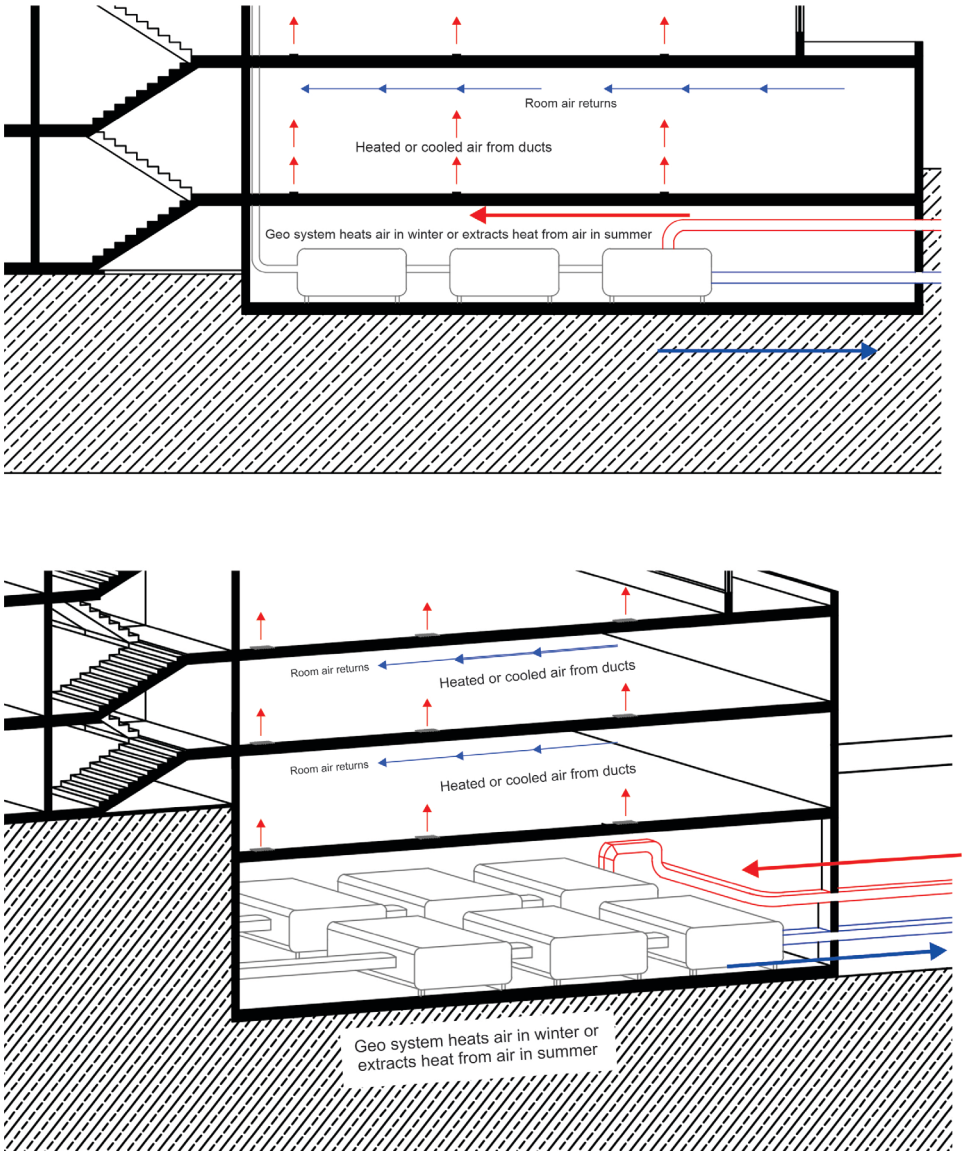

Figure 13. Direction of airflow of hot or cold weather produced.

Source: Drawn by the author

3.2. Photovoltaic system

Energy that is emitted to the solar panels and converted into electrical voltage by cells sensitive to light is then stored in an energy source sensitive to changes in light by the solar panel is not transferred the load connected to the system, finally, for using the solar system, it is necessary to create these conditions for electrical loads. Accordingly, for AC loads an DC-AC inverters, and for DC loads, an DC-DC invertor will be needed. In some systems a charge controller is used to conserve batteries and solar panels; that is, it will prevent overcharging of the battery by the panels and prevent battery drain when the power is not produced by the panels (Author).

Public building and buildings that function 24 hours a day in terms of area and power requirements require more panels and consequently, require more inverters, as is designed schematically in the images (Figure 14, 15, 16).

Information of designed system to image

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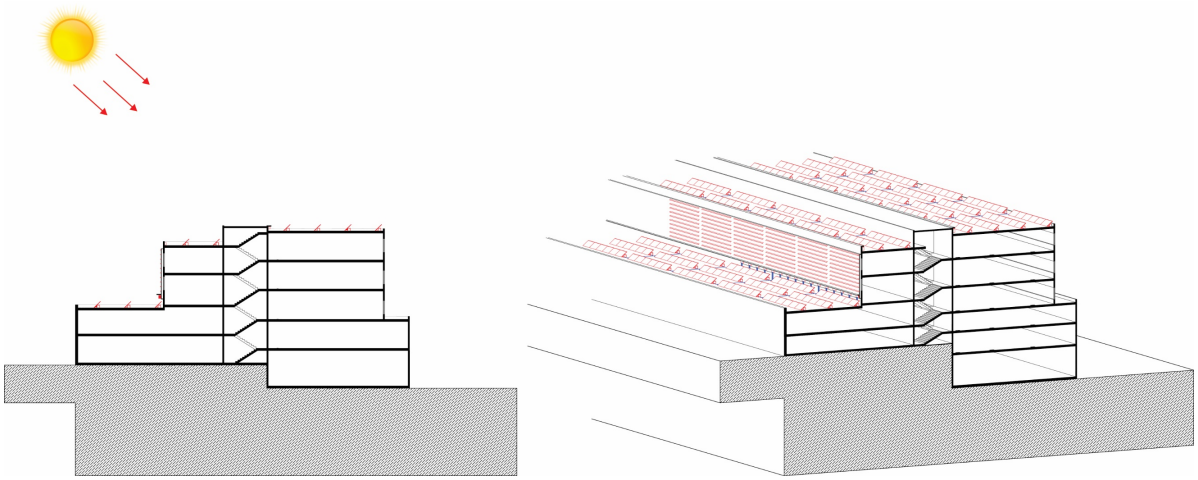

Figure 14. The overall picture of designed photovoltaic system

Source: Drawn by the author

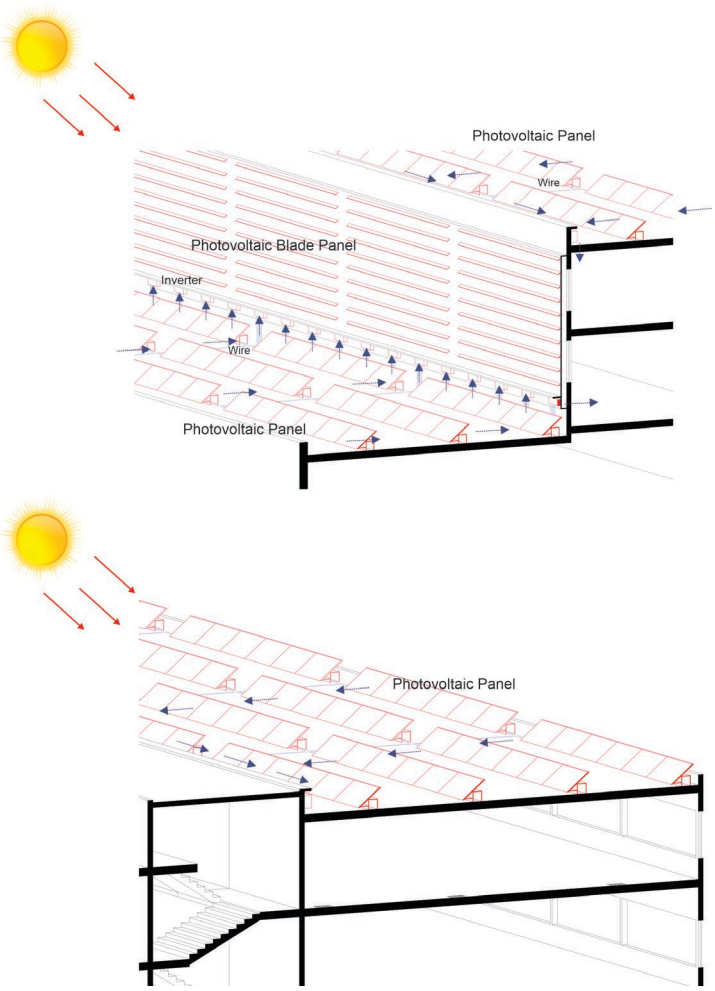

Figure 15. Magnified section of photovoltaic system

Source: Drawn by the author

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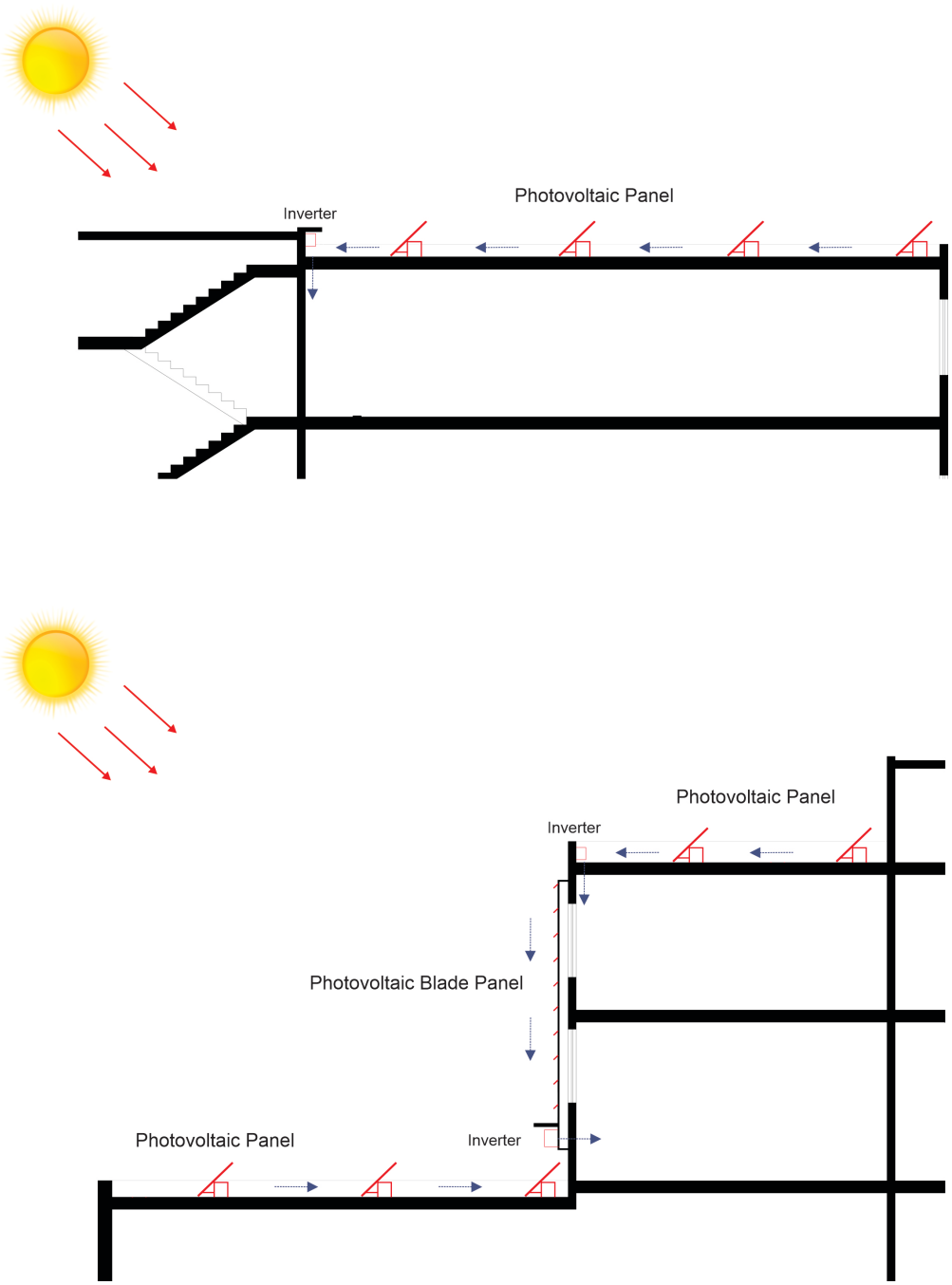

Figure 16. Power flow path

Source: Drawn by the author

4. Conclusion

During this research, renewable energies, how they are used and the systems used to benefit from these energies were investigated and studied. Finally, two systems (photovoltaic and geothermal) were simulated and used in a case study, with regard to energy systems that were tested in this study, it can be concluded that:

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The widespread use of this energy in Iran is still many years away. The location of Iran at the limits of tectonics shows that the geographical body has a great power. Its location on the volcanic belt, which is very far apart in terms of structure, is very active and has the advantages of geothermal energy. According to the international classification carried out, Iran is among the countries with the most probable reserves for electricity generation (with a capacity of more than 200 MW), as well as for the generation of cold and hot air for heating and cooling buildings through geothermal energy. As mentioned above, this method could be used in all buildings, especially in public buildings (author).

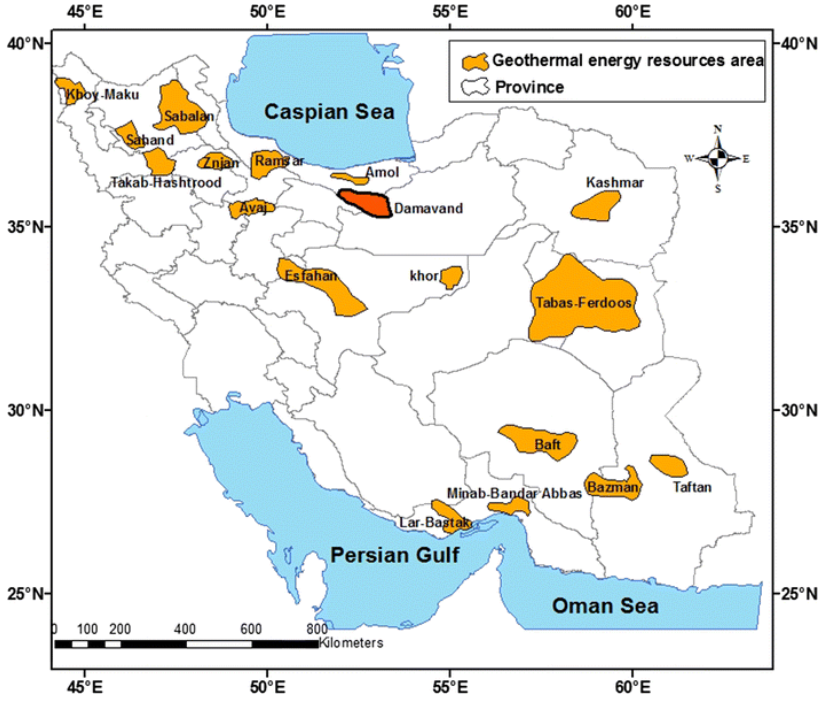

Figure 17. Iran map of geothermal energy resources

Source: (Karimi, Mohammadi, & Samani, 2017)

According to scientific estimates, about 6 billion years have passed since the birth of the sun. According to these estimates, the sun is about 333,000 times larger than the earth, and we can count this luminous globe as a great source of energy for another 5 billion years. In this regard, the process of the research and studies concludes that (according to the performance of photovoltaic systems), because of proper operation of photovoltaic systems, environmental issues and the growing price of energy derived from fossil fuels, the growth rate of installation of the system is 20-30 percent annually in the world, however, in some countries this figure is up to 40 percent. Also, in the production per GWh of electrical power unit derived from these systems, 1,000 tons of carbon dioxide (CO2) and environmental pollution is prevented, and the impact of these systems on the environment is important to note. Finally, it will reduce our dependency on fossil fuels.

Advantages of Solar Panels:

- The lack of environmental pollution
- Ease of installation
- No need for fossil fuels or other non-renewable energy sources
- No need for special servicing
- Free supply of electrical energy to install and delete the current costs.
- Appropriate to the climatic conditions of Iran and the ability to work in a wide range of temperatures and humidity.
- Low wear and long life

ETİK STANDARTLAR:

Çıkar Çatışması: Yazarlar herhangi bir çıkar çatışması olmadığını beyan eder.

Etik Kurul İzni: Etik kurul iznine gerek yoktur.

Finansal Destek: Yoktur.

RESOURCES:

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