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How Did Turkey Succeed in Raising Public Awareness and Environmental Protection Along with Geothermal Developments?

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ABSTRACT

Turkey, as a foreign-dependent country, is trying to break its bond with fossil-fueled power plants in recent years. The recent government started a campaign and supported it with generous feed-in tariff mechanisms to use energy sources that the country possesses inside its borders such as hydro, solar, wind, geothermal and biomass. For renewable energy concept, geothermal energy holds in a different ground comparing to others. Geothermal energy is the most vulnerable renewable energy source in terms of public concerns. While foreseeing a powerful and instant development, any country should approach cautiously and develop the whole ecosystem with itself. This ecosystem development means both protection of the environment and improvement of the local communities.

Turkish government and investor companies jointly succeeded a rapid geothermal development while protecting fauna, flora and human-rights with community friendly regulations and investment perspectives. In this article, we try to examine the cornerstones of this successful development process reaching 1155 MWe installed geothermal power and demonstrate all of the factors with concrete outputs. For the environmental protection; the authors will analyze how the reduction of carbon emissions, forestation operations and greenhouse cultivation play a huge role carrying out the social impact. On the other side; thermal tourism, balneology, local economy and employment growth will be unveiled for the public awareness and welfare.

1. INTRODUCTION

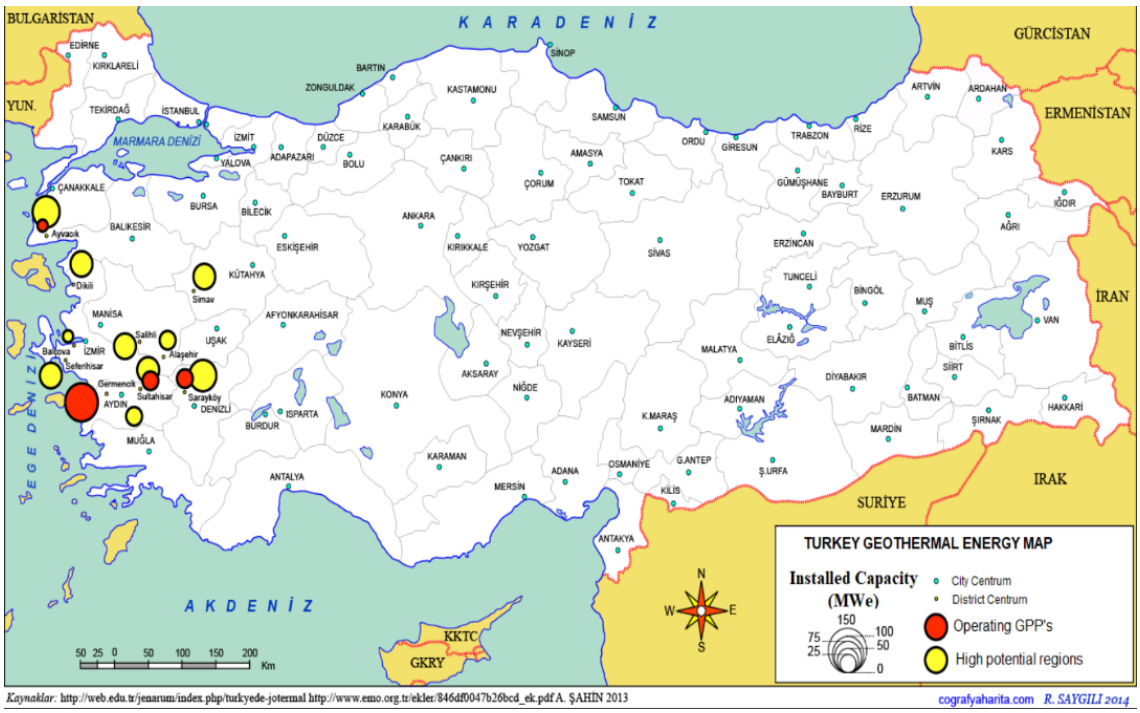

Figure 1: Turkey Geothermal Energy Map[1]

Energy is identified as one of the main elements in economic development, especially for non-developed and developing countries. Providing a low-cost energy to their community and industry would take a developing country many steps further compared to others. When providing geothermal development, social and economic growth are also a necessity. Dependent countries are forced to develop renewables but there is a feature of geothermal energy that separates it from other renewables. The feature is that geothermal energy is not generated but is rarely found. Due to restrictions of our recent technology, geothermal power generation can only be provided

if proper reservoir characteristics are present. So, this means that some countries are fortunate to have these resources, but it is important to use them wisely. Developing Geothermal Power Plants provides widespread improvement of community, public, private sector and environment if it is supported with professionally surveyed and conducted incentive methods, such as feed-in tariff mechanisms and regulations.

Nowadays, it is highly crucial to not rely on other countries and to become self-sufficient. Geothermal energy and biomass energy (but mostly geothermal for reaching higher power) are the foundations of renewable energy development. Being able to generate baseload electricity differentiates these sources. Our age's technology is not letting humans generate electricity without affecting nature, every power generation technology has a carbon foot print. According to ESMAP Geothermal Handbook published in 2012, $C0_2$ emissions of geothermal energy are far below of fossil-fueled power generation types. [2] Geothermal power plants must replace the coal and natural gas plants if human kind wants to live longer on this planet.

Turkey, as a developing country, aimed its way to self-resourced power generation. Turkish Ministry of Energy started a feed-in tariff mechanism for renewable energies. As shown in Table 1, geothermal energy also got its share from this policy change. As a result of having 31,000 MWt geothermal energy potential, the installed geothermal capacity had increased from 15 MWe to 1,155 MWe between 2008 and 2018. This growth is accomplished by the whole country. Contribution of farmers, local communities, academicians, investors and public institutions provided a strong development with a solid foundation. People helped to develop geothermal energy and geothermal energy helped people to develop. Industry, tourism, agriculture, education and infrastructure are among the top sectors that geothermal energy developed directly or indirectly. It is the only resource that enhances its surroundings with not just only power generation but also with social impact it creates under good administration; this is what happened in Turkey.

Table 1. Renewable Feed-in Tariff Mechanisms in Turkey[3]

Renewable Energy Source	Feed-in Tariff ($cent/kWh)
Hydropower	7,3
Windpower	7,3
Geothermal	10,5
Biomass	13,3
Solar	13,3

2. PUBLIC AWARENESS AND WELFARE

2.1 Raising Public Awareness

Public is the most important social factor in geothermal development. In most of the countries, investors and state institutions collaborate well for developing geothermal energy but this partnership lacks the involvement of the public.

It should be remembered that local community is generally the most affected side of energy developments. Most of them do not have the education and knowledge to understand the importance and to analyze pros and cons of these activities. From their perspective, some strangers are entering their comfort zone. Therefore, local community should be well informed to join the partnership. If proper information methods are presented to public, they would start to see other side of the incident. Also there will be an opportunity to express their concerns and thoughts to authorities.

Turkish authorities are pursuing a successful campaign in this manner. Turkish Ministry of Environment and Urbanization started a regulation which obligate investors to organize and join a "Public Involvement Meeting" as seen in Figure 2 to obtain an Environmental Impact Assessment (EIA) Report for their investments. This assembly is generally organized with collaborate efforts of Ministry, investors and EIA companies for each project separately. The main goal of the assembly is to inform the local community and to collect their thoughts, problems and suggestions about the project. Local and national newspapers announce the date, time and location of the assembly at least 10 days before. Ministry's EIA Director, as the chair of the assembly opens the Public Involvement Assembly. Agenda mostly contains the topics of EIA Report that will be created for the project. EIA Company reads the draft of the EIA Report's contents to the public and then the local community is expected to offer their consideration and suggestion.

Figure 2. Public Involvement Meeting for Kızıldere-III GPP

2.2 Thermal Tourism

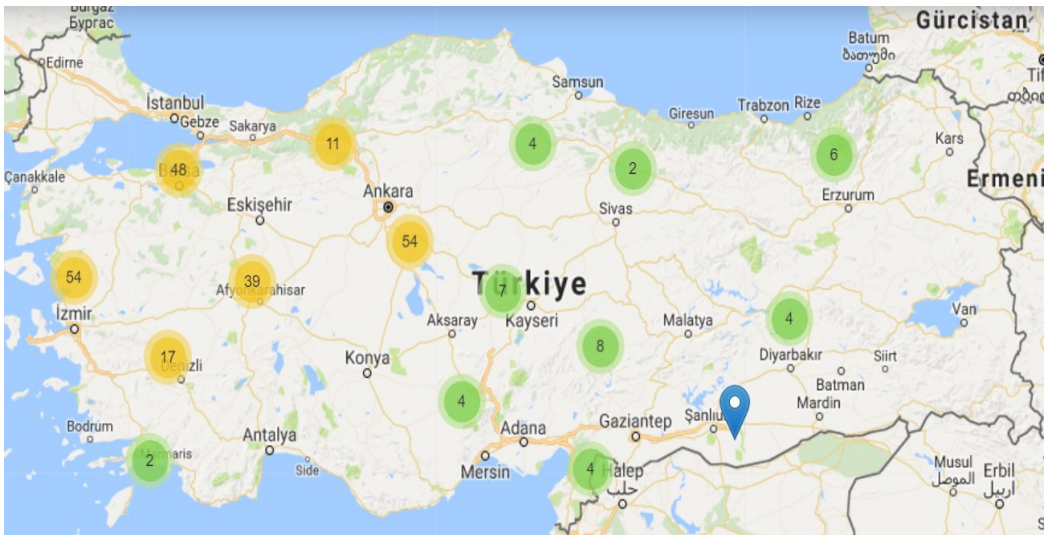

Figure 3. Turkey's Thermal Springs Map [4]

Turkey is located on a fertile geothermal region. Natural thermal water is an important factor in tourism which is an amazing contribution to a country's economics. Recent figures show that around 16 million people are visiting thermal water facilities every year.[21] Figure 3 shows the thermal water facilities in different regions of Turkey. (Above 10 facilities expressed in yellow, below 10 facilities expressed in green.) In thermal tourism, chemical properties of water resources are as important as the quality of the facilities.

Thermal tourism uses the geothermal brine which has temperature higher than 20ºC and contains various minerals for cleaning, resting and dwelling purposes. According to the MTA (Mineral Research & Exploration General Directorate), thermal springs operate at temperatures ranging from 20ºC to 110ºC in Turkey. Having an artesian flow and abundant mineral contents such as sulfur are strong characteristics of the resources in Turkey. The volume and importance of thermal tourism is increasing day by day for Turkey. Figure 3 shows the location of 117 thermal hotels with 46,184 rooms are ready to serve tourists from all around the world.[5] Turkish Ministry of Culture and Tourism composed a master plan about thermal tourism. Moreover, health & thermal tourism are one of the main focus points of the 10th Development Plan (2014-2018) under the title of "Health Tourism Development Program". The aim of the plan is:

- Reaching 100,000 bed capacity in thermal tourism end of 2018.
- Providing services to 1,500,000 (600,000 treatment purposes) foreign thermal tourists in thermal tourism
- Gaining a revenue of $3 billion in thermal tourism
- Being the first 5 destinations of the world in medical tourism
- Directing incentives for thermal facilities to investments in areas, especially geothermal resources and natural thermal waters.

The facilities are planned to be built in 4 main thermal regions. These regions are; South Marmara, South Aegean, Frigya and Middle Anatolian.

- Southern Aegean: Aydın, Denizli, İzmir, Manisa
- Southern Marmara: Balıkesir, Çanakkale, Yalova
- Frigya: Afyon, Ankara, Eskişehir, Kütahya, Uşak
- Middle Anatolian: Aksaray, Kırşehir, Nevşehir, Niğde, Yozgat

Southern Aegean region is the most important and developing region because of the high temperature reservoir. The temperature varies between 70ºC to 240ºC. Thermal tourism can be developed with waste energies of geothermal power plants with this reservoir characteristic. Kızıldere GPP is supporting this business model and created a new employment area for the local economy by kick-starting thermal tourism in the region and providing free geothermal brine to 3 hotels which were built as part of thermal tourism initiative.

2.3 District Heating

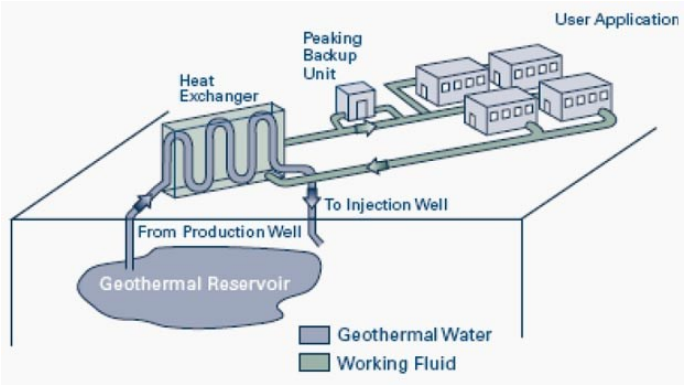

Figure 4. District Heating with Geothermal Energy Illustration[6]

For household expenditure, heating bills cover a big portion in cold seasons. If the country imports the fuel from other countries (e.g. Turkey), heating costs tends to depend on political and economic situations between governments. By the beginning of the 21st century, Turkey started to invest for natural gas heating systems in most of the regions. Natural gas was naturally cheaper than other fuels. As a result of having instable foreign exchange rates and increases in natural gas fee, people started having difficulties to pay their bills. Renewable energies such as geothermal and biomass are clean and cheap answers to this trouble. Although it is obvious that providing a comfortable and warm house for all of the 80 million people living in Turkey with renewables is not feasible in *short term*, this shouldn't conceive an excuse for not developing related technologies. Instead, providing this opportunity to nearby villages triggers more valuable factors than just reducing usage of imported fuels. There are many different geothermal based district heating systems recently in Turkey. Main ones are:

Table 2: # of Residences Heated with Geothermal [7]

Region	# of Residences
Gönen	3,400
Simav	3,200
Kırşehir	1,800
Kızılcahamam	2,500
Balçova	11,500
Afyon	4,500
Kozaklı	1,000
Sandıklı	2,000
Diyadin	400
Narlıdere	1,500
Sarayköy	2,500

The main factors providing this great expansion of geothermal heating are: developing a domestic standard heating system, involvement of public to the development cost with a heating registration fee and price difference between geothermal heating and natural gas heating where geothermal is approximately 50-60% cheaper than natural gas.[8]

To be able to set an example for demonstrating the good cooperation between local community, private companies and public institutions Kızıldere-1 GPP can be pointed out. Kızıldere-1 GPP is the first geothermal power plant of Turkey. It was commissioned in 1984 with 15 MWe installed capacity. At first, it was operated by the Turkish state. The state aimed to provide a heating system to the nearest village of the plant, Sarayköy village, but they didn't have the resources and man power in that time. Kızıldere-1 power plant provides free district heating for 2,500 residential houses in Sarayköy district of Denizli province through Bereket Enerji. Bereket Enerji committed to develop pipelines and distribution system in exchange for receiving the hot fluid from Kızıldere-1 for free. The company also gained the right to generate electricity with that fluid in hot seasons by utilizing a binary cycle unit. Even after the privatization of Kızıldere-1 GPP (acquired by Zorlu Energy), the new owner Zorlu continued to supply hot fluid to Bereket. Approximately 200 tph geothermal fluid is being used for Sarayköy district heating system. The geothermal fluid is carried to 3 main heat exchangers with 400 mm diameter pipes. The geothermal fluid is exchanging its heat with the second fluid (water, in this case) than the second fluid is pumped to residences where again a 2nd heat transfer process occurs to circulate the heater fluid around the house. [7]

As defined previously, there are 11 regions using geothermal heating system in Turkey. At total, around 114,000 residences are keeping themselves warm with geothermal energy. [9] This leads to a non-negligible amount of savings for country. These savings are calculated with an easy approach below:

- Annual natural gas consumption of a resident[10]: 1,032 m^3
- 2018 yearly natural gas unit price[10]: 1.16 ₺/m^3
- Total natural-gas heating subscribers[10]: 13,610,325 residences

Turkey is annually importing 3.4 billion$ natural-gas for heating. With total of 144,000 residences using geothermal heating, around 30 million$ is staying in Turkey. While analyzing this outcome, one should keep in mind that Turkey is using only 827 MWt out of potentially 60,000 MWt yet.[21]

2.4 Local Economy and Employment Growth

Geothermal energy also contributes to local economy and employment growth. Geothermal is a wide spread field, which means that various expertise should keep on working with a harmony during development, construction and operation phases.

All geothermal activities represents an added-value for Turkey. Approximately 42,000 people are working directly in different areas of geothermal energy. [11] This includes all phases of geothermal power plants. However, it is increasing in construction phases of GPP's. It is estimated that employment rate generally doubles in construction phases. More geothermal development directly provides new job opportunities in different areas, such as:

- Drilling engineers
- Welding and quality engineers
- Mechanical, civil and indsutrial engineers
- Electrical and chemical engineers
- Geoscientists
- Technicians in related fields
- Fitting & installation workers

According to Turkish Ministry of Development, direct and indirect use of geothermal energy (power plants, greenhouses and district heating centers) have the potential to create job opportunity for 300,000 people.[21]

Subjects mentioned above are measurable contributions of geothermal. But there are plenty of affects to local economy which is not archived by responsible organs of government and local authorities. These contributions can be listed as:

- Infrastructure development; new roads and electricity distribution lines
- Increased land prices; local community started to make an earning from even poor lands for developers drilling purposes
- Increased turnover of local companies; developers prefer to work with local companies for low transportation costs

Moreover, there is one highly effective policy of Turkish State's local energy campaign which must be emphasized. Turkish Ministry of Energy and Natural Resources added an incentive rate to their feed-in tariff mechanism (10.5$/kWh) to increase the use of the local goods. Additional incentive rates are shown in Table 2 below. Developers desire to sell their generation from a higher fee. That leads to a wide usage of local equipment. For geothermal power plant, recent stats show that nearly 52,3% local equipment is being used except drilling operations.[22] Total geothermal investment reached 2 billion$. If local equipment usage reaches 70%, this means that geothermal energy would contribute to local economy around 1.75 billion$. [12]

Table 3: Additional Incentive Rates Local Manufactured Goods for Geothermal Energy, Turkey [3]

Incentive Type	Rate
Usage of local gas or steam turbine	1.3 $cent/kWh
Usage of local generator	0.7 $cent/kWh
Usage of local ejector or vacuum compressors	0.7 $cent/kWh
*Goods manufactured in Turkey counts also as local	

3. ENVIRONMENTAL PROTECTION

The population of the world is increasing day by day, and this growth directly affects energy demand. Projects are developing to compensate this demand but it also has some pressure on the environment. Proper evaluation of the environmental impacts of the projects needs to be done in order to reach sustainability of natural life, agricultural activities, forestry and landscape planning.

In geothermal development, there are some occasions that agriculture field and geothermal site encounter. For example; the exploration team of an investor prepared a report to determine to drilling location and direction into the reservoir but in Turkey exploration license holders are not land owners, therefore agreements must be made with landowners before any drilling can be done. This is usually done through land acquisition or leasing.

After the land acquisition, even though there isn't a strict Turkish regulation to prevent the investor from transforming the agricultural field, some Turkish investors care much about the nature. Zorlu Energy's Kızıldere field is also a good example in this subject. Zorlu Energy group carries out risk assessments which are analyzing environmental and social effects of investments in accordance with international standards. Then, investments are made in light of these findings. In all of the investments, the investors analyzes the impact of projects on the environment and mitigate the possible negative effects beyond the legal and administrative requirements, and even develop and implement environmental management and investment plans and programs to create additional value. In line with the results of environmental and social impact assessments, detailed biodiversity studies, regular ornithologic monitoring and ecosystem evaluations are carried out. These studies determine the current situation in order to prepare monitoring and intervention plans and Zorlu Energy takes measures to prevent the disruption of habitats where habitats are restored with landscape restoration plans in completed investments.

Zorlu Energy had carried out the projects below in the region beyond the national legal requirements are as follows;

- Kızıldere I, II, III GPP Environmental and Social Impact Assessments and Management Plan
- Kızıldere I GPP Helitrophium Thermophilum Protection Program
- Kızıldere GPP Landscape Restoration Plan and Habitat Restoration Project

Figure 6. Transplantation Area in Sarayköy, Denizli[15]

3.1. Greenhouse Cultivation

As known well enough, most of the GPP's are built in rural regions all over the world. In Turkey, most of the plants are located in the Western Anatolia region in cities such as Aydın, Manisa, and Denizli where local people are earning their live hood mostly from agriculture. They are using the virtue of being settled on top of fertile lands. Grape, fig, olive, peach and apple are among the most common products of these cultivated areas. The State of Turkey started an incentive campaign to support geothermal greenhouse cultivation areas. The campaign positively affected the geothermal energy perspective among the local community. Local community had seen the opportunity of 4 season cultivation.

Geothermal greenhouse cultivation can be obtained in 2 different scenarios. Most common scenario is to benefit from the waste heat of geothermal power plants and the other one is to use geothermal fluid directly by drilling a well. Drilling costs, which fluctuates around 800-1,000$/m, are extremely high for local residents to cover. Thus, they rely on investors who had already drilled wells for power generation purposes. According to Ministry of Agriculture and Forestry, the geothermal greenhouse cultivation is used for planting mostly tomato, pepper, eggplant and cucumber. Table 3 below shows that a total of 531.52 MWt of geothermal energy is used for greenhouse cultivation around Turkey. In Denizli around approximately 1.6% of a total area used for greenhouse cultivation using waste energy of private sector's geothermal power plants.

Table 4: Geothermal Green housing Areas and Capacities in Turkey [13]

Location	Greenhousing Area (m2)	Installed Capacity (MWt)
Afyon	50.000	131,475
Ağrı	2.000	0,4
Ankara	500	0,1
Aydın	134.000	19,87
Denizli	316140	81,49
İzmir	977000	194,47
Kırşehir	100000	19,6
Kütahya	310.000	60,76
Manisa	250.000	49
Nevşehir	67.000	13,13
Urfa	424.000	33,32
Yozgat	211922	33,61
Total	2,924,037	531.52

Zorlu Energy's Kızıldere-2 GPP is a suitable case for demonstrating the cooperation between private sector and local authorities to provide benefits to the regional agriculture. Zorlu Energy's Kızıldere-2 GPP is situated next door to the Sarayköy Organized Industrial Zone (SOIZ). SOIZ agreed to provide land to Zorlu Energy, which would allow an expansion of 20MWe, in exchange for 80°C cascaded geothermal brine and two heat exchangers; 20MWt and 30 MWt for greenhouse use.

Figure 5. A greenhouse cultivation field using geothermal energy for heat source [14]

3.2 Reducing CO_2 Emissions

Effects of global warming are increasing rapidly with the latest industrial and technological developments. Electricity generation is one of the main contributors of this problem due to a very common utilization of fossil fuels for power generation. Many countries have already started to decrease the level of fossil fuel fired power plants and the world's trend moves towards renewable energy generation.

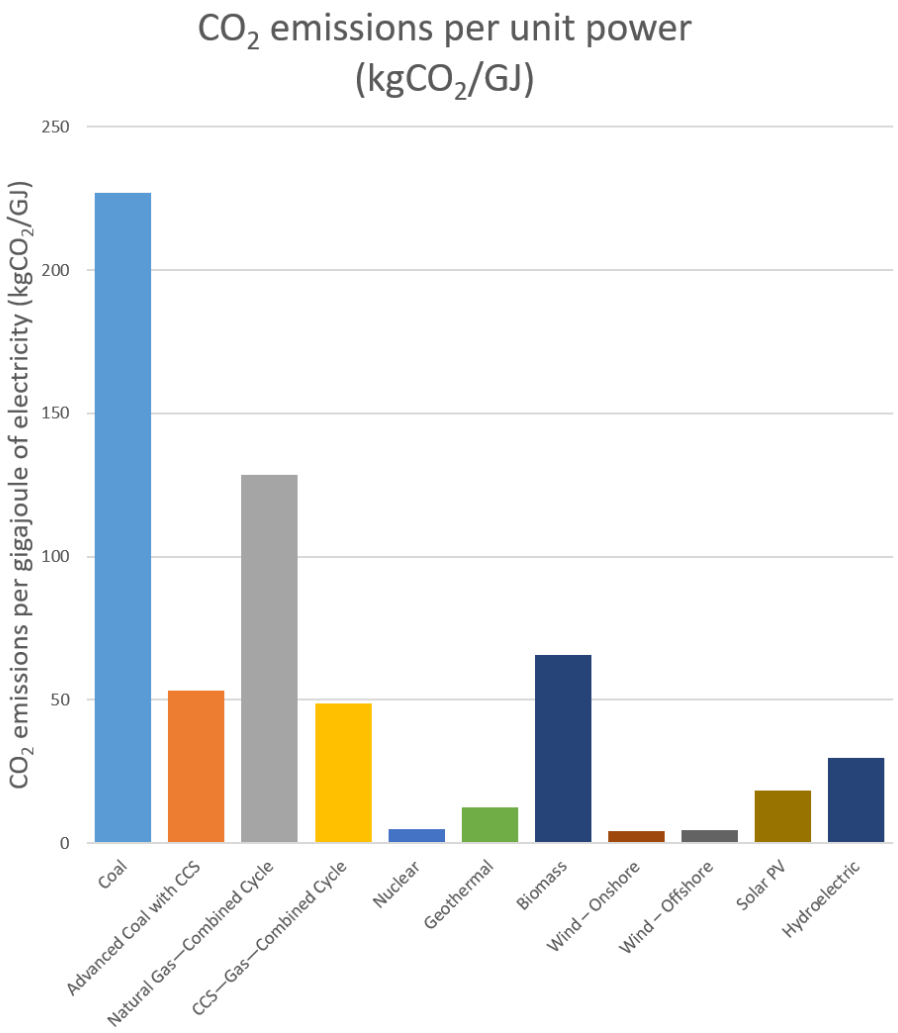

Figure 7. Average CO_2 Emissions of Energy Sources[18]

Geothermal resources are composed of some naturally occurring non-condensable gases (NCG's) with differentiating percentages of different gases including CO_2, H_2S, N_2, CH_4 etc. NCG content of geothermal brine varies with the field characteristics and Turkey has one of the highest content of NCG compared to other geothermal fields throughout the world. For example, weighted 3% of the total geothermal brine is composed of NCG's in Kızıldere geothermal field. This number is also used for plant design considerations.

Due to a continuous electricity generation in one field, NCG content tends to decrease over years of utilization. This number starts to increase again with the exploration of new make-up wells and some other virgin fields. However it will also continue to decrease again with the generation.

There is still some ongoing R&D projects to discover the potential of re-injecting the CO_2 back into reservoir to maintain the sustainability but Kızıldere field is already utilizing another way to reduce CO_2 emissions. In order to reduce and economically evaluate carbon emission in Kızıldere site, Zorlu supplies a considerable amount of CO_2 to a nearby pure carbon dioxide and dry ice facility, achieving a symbiosis of technologies. Thus, no additional sources and/or fossil fuels such as coal or natural gas are used for producing CO_2, which is the main raw material for dry ice. This helps achieve economic and environmental benefits for the region. [18]

Market players for commercial CO_2 production in Turkey are shown in Table 3. Linde is the dominant player with the highest production of 460 t/day from two geothermal power plants.

Zorlu also joined one of the Horizon2020 calls that is supported by European Commission (EC). The acronym of the project is GECO which means Geothermal Gas Emission Control and the project will be demonstrated within four different fields with different reservoir and formation characteristics. The main purpose of this study is to be able to operate geothermal power plants with zero emission by re-injecting CO2 gases back into the reservoir. Turkey, Iceland, Germany and Italy are planned to be the demonstration sites for possible CO2 reinjection. Kızıldere field will be utilized as a Turkish demo-site. Grant Agreement was signed on October 2018 and the re-injection system is planned to start in April 2021.

Table 5: Commercial CO_2 production capacity from geothermal sources [19][20]

No	Company	Plant	Plant Location	Capacity (Tonnes/Day)
1	BM Holding	Gümüşköy GPP	Aydın-Germencik	25
2	Linde	Kızıldere GPP	Denizli-Sarayköy	360
3	Linde	Dora-1 GPP	Aydın-Köşk	100
4	HABAŞ	Dora-2 GPP	Aydın-Köşk	300
	Liquid CO_2 is used as the product in all cases			

4. CONCLUSION

The context of this paper expresses the geothermal development strategies in Turkey. Geothermal installed capacity increased from 15 MWe to 1,155 MWe between 2008-2018 with 40 new geothermal power plants. All of this development occurred with supporting schemes and regulations of the government. Turkey's 10th Development Plan targeted a circular geothermal economy with electricity generation, district and greenhouse heating and tourism activities along with employment increase. In this paper, the authors tried give examples of the best practices according to the development plan.

Turkey is now providing electricity to a few million citizens and heating a few thousands of houses with geothermal energy. Geothermal energy in Turkey has many aspects to develop but with this pace of development, it will not be a surprise to see Turkish developers starting to transfer their knowledge, experience and best-practices to newly developed geothermal sites in any country.

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