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Environmental impact of using geothermal clean energy (heating and cooling systems) in Economic Sustainable modern buildings architecture design in Iraq: A review

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Abstract. Nowadays, with all the climate change problems that we face worldwide, engineers from different specialists work together towards Sustainability and finding solutions, and investigating its environmental impact thoroughly. Architectural, Chemical, environmental, civil engineers have always been closely linked in designing and constructing buildings.

Geothermal energy is a local, resilient, reliable, ecologically benign, and sustainable form of the renewable energy system. This type of natural energy could be generated from the earth's heat and takes a variety of purposes, including building heating and cooling, electricity generation, supplying warm/cold water for agricultural products in greenhouses, as well as balneological usage. Furthermore, geothermal energy isn't affected by weather and could provide electricity and heat nearly constantly through the year. This study intends to investigate the opportunity of using geothermal energy in Iraq under the ground represents one of the sustainable energy resources we can use it will be a significant environmental benefit in our housing in air conditioning applications.

This review gives a summary of geothermal energy systems in general. Topics addressed include: an introduction to the environments and the energy, also their relationship, a geothermal energy history brief, an overview of geothermal energy systems throughout the world and also through Iraq, and an overview of geothermal systems environmental impacts as well as the environmental impact of Sustainable buildings architecture design, are just a few of the topics covered. Hence, the achieved conclusions of this review can make changes towards sustainable environmental design.

Keywords: *Geothermal Energy, Renewable Energy, sustainability, Environmental design, Architecture design.*

INTRODUCTION

Fossil fuel development and consumption have resulted in environmental issues. If human's reliance on fossil fuel resources continues, global warming will most likely accelerate. Global environmental issues will have a significant impact on people's energy usage patterns in the future.

In some countries, air pollution is a major environmental concern (Li et al., 2015). As stated by (the 2021 World Energy Outlook), environmental regulations and air pollution warnings have increased. The IEA's early estimate of worldwide energy-related carbon-dioxide (CO2) emissions in 2020, as shown in Fig. 1, shows that emissions remained flat (IEA, 2020).

There has a strong link between energy consumption, economic increase rates, and energy-related CO2 and greenhouse emissions, as seen in Fig. 1. But, due to the favorable outcomes of climate debates (IEA, 2020), there was a significant decoupling of this previously strong association in 2020. For environmental pollution reduction, using renewable energy resources is a viable choice to using fossil fuels.

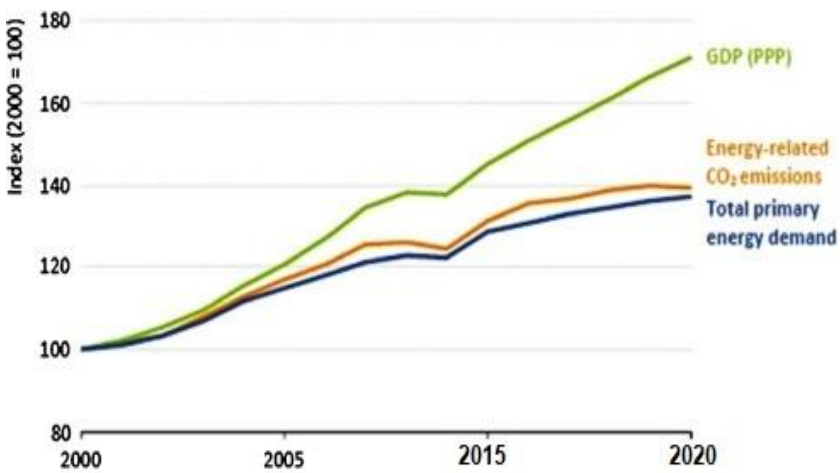

FIGURE 1. Variations in energy usage, global economic output, and energy-related CO2 and greenhouse emissions (IEA, 2020)

* In this Figure, GDP (PPP) stands for domestic product at a purchasing power parity level.

The building has a substantial effect on natural resources reduction (Nejat et al, 2015; Lechtenböhmer and Schüring, 2011; Cabeza et al.,2014), and heating and cooling usage significantly increase worldwide energy needs (Dincer and Acar, 2015). Dwellings account for 3/4 of all energy usage in the design industry; as a result, its critical toward improving their energy efficacy and give priority to this (Nejat et al, 2015; Outlook SAE,201). Figure 2 shows the fraction of total energy consumption consumed by buildings in various parts of the world. Residential buildings account for an average of 20% of overall consumption in developed countries, and more than 35% in developing ones (Yau and Hasbi, 2013), as seen in Fig.2.

Figure 3 depicts the use of cooling and heating energy in buildings (including residential and commercial buildings) in various areas of the world from 2010 to 2020, as well as forecasts for 2020 to 2050. Figure 3 shows that, with the exception of South Asia and Oceania (Ürge-Vorsatz et al., 2015; Ürge-Vorsatz et al., 2013), residential buildings' energy consumption is increasing in most countries, and commercial constructions energy consumption is also rising.

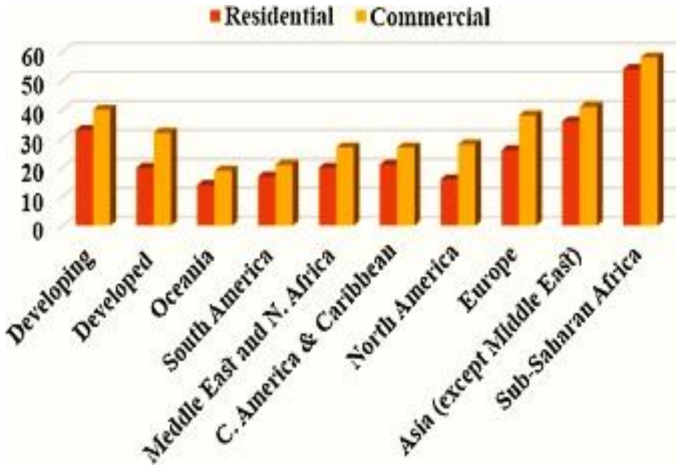

FIGURE 2. The buildings' energy usage as a % of overall energy use throughout various countries. (Robert and Kummert, 2012)

The buildings constructions are account for one-third 1\3 of all Greenhouse gases (Nejat et al., 2015; Robert and Kummert, 2012). GHG emissions significantly increased as a result of fossil fuels including natural gas, oil, and coal, as well as climate changes, as well as ozone layers' depletion, all of these things have side effects on the environment and people's life all around the globe. (Robert and Kummert, 2012; Nejat et al., 2015). Annual CO2 emissions have increased by more than 100 percent in the last four decades, surpassing 32 billion tons in 2012 (Robert and Kummert, 2012; Nejat et al., 2015). In addition, CO2 emissions are expected to rise to (36 billion tons) by 2021 (Robert and Kummert, 2012). Residential structures accounted for roughly 6% of direct CO2 emissions (in 2011) (Lising, A.J., 2012), and they were responsible for 13% of indirect CO2 and greenhouse gas emissions due to electricity usage, making them the fourth highest CO2-producing in the worldwide (IEA, 2013).

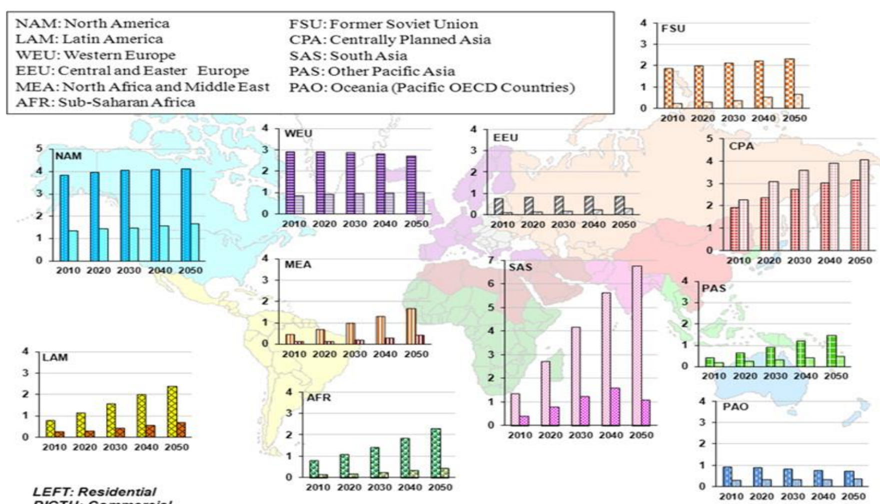

FIGURE 3. From 2010 to 2050, the use of cooling and heating energy in buildings in various countries. It's worth noting that the energy is measured in (PWh). *Predictions are based on a scenario with frozen efficacy

Renewable energy sources could be a useful alternative for fossil fuel systems in commercial and residential building to provide more sustainable heating and cooling solutions. Renewable energy sources offer 14 percent of the world's overall energy needs. Hydropower, geothermal, wind, sun, and marine energies are examples of renewable sources that are both clean and limitless.

Renewable energies accounted for roughly 8.88 percent of energy generation in the United States in 2005, as shown in Fig. 4, and this percentage climbed to 13.24 percent in 2014. It is also expected to increase to 18 percent by 2040 (Robert and Kummert, 2012; Nejat et al., 2015; lake et al., 20017; Outlook, 2015; Marinova, et al., 2008). The usage of geothermal energy for heat pumps has expanded dramatically (Marinova, et al., 2008), with geothermal district heating system now accounting for 10percent of total of all district heating systems. The usage of geothermal energy has risen dramatically (Marinva, et al., 2008), with geothermal district heating systems accounting for 10percent of all district heating systems used in the last 30 years (Lund, 2006).

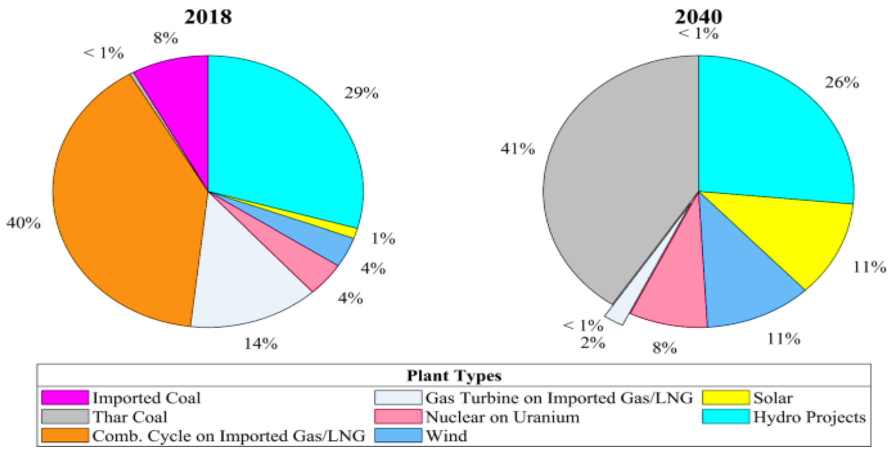

FIGURE 4. The renewable energy contribution in the USA energy generation in 2018 and its estimate for 2040 (Robert and Kummert, 2012; Nejat et al., 2015; lake et al., 20017; Outlook, 2015; Marinova, et al., 2008).

District cooling and heating systems, according to Werner (Werner, 2017), have a lot of promise to be viable cooling and heating supply choices throughout the future. In general, there are various things to consider when comparing renewable energy sources, including economics, energy, social issues, and the environment. Figures 5 and 6 outline the benefits and drawbacks of sources of renewable energy used in district cooling and heating systems.

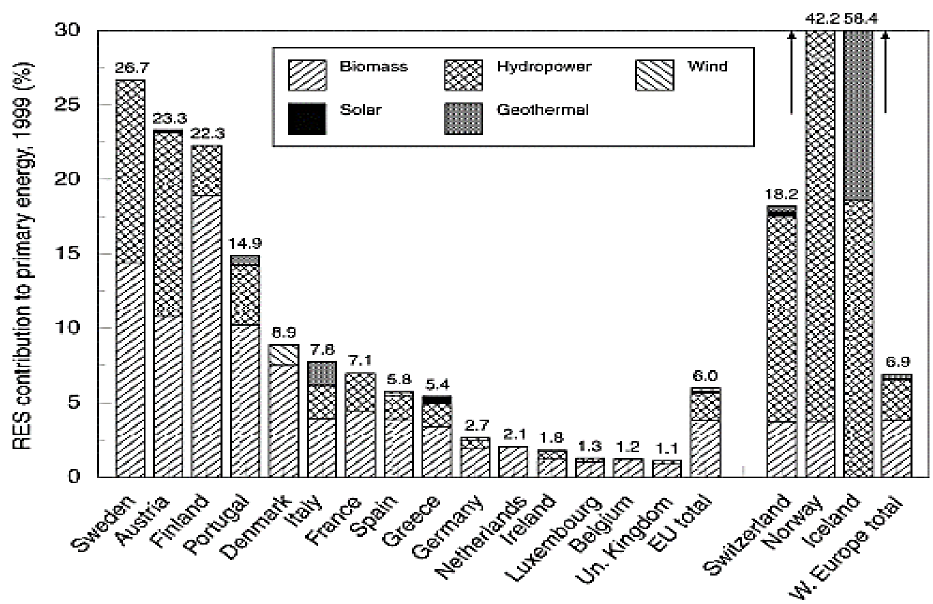

FIGURE 5. renewable energy sources (Bigerna, S., Bollino, C.A. and Micheli, S., 2015*)*

Geothermal energy systems can offer low-cost heating & cooling, as demonstrated in Figure2. They have a longer lifespan than other systems and, unlike some other sources such as solar, may be used all year. So, when cooling and heating activities are feasible and ecologically aware, geothermal as well as biomass have similar technical and cost performances, but solar has lower performance (Dincer and Acar, 2015).
Despite all attempts, there is no thorough assessment of geothermal energy utilization in cooling & heating systems, to the best of the authors' knowledge and based on literature review. As a result, this paper aims to provide a review on the opportunity of using geothermal energy in Iraq under the ground represents one of the sustainable energy resources we can use it will be a significant environmental benefit in our housing in air conditioning. Hence, the achieved conclusions of this review can make changes towards sustainable environmental design.

GEOTHERMAL ENERGY SYSTEMS THROUGH THE WORLD

The degree to which geothermal energy is adopted is affected by policy and other technological challenges (Eriksson and Vamling, 2007). Geothermal energies have been used for 120 years (DiPippo, 2012) and are a clean and sustainable renewable energy source (DiPippo, 2012). Hot springs were used by indigenous Americans many years ago, according to discoveries (Bucher and Stober, 2013). South Dakota's hot springs encouraged Sioux and Cheyenne tribes to battle spurred the US. Humans were not blind to the healing value of hot springs. At the springs, for example, inhabitants had bathtubs carved out of the rocks (Stober and Bucher, 2013). To address gastrointestinal problems, they would sip water from hot springs. According to documents discovered, the use of cooking geothermal energy was prevalent amongst Romans, Turks, Icelanders, and Japanese. Moreover, there were bathing and health treatment establishments in China about 2000 years ago. Hot springs were widely produced by the Romans in Europe for a variety of uses. Bathing was a very important practice for the Romans (Stober and Bucher, 2013). According to sources, People in china produced advice on cultivation and therapy using hot springs between the fourth and sixth centuries. Chinese farmers, for example, may apply hot waters into their rice crops in March, allowing three harvests annually (Bucher and Stober, 2013). The mining industry has also used geothermal energy (Stober and Bucher, 2013). Agricola discovered in 1530 that temperature increased with depth in underground mines. Later, in the 1740s, De Gensanne used a thermometer to measure the temperature of a mine in France (Fanelli and Dickson, 2002). Alexander von Humboldt (Stober and Bucher, 2013) proposed a relationship between the increase in depth and temperature for the first time in 1791, which was a key metric in geothermal energy exploration. In Freiberg, Saxony, he found a temperature increase of 3.8 degrees Celsius per 100 meters of depth.

Currently, geothermal energy was being used in more than 20 countries throughout the world, with a total power of 13.3GW (REN21, 2019). Geothermal energy cooling and heating systems could offer low-cost heating and cooling, as demonstrated in Figure2 and Table 1. They have a longer lifespan than other systems and, unlike some other sources such as solar, may be used all year. So, when cooling and heating activities are feasible and eco-friendly, geothermal and biomass have similar technical and cost performances, but solar has lower performance (Dincer and Acar, 2015). It has been demonstrated that geothermal consumption has increased rapidly in recent years. In the next 6 or 7 years, 1GWe of installed geothermal powers generation capacity is expected to be added annually. There are numerous benefits to geothermal energy potentials that should not be overlooked. In general, geothermal energy can be classified into two categories:

Heating in the winter: because the temperatures of the ground are higher than the temperatures of the atmosphere, it is sometimes adequate for heating or merely preheating. Furthermore, using and utilizing heat pumps significantly enhances heat evacuation from the ground (Koohi-Fayegh and Rosen, 2017). **In warmer seasons**, cooling is possible because the temperatures underneath are colder than the temperatures above the earth, and the difference can be used for cooling or precooling. Heat pumps in cooling mode can improve efficiency while lowering the temperature used for cooling (Rosen and Koohi-Fayegh, 2017).

Heat pumps, a heat exchanger that is buried beneath the ground, also air ducts are part of a common air distribution system are the three basic components of geothermal-based cooling and heating systems (Koohi-Fayegh and Rosen, 2017). The price of the entire system is determined by the heats exchanger's size, which differs. Calculations and economic analysis are necessary to calculate and construct the correct heat exchanger based on daily and average annual loads. Furthermore, several difficulties, such as subterranean water streams and the freezing danger, the thermal characteristics of soils, and underground temperature distributions, can compromise heats exchanger effectiveness. Ground heat exchangers (GHEs) could, however, be made more ecologically friendly and cost-effective (Koohi-Fayegh and Rosen, 2017). Figure 7 displays that using geothermal energy in the HVAC systems can reduce your energy bill in half.

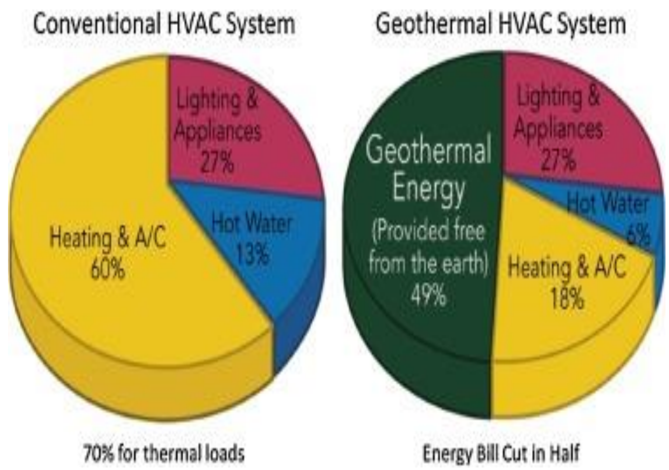

FIGURE. 7. Choosing between a geothermal and a traditional HVAC system

https://www.geoexchange.org/

Figure 8 shows the total amount of geothermal power installed in different nations, as well as an estimate of the amount of energy produced by these power plants (2015). In 2015, set up geothermal energy reached 10,716 MW, a growth in generated electricity that indicates a bright future in geothermal power plants worldwide.

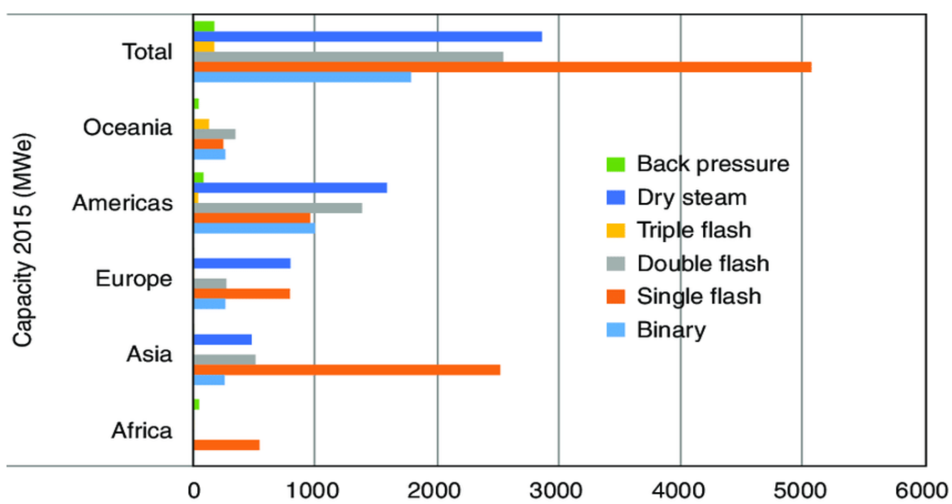

FIGURE 8. Total geothermal power installed global in 2015

Bertani R. Geothermal power generation in the world 2010-2014 update report. In: Proc. world geothermal congress; 2015.

GEOTHERMAL ENERGY SYSTEMS IN IRAQ

Iraq is located on the Arabian Peninsula's northernmost tip. Iraq's topography is described as a desert in the western and the Taurus and Zagros mountains in the northeast, separated by Mesopotamia's core fertile depression.
Iraq's geothermal gradient map reveals two different zones with high geothermal gradients of up to 40 degrees Celsius per kilometer. West Iraq and Northeast Jordan have the largest temperature gradient, which approaches 40°C/km, Fig.9&10, (Abdula,2017). The Salman Zone, as well as the Tharthar and Tigris lines in northern Iraq, have temperatures ranging from 12 to l8°C/km. In the Mesopotamian Zone's northeastern part, the gradient rises to 20°C/km (Abdula,2017). The temperature gradient along some of the Foothill constructions varies; some, like Kirkuk, have a moderate thermal gradient, while others, like Hemrin, have large thermal gradients surpassing 33°C/km, Fig.9&10, (Salloom et al., NA). As illustrated in Fig.10, the sedimentary cover's thermal conductivity was calculated as a weighted average of the average conductivity of 14 layers, Fig.9&10. The temperature gradient was recalculated using a uniform heat flow of 58 kWm-2 from the crust and averaged thermal conductivity (Salloom et al., NA). Except in the Western areas of the Rutba Subzone, where the former is around 10°C less than the earlier, the computed gradient varies somewhat from the actual gradients in much of Iraq. This could be due to increased heat movement from the crust within that area, or to Neogene volcanic activity related to the Red Sea opening, which impacted the western Arabian Plate with flood basalt eruptions in Southeast Syria and Northeast Jordan. Aeromagnetic studies in Western Iraq could also be used to locate some buried volcanic bodies (Salloom et al., NA).

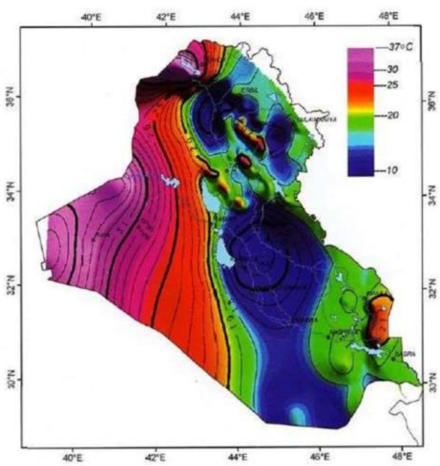

FIGURE 9. Temperature gradient in degrees Celsius per kilometer calculated using uncorrected bottom-hole temperature(Abdula,2017)

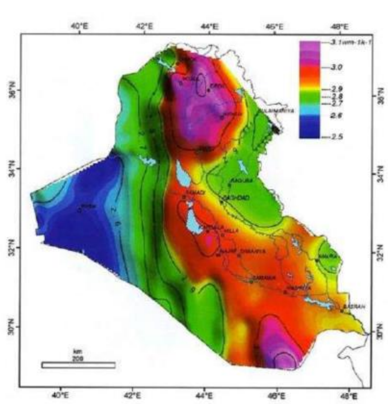

FIGURE 10. The weighted average of thermal conductivity of 13 sedimentary layers was used to obtain the mean thermal conductivity of the sedimentary cover in (Wm-1k -1). (Abdula,2017)

GEOTHERMAL SYSTEMS ENVIROMENTAL IMPACTS

Land-use changes usage connected with plant constructions and exploration, water also gas discharge, noise and sight pollution, the foul odors formation, and soil subsidence are environmentally friendly impacts of geothermal developments and energy generations (Tester et al.,2006; Dickson,2004; Barbier,2002).
The most of these impacts, but, with contemporary technology, these issues may be overcome, resulting in geothermal energy being just an insignificant impact on the environment. Klamath Falls, Oregon, for instance, has around 600 geothermal wells for domestic solar thermal. The city too has investing in district heating systems as well as downtown snow-melting systems, which it uses to heat local businesses. In town, though, neither of the systems for supplying and delivering geothermal energy are evident (Tester et al.,2006; Dickson,2004).

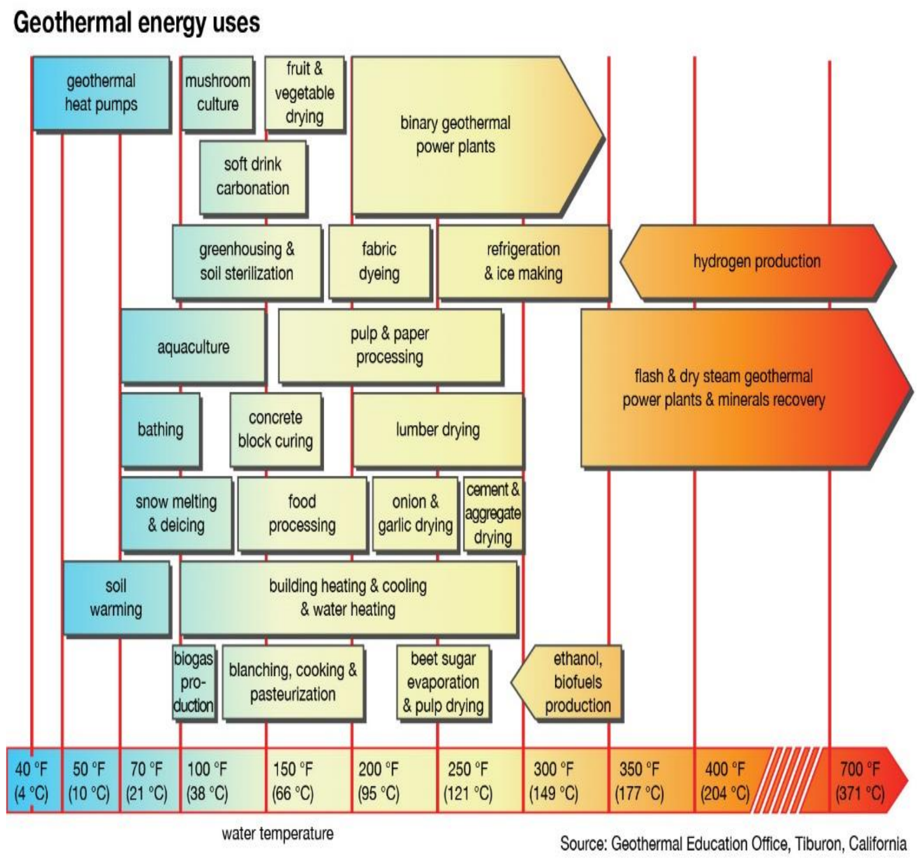

FIGURE 11. Various geothermal energy applications are depicted in a graph based on the geothermal resource's water temperature.

Furthermore, because GHPs employ shallow geothermal resources within 100 m (approximately 330 f) of the surfaces, they have a relatively low environmental impact. Groundwater, rocks, and ground soil experience only minor temperature changes as a result of GHPs (Glassley,2014; Stober and Bucher,2013). The ground temperatures around the vertical boreholes have been slightly gone up or down in closed-loop system; the temperature change direction is determined by whatever the systems are dominated by heat treatment (which would have been the case through colder climates) or cooling (which would have been the case in hot climates). Ground temperatures would remain consistent if cooling and heating loads are balanced. Similarly, open-loop systems that use underground water or lake water may have little influence on temperatures, particularly in areas with high groundwater flows (Glassley,2014; Stober and Bucher,2013; Tester et al.,2006; Dickson,2004; Barbier,2002; Armstead,1978).

When comparing the advantages of geothermal energy to those of other renewable resources, the fundamental benefit of geothermal energy though is that its baseload is available 24 hours a day, seven days a week, while solar and wind are indeed available around 1\3 of the time (Tester et al.,2006; Dickson,2004; Barbier,2002; Armstead,1978). Also, Geothermal energy costs between 5 -10 cents per kWh, making it similar to all other energy sources like coal. The biggest disadvantage of generating geothermal energy is the expensive cost of infrastructure and services, as well as the huge risk of verifying the resources. Nevertheless, once the resources have been established, the annual cost of fuel (steam and hot water) is modest and does not likely to rise in price (Glassley,2014; Stober and Bucher,2013; Tester et al.,2006; Dickson,2004; Barbier,2002; Armstead,1978).

An in-depth life cycle analysis was used to assess the environmental impacts of high and low enthalpy geothermal systems (Martín-Gamboa et al., 2015). Working fluid losses in ORC energy plants account for 73 percent of ozone layer depletion and 28 percent of global warming potentials, according to their findings. They also concluded that using environmentally friendly fluids and optimizing material resources will boost ORC benefits even further. Local geological factors, life span, system boundaries, influence assessment technique, and distribution mechanism were demonstrated to alter the outcry in a review of various LCAs for binary, a single and double flash, also dry steam plants.

As a result of the particular intricacies intricate inside each power plant's design, it's indeed hard to examine geothermal technologies as a whole because the majority of studies focus on local ecological, technical, economical, and environmentally friendly issues. The lack of trustworthy data makes the LCA of geothermal plants even more difficult (Bayer et al., 2013). Because most data are reported anonymously, there is a lot of uncertainty. Furthermore, some areas don't regulate CO2 emissions, compounding the problem of incorrect data.

In Italy, the ecological impact of four geothermal energies was found to be comparable to natural gas plants. Acidification was shown to be (2.2) times more likely in geothermal power than in coal power, and (28) times more likely in natural gas power (Ottman et al., 2019). Flash steam or dry steam cycles, for example, are open-loop systems that discharge gasses that would otherwise be trapped beneath. When it comes to releasing gasses, two cycles, which are closed-loop systems, maybe a superior solution (Ottman et al., 2019).

ENVIROMENTAL IMPACT OF SUSTAINABLE BUILDINGS ARCHITECTURE DESIGN

With the growth of interest on the environmental issues of the sustainable green design of the new building taking into consideration new low carbon technologies presenting how Carbon dioxide levels and average world temperatures have risen dramatically over the same period, and its applications on geothermal housing. The main concern to determine sustainable environmental housing is by making a stable balance between energy, environment and inside climate (Baker et al., 2000; Jones et al., 2009; Stulz et al., 2011; Nik et al., 2015). Several authors investigate the Environmental impact of Sustainable buildings architecture design recently. (Bassas, et al., 2020; Rushdi et al., 2020; Lahieb et al., 2020; Nagam et al., 2020; Nahi et al., 2020; Muhsun et al., 2020). These phenomena started in the 20th century by including the environmental concerns aiming to have an impact across every day, and it is known today as "Green architecture" (Maziar, 2012, Steele et al., 2005, Tabb et al, 2013; Ragheb, et al., 2016; Szokolay, 1998) Bassas et al.,2020 argues that, while it is essential to make a difference in architectural design, sustainable strategies are still evolving from the marketplace that will allow green housing to become the standard for a future low-carbon building design. Bassas illustrate that green building architecture is important at changing speeds depending on the technical, environmental, economical, and political barriers at the time. 82 case studies in the UK but also Europe, the USA, and worldwide (Bassas et al.,2020). In Turkey, Kotcioğlu et al., 2011, investigate Clean and sustainable energy as it is important to human life, as the energy we knew before which cause pollution and it has a great impact to global climate change. Kotcioğlu et al., 2011, presented in their paper that Turkey's renewable energy resource is sufficient to reduce the country's energy dependence and greenhouse gas emissions (Kotcioğlu et al., 2011; Yüksel et al., 2010; Bilgen et al., 2008; Kaygusuz et al., 2002). There are rising concerns that sustainability could be compromised unless steps are done to create a balance between economic, environmental, and social values (Kaygusuz et al., 2010; Kaygusuz, 2009;

Akpınar, 2008). Norouzi et al., 2021 examined the landscape architecture for the utilization of renewable energy resources and potential applications at the urban level in Iran as a case study. The researchers calculated the amount of wind, solar, geothermal energy in Iran, as well as the possibility for sharing renewable energy with neighbors and techniques for incorporating these energies into the architectural design (Norouzi et al., 2021). In addition, the rapid increase in the development of industries leads to a high need for renewable and sustainable energy systems all over the world (Yoro et al., 2021; Yoro, 2020) Finally, Reducing Environmental pollution is essential in any new structural design in addition to any energy productions. governments from different countries worldwide added new regulations to control Air Pollution (Al-Mashhadani et al., 2020; Murtadah et al., 2020; Al-Sharify et al. 2020). Work has been made to investigate the environmental impacts of the high sulfur content of domestic lignite which is even from oil factories or airports, or any other pilot plants that through its wastes as wastewater in the river, all that causes not only Air Pollution but even water (Al-Sharify et al. 2018; Al Jaaf et al. 2020., Rzaij et al., 2020; Zainab et al, 2020), solid, and soil pollution.

CONCLUSION

Because of the environmental difficulties caused by GHG emissions, employing renewable energy sources is now required. So the usage of renewable energy has grown in recent decades, it is critical that it should be given more attention. Geothermal and biomass energies perform similarly in renewable direct cooling and heating systems, but solar energy performs less well. There are however certain drawbacks to employing geothermal energy, including the high initial costs and lengthy building design period. It has several benefits that the other renewable energy sources don't, like the ability to work all year, and use less land, to mention a few, and these advantages make geothermal energy appropriate.

The use of geothermal energy is briefly discussed in this study. Furthermore, the background of geothermal energies in many areas of the world and Iraq is examined, as well as various types of geothermal energy consumption. Geothermal gradients vary significantly from well to well even with depth throughout Iraq. Differences in the thermal conductivity of rocks, thermal energy, and/or subsurface water movements are thought to be the cause of these discrepancies.

The lack of awareness about geothermal resources has an effect negatively on the overall energy resources, and the government's preference for fossil fuels has led to the abandonment of sustainable energy for years. Nevertheless, research into Iraqi geothermal resources is rapidly expanding to keep up with the world developments.

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CONFLICT OF INTEREST

The authors confirm that there is no conflict of interest.

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