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Reflecting Supportive Mechanisms and Experience of Turkey - Zorlu Case Study

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ABSTRACT

Geothermal development in Turkey had a great success over the recent decade. With the regulations numbered 5346 and 5686 approved in 2005 and 2007 respectively, most of the investors directed their routes for electricity production to renewable energy sources. Geothermal is one of these sources that proved its potential and development through new investments, with Turkey increasing installed capacity from 15 MWe in 2007 to 1100 MWe in early 2018. The purpose of this paper is to review and explain the driving forces behind this pace of development in Turkey. These perspectives are provided through best experiences on the development, construction and operations sides faced by Zorlu Energy Group which holds one fourth of the geothermal installed capacity in Turkey.

1. Introduction

Global warming and its effects are getting more harmful to the earth and our environment day by day. Many countries, including Turkey, are trying to address the challenges of climate change that is caused by global warming, with some common declarations such as Kyoto Protocol signed in 1995 with the participation of 169 countries and entering into force in 2005.

Emissions from the energy and electricity generation industries are one of the main contributors of global warming. The need for energy is increasing rapidly with the technological developments throughout the world. Fossil fuels are one of the most common and traditional ways of producing energy but they have many side effects at the same time. The trend towards cleaner, indigenous renewable energy is getting more popular thanks to its environmentally friendly technologies and developments and decreasing investment costs.

In this paper we will try to explain the triggering factors that enabled Turkey's development in renewable energy sources especially for the utilization of the Mother Earth's heat; geothermal. Moreover, this paper will also try to explain the Turkish geothermal sector' s journey starting with 15 MWe capacity in 2007 leading to one of the top four countries in the world with 1100 MWe capacity in early 2018.

2. Supportive Mechanisms in Turkey

2.1 Feed-in Tariff Mechanism

Regulation numbered 5346, approved in 2005, is one of the first and most important steps to support the development of the Turkish renewable energy market. It clearly described renewable energy sources and utilization mechanisms but the feed-in tariff was fixed to a common price regardless of the renewable energy source. This type of feed-in tariff (FIT) mechanism did not encourage most of the investors especially the ones who would like to invest on renewable energy sources such as solar, geothermal etc. where initial investment costs are higher compared to other sources (Yilmaz et al 2015).

The government was receptive to feedback from the industry on better ways to define and support renewable energy sources, and as a result decided to accommodate some of the items through better regulation. As a result, regulation numbered 6094 was put into force in 2010. This regulation with a more sophisticated tariff mechanism markes the date renewable energy sources development in Turkey started to accelerate.

The FIT mechanism defined with the regulation 6094 offers a fixed purchase price for the electricity generated via different types of renewable energy. This FIT program has also simplified the power purchase agreement (PPA) process and transmission interconnection process, allowing developers to move forward with greater revenue certainty. This in turn has facilitated a swifter funding process for project development.

The FIT only covers the plants commissioned and approved for commercial operation before 31 December 2020. Table 1 shows the purchase price that is applicable for ten years starting from the commercial operation date (Gazette 2018). Market price will be applicable as soon as 10 years period is over.

TABLE 1: FEED-IN TARIFF PRICES IN TURKEY

Type of Renewable Energy Source	Applicable Price (USDcent/kWh)
Hydro Power Plants	7.3
Wind Farm Plants	7.3
Geothermal Power Plants	10.5
Biomass Power Plants (including Biogas)	13.3
Solar Power Plants	13.3

The same regulation also provides incentives for local manufacturing. Table 2 shows these incentives that would be applied in addition to the purchase prices over Table 1 (Gazette

2018), where in-country manufacturing can be appropriately certified. These additional prices are applied only for 5 years after commercial operation starts. Increasing the number or types of supported local manufactured equipments is also one of the main discussions held over the governmental authorities to designate the future of FIT mechanism.

TABLE 2: LOCAL MANUFACTURING INCENTIVES

Type of Power Plant	Local Manufactured Part	Local Manufacturing Incentive (USDcent/kWh)
Hydro Power Plant	Turbine	1.3
	Generator and power electronics	1.0
Wind Farm Plant	Blade	0.8
	Generator and power electronics	1.0
	Turbine tower	0.6
	All mechanical sections in nacelle and rotor groups (Excluding the payments done for blade and generator and power electronics)	1.3
Photovoltaic (PV) Solar Plant	PV panel integration and manufacturing of solar structural mechanics	0.8
	PV modules	1.3
	PV module cells	3.5
	Inverter	0.6
	Material focusing the sunlight on PV panel	0.5
Concentrated Solar Plant	Radiation accumulation tube	2.4
	Reflecting surface plate	0.6
	Solar tracking system	0.6
	Mechanical parts of thermal energy storage system	1.3
	Mechanical parts of steam generation system accumulating the sunlight in tower	2.4
	Stirling engine	1.3
	Panel integration and solar panel structural mechanics	0.6
Biomass Power Plant	Fluidized bed steam generator	0.8
	Liquid or gas fuel fired steam generator	0.4
	Gasification and gas purification group	0.6
	Steam or gas turbine	2.0
	Internal combustion engine or Stirling engine	0.9
	Generator and power electronics	0.5
	Cogeneration system	0.4
Geothermal Power Plant	Steam or binary turbine	1.3
	Generator or power electronics	0.7
	Steam ejector or vacuum compressor	0.7

2.2 Geothermal Resources and Natural Mineral Water Regulation

This regulation, ratified in 2007, is numbered as 5686 in Turkish regulation. It mostly defines geothermal and natural mineral water resources and their utilization methods. As established by the law, the water resources belong to the state and require special licenses to carry out operations related to exploration and operations. The regulation helps lower risk of over-development and depletion of the resources by limiting the area in which utilization can take place, as well as setting a fixed duration of activity. Additional risk-mitigation provisions include required technical supervision, mandatory inspections and methods of transfer for delinquent or unused licenses.

Two types of licenses are applicable within this regulation including the first phase starting with the research and exploration activities which is named as exploratory license. The durations of the exploratory licenses are three years. In the event of the operations progressing positively and requiring additional works, a revised project schedule shall be submitted and if the Administration finds it acceptable, the duration may be extended for another year and a notice of such extension shall be given to the related authority. There are two different Administration mechanisms in Turkey. Investment Monitoring and Coordination Department is the responsible Administration in metropolitan municipalities while the Special Directorate of the City is responsible for remaining municipalities.

In the event of the exploratory license holder submitting an application to the Administration for an operating license along with an operating project prior to the expiration date of the current exploratory license, an "operating license" shall be issued to the applicant and the related authority shall be notified, along with blocked areas determined, if any. The duration of the operating licenses are thirty years. If the license holder requests an extension at the end of the license term, the duration shall be extended in ten year interval periods. Administration shall be notified of the time extensions.

2.3 Tax Exemptions and Other Supportive Mechanisms

The government also supports the private sector to invest in renewable energy sources by providing them, in addition to the abovementioned incentives, exemption of Value Added Tax (VAT) for most of the imported and locally supplied balance of plant materials. The Energy Market Regulatory Authority (EMRA) helps investors to develop fields faster by taking Prompt Expropriation Decision for the required land when necessary (Halaçoğlu et al 2017).

Customs duty exemption is also applicable for power plants utilizing renewable energy sources. This is also one of the most prominent incentives that attracts most of the investors to decrease initial investment costs.

2.4 Project de-resking by Government

The efforts of the government through the General Directorate of Mineral Research and Exploration (MTA) have helped to de-risk the early stage exploration phase of project development. Geological and geophysical surveys of domestic geothermal resources by the MTA have allowed smaller developers to become engaged without needing to expend significant early stage capital. This was the method applied in the very early stages of geothermal development in Turkey. This method started to turn into a self-exploration with the participation of private sector in this business.

2.5 Harmonizing the Experience of Veterans with the Ambition of Young Professionals

"The only source of knowledge is experience" said Albert Einstein. Experience is gained through years, good and bad memories or long-term studies and never forgotten throughout our lives. The many aspects of geothermal development rely on various specialties, spanning the subsurface and surface aspects. Over the past decades, Turkish geothermal expertise has been gradually accumulating at the government, academic and industrial sectors to support the country's accelerating development.

2.5.1 Drilling Veterans

Geothermal exploration in Turkey started in the early 1960s. The first use of geothermal resources dates back to the central heating system of the Gönen Park Hotel in 1964. The first geothermal well in a high enthalpy field for potential power production was drilled in 1968; it had a depth of 540 m and a temperature of 198 °C (Kaya 2012). Turkish drilling capabilities have steadily grown over the past decades, with many plant operators now owning/operating their own rigs.

2.5.2 Engineering Veterans

In contrast to many countries whose projects rely on Engineer-Procure-Construct (EPC) project delivery methods, many Turkish geothermal projects use a Design-Bid-Build approach. The owner may partner with international experts and work together through conceptual and detailed design to procure equipment and materials and develop construction packages for bid. This greater level of detail that is performed directly under the supervision of the owner can allow for swifter project completion, greater control of the quality of the works by the owner, and builds a higher degree of engineering knowledge within the owner's organization. As a result, many owners can proceed from one project phase to the next expansion with less burdensome specification/bidding intervals that might be encountered if EPC was the only option.

2.5.3 Construction Veterans

While in many cases equipment may be provided by package suppliers (e.g. binary units, cooling towers etc.), local Turkish firms are usually available to perform the civil, mechanical, electrical and controls installation works. The types of equipment and materials such as switchgear, transformers, pumps and even binary turbines and generators available in the local market has increased over the past decade, due to demand and the high quality of Turkish manufacturing facilities. This growth of manufacturing and construction expertise has reduced project schedules and costs for all owners as well as contributing to the Turkish economy.

2.5.4 Integrating Experience

Many Turkish geothermal operators entered the geothermal market without significant background in geothermal specific design. The partnerships they established and experience gained through construction and operations has brought about a knowledge transfer that has allowed their own internal exploration, development and engineering teams to flourish and expand beyond their borders. Some of these now-experienced firms are taking their skills on the road and helping develop geothermal projects on the international level.

The same veteran teams have also helped increase domestic and international geothermal industry participation and establish associations where industry and academia can come together, network and collaborate on key issues, such as forming best practices, implementing new technology, and advocating for policy changes through official government channels. This process has helped propel one operator, Zorlu Energy Group, to the forefront of the Turkish geothermal industry.

Geothermal Power Plant Investors Association, Turkish named as JESDER, is the first and one of the key foundations that helps all Turkish geothermal investors share their experience and problems within one hand. This association is composed of sub-task force groups to better clarify or find a solution for the problems commonly faced by investors or government for the Turkish geothermal development.

The following section will dive deeper into Zorlu's history and the successful strategies that drove its growth.

3. Zorlu's Geothermal Portfolio and Experiences

Zorlu Energy Group was first established in 1993 to compensate the need for steam and electricity for its core textile business factories. It is a group of companies serving at a global scale in different fields of the energy sector. Zorlu Energy Group offers an integrated service in various fields of the energy sector especially through production and sales of electricity and steam carried out by Zorlu Energy (Zorlu 2018).

Zorlu first entered into the geothermal business with the privatization of Kızıldere geothermal concession area and Kızıldere-1 geothermal power plant which still holds the honor of being the oldest operating geothermal plant in Turkey since commissioning in 1984. As of March 2018, Zorlu's geothermal portfolio has surpassed 305 MW, or about one fourth of the total installed capacity of the Turkish geothermal market as shown in Figure 1.

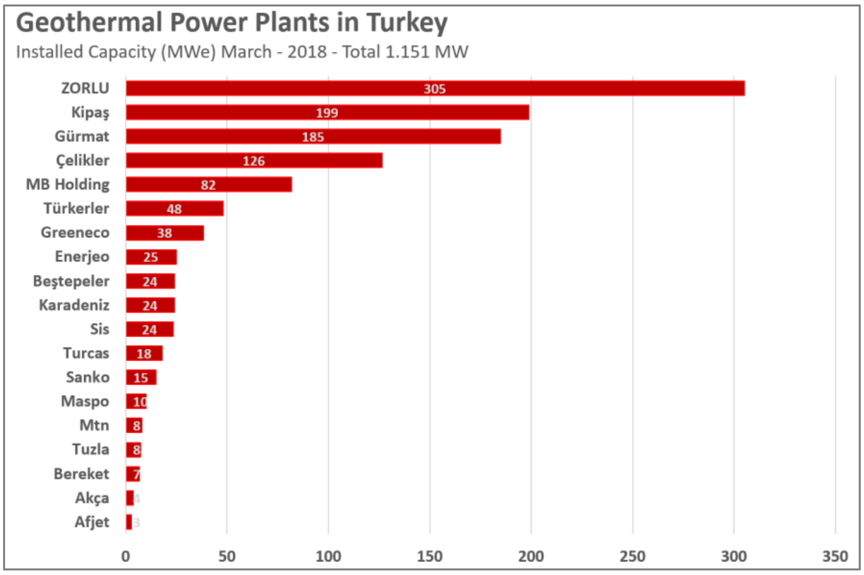

Figure 1 - Geothermal Installed Capacity by Operator

3.1 Lessons Learned With O&M Activities

3.1.1 Kızıldere Field O&M Activities

Kızıldere is the first concession area Zorlu acquired after the privatization of the field in 2008. Zorlu has reached the capacity of 260 MWe as of March 2018 with the commissioning of the 165 MWe Kızıldere-3 geothermal power plant with two units, 99,5 MWe and 65,5 MWe respectively.

Kızıldere-1 is the first geothermal power plant in Turkey and was acquired by Zorlu in 2008 with 15 MWe single flash turbine capacity. At the time of acquisition, the plant was suffering from reduced performance. Calcium carbonate scaling in the production wells had reduced capacity to just under 6 MW. To rectify the performance issues, the wells were mechanically cleaned and an intense testing program was implemented to determine the most effective method of scale mitigation. The chemical injection systems that were installed at the wellheads allowed testing and verification of many inhibitors and the successes achieved at the Kızıldere field have served as a model for similar wells throughout Turkey. (Halaçoğlu et al 2018).

After the successful rehabilitation of Kızıldere-1 and the determination that the field could support additional generation, an 80 MW water-cooled combined cycle (flash and binary units) at Kızıldere-2 was commissioned in fall 2013. The first major overhaul of the power plant was conducted in 2014 due to an unexpected minor scaling problem that has since been rectified. Figure 2 shows the Kızıldere-2 power plant, with the triple flash separation station to the left, powerhouse in the center, and cooling tower to the right.

Figure 2: Overview of Kızıldere-2 geothermal power plant

Kızıldere-3 became one of the masterpieces of Turkish geothermal power plants including two units with capacities 99,5 and 66,5 MWe respectively. Preliminary feasibility studies and environmental impact assessment (EIA) started with 100 MWe capacity. After getting first well testing results, it was clearly seen that reservoir capacity was over 100 MWe and it was decided to proceed with an additional unit totaling the capacity up to 165 MWe. Figure 3 shows the two units at Kizildere-3, with the larger Unit 1 in the foreground.

Figure 3: Overview of Kızıldere-3 geothermal power plant

3.1.2 Alaşehir Field O&M Activities

Leveraging Zorlu's experience with the combined cycle at Kızıldere-2, the first geothermal power plant for Zorlu in the Alaşehir region of Manisa city was commissioned in two stages starting from the commissioning of the flash steam turbine in September 2015 and binary turbine in January 2016. Total installed capacity of the Alaşehir-1 power plant is 45 MWe, composed of 33.73 MWe flash and 11.27 MWe binary turbines respectively. Figure 4 shows an overview of the Alaşehir-1 plant, with the double flash separation station to the left, ancillary buildings in the center, and the powerhouse behind the cooling tower to the right.

Figure 4: Overview of Alaşehir-1 geothermal power plant

3.2 R&D Studies and New Technologies

For all its developments, the Zorlu team conducts a comprehensive review of the geoscience, drilling strategies, appropriate surface facility technologies, estimated costs, anticipated financial performance and develops a comprehensive project execution plan and detailed schedule. Zorlu gathered a great deal of commercial and technical experience and knowledge in the energy sector and power project development process thanks to its 78% domestic renewable energy portfolio, staff growth and successfully commissioned projects throughout the world including Pakistan and upcoming Palestine and Jordan renewable energy projects. This in-house expertise is essential for maintaining swift project execution and high levels of quality.

It is time for Zorlu to harmonize this experience and knowledge with research and development projects with the collaboration of other partners worldwide.

3.2.1 Cycle and Technology Selection

Kızıldere-2 is one of the first triple flash combined cycle geothermal power plants generating electricity from both flash and binary cycles. Triple flash combined cycles are one of the most efficient thermodynamic cycles compared to its conventional only flash or only binary cycle plants all over the world, due to the additional degrees of freedom and capability to utilize water cooling. This cycle is also utilized in both of the units of Kızıldere-3 geothermal power plant. The 45 MWe Alaşehir-1 plant is also utilizing one of the other most efficient double flash combined cycle geothermal power plant technology.

Detailed studies were conducted for the selection of the appropriate power cycle. POWER Engineers were the main engineering company for the feasibility studies and cycle evaluations of the abovementioned projects. These feasibility studies considered the well productivity and characteristics of the geofluid, such as solids and non-condensible gas (NCG) concentrations. Zorlu and POWER conferred at the outset of the project to define the desired design criteria, including environmental data, performance targets and desired plant features (incorporating feedback from O&M staff). The studies for each subsequent plant built upon the experience of the previous projects, and historical construction and operating data allowed greater and greater confidence in the technical and commercial projections. Strong partnerships with experienced major equipment suppliers have helped the Zorlu team achieve their objectives and carry projects swiftly from the study to the execution phase. The benefit of experienced project teams is highly noticeable from the acceleration of project delivery, as shown in the project completion timelines in Figure 5.

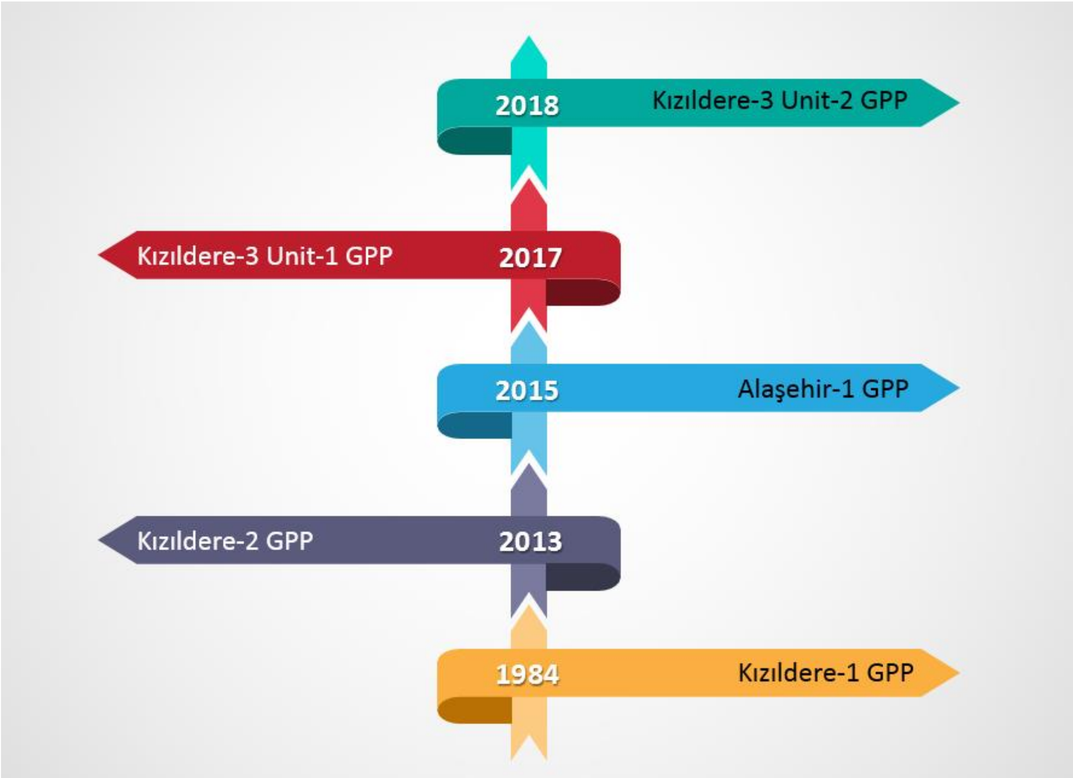

Figure 5 – Zorlu Project Completion Timeline

3.2.2 Research and Development Studies

Kızıldere is one of the oldest and most commonly known geothermal fields of Turkey. This helped Zorlu to harvest a variety of information, paper and academic studies about the field. All those academic studies naturally lead the way to a close and good collaboration with most of the universities and institutions in Turkey.

A great majority of reservoir assessment reports and reservoir related studies are prepared and consulted by Turkish universities and academicians. It is always believed that Kızıldere is an open laboratory in Turkey for the people who would like to utilize and create new ideas or concerns. This open laboratory first was constructed by government then privatized and taken to a different level by Zorlu Energy Group in 2008. The field has now stepped up the capacity from 15 MWe to 260 MWe and hosts many studies and activities.

One of the studies that is planned to be conducted in the Kızıldere field is called GECO (Geothermal Gas Emission Control). The GECO project will be funded by the European Commission (EC) and is one of the highest priority programs within its Horizon2020 program. It has recently been announced by EC and preparations for grant agreement is still in progress and planned to be signed in fall 2018 to make a fresh start for related activities.

The goal of this GECO project is to advance the consortium's ability to provide cleaner and cost-effective non-carbon emitting geothermal energy across Europe and the World. The core of this project is the application of an innovative technology, recently developed and proved successful at the pilot plant scale in Iceland that can limit the production of emissions from geothermal plants by condensing and re-injecting gases or turning the emissions into commercial products. To both increase public acceptance and to generalize this approach it will be applied by GECO in four distinct geothermal systems in four different European countries:

1) a high temperature basaltic reservoir in Iceland,

2) a high temperature gneiss reservoir in Italy,

3) a high temperature volcano-clastic reservoir in Turkey, and

4) a low temperature granitic reservoir in Germany.

The approach of the study is to capture and inject the soluble gases in the exhaust stream as a dissolved aqueous phase. The low pH resulting from dissolving gases in the geothermal liquid to be injected to the reservoir promotes the dissolution of subsurface rocks, both increasing reservoir permeability and the fixation of the dissolved gases as stable mineral phases. Not only does this approach lead to the long-term environmentally friendly storage of effluent gases, an economic analysis shows that it lowers considerably the cost of cleaning geothermal gas compared to standard industry solutions. A detailed and consistent monitoring program, geochemical analysis, and comprehensive modelling will allow the consortium to characterize the reactivity and consequences of fluid flow in our geologically diverse field sites letting them create new and more accurate modelling tools to predict the reactions that occur in the subsurface in response to induced fluid flow. This tool should prove invaluable to identify and develop enhanced geothermal systems in any number of rock formations, fluid compositions and temperature conditions (GECO Proposal 2018).

4. Conclusions

Turkey's geothermal development continues at a strong pace thanks to its applicable supportive mechanisms. Regulation number 6094 states that these supportive mechanisms will be applicable for power plants commissioned before 31 December 2020. This is the most critical and crucial date for all the developers to accelerate their works to take advantage of these supportive mechanisms. The future of feed-in tariff mechanism is still not clear as of July 2018. Investors and associations have presented some feasibility studies to show the necessity of supportive mechanisms to continue the development of Turkish renewable energy market, and it is hoped the government will be responsive to these facts in order to continue to support this indigenous industry.

Zorlu has already started to look for possible future collaborations not only in Turkey but also in some other countries like Kenya, Ethiopia, Djibouti, Greece, Philippines, Malaysia, Indonesia etc. It is a group priority to form productive collaborations between its experienced staff and partners in other countries to help accelerate geothermal development worldwide.

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