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Sustainability Analysis of Turkey's Leading Geothermal Energy Company Based on Responsible Research and Innovation Theory

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Section 8

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1. Introduction

Zorlu Energy is the leading company in the energy sector in Turkey and provides numerous globally integrated energy services. The company invests heavily in renewable energy by having 87% of its energy production depending on renewable energy alternatives. In the term project, our goal is to focus on the sustainability of geothermal energy since Zorlu Energy highly focuses on this type of renewable energy by producing 25% of Turkey's geothermal energy production, they have the highest market share in this area of competency. Moreover, they have multiple ongoing projects and initiatives to increase the number of their facilities and productions. Geothermal resources are much less familiar to the general public than other renewable technologies. Although the biological and physical effects of geothermal siting are well established, the social impact has not been sufficiently explored. Thus, with this study, we aimed to examine these effects of geothermal energy in a detailed manner. We investigated the sustainability of geothermal energy and analyzed the response and perception of the local communities. Effects of the geothermal energy with the fluids and CO_2 emissions on the environment and the alternative applications to decrease the adverse effects, while contributing to the sustainability of the systems is investigated. How the local communities respond to these activities and how the Zorlu Energy reacts to the society by taking initiatives in different manners become one of the main focuses of the project [1], [2].

From the background research, there are many articles on the environmental, social, and ethical effects of geothermal energy from different countries. For instance; from an environmental perspective, it was observed that geothermal fluids which may leak during field operations, can lead to severe dangers for the living creatures in the area. These environmental impacts that are caused by geothermal power plants provoke society to have a negative perception towards the acknowledgment of this energy source. As mentioned above, one of the most controversial topics regarding the social acceptance of geothermal energy is it's potential to cause social resistance, although renewable energies are generally associated with sustainability and friendliness. In times in which sustainability is on the international agenda of the energy sector, this project could be fruitful in terms of raising the public awareness of renewable energy users in Turkey with the help of resources we find on these topics from other populated countries. Even though Zorlu Energy's policy is characterized by a strong focus on sustainability, the company suffers from an underdeveloped communication culture with stakeholders, hence, in the light of responsible research and innovation theory,

they should take the opportunities to engage in communication to strengthen stakeholder engagement.

2. Theory

While investigating the innovation practices, we observe that the process of developing a technology is a result of the interaction of multidisciplinary groups that come from different backgrounds, have different expertise and experiences. Therefore, responsible innovation is chosen to be the theory that is used in the examination of the focus area of our project.

Responsible innovation is a process that includes transparency and interaction of both innovators and societal actors such as local people and company executives. They are jointly responsive to each other related to sustainability, and social desirability of the innovation process [3]. Responsible Innovation values such as reliability, safety, and sustainability will be taken into consideration throughout the project. Six practical lessons that are useful for effectuating RRI in industry are presented as strategizing for stakeholder engagement; broadening current assessments; placing values center stage; experimenting for responsiveness; monitoring RRI progress; and aiming for shared value.

Throughout the project we focus on three of four dimensions of responsible innovation, these are reflexivity, inclusion and responsiveness. Reflexivity means that one is being aware of its own activities, commitments and expectations. In reflexivity, the agents in the institution such as scientists should make the line between their responsibilities in the company and moral responsibilities more transparent. For the inclusion dimension, the organization makes its assumptions or plans by including other parties in their processes themselves. The responsiveness dimension, that we focused immensely on, is the ability of the organization to shape or direct themselves in response to the stakeholders, public, or the changing status of the technology. All of these dimensions cannot be separated and therefore, integrated into the project as a whole by mutually supporting each other.

Finally, as an important aspect of social science and technology, we included democratic rationality in our project to emphasize whether geothermal energy technology develops in accordance within the community’s view or it only develops as an instrumental technology. Connecting these six lessons with the three different targeted RRI process dimensions is believed to assist better analyze the geothermal energy practices within the

“Zorlu Energy” and how the Zorlu Energy implements their responsible innovation practices [4].

3. Background Research

3.1 Industrialization of Geothermal Energy

Throughout technological developments, geothermal energy has been utilized for power generation and other purposes related to industrial production [5]. The changes initiated during the Industrial Revolution throughout the 19th century opened up new directions for the utilization of geothermal energy for industrial purposes and power generation. A significant milestone is the use of thermal springs for the boron industry in the Italian region of Tuscany in the first half of the 19th century. This application initiated further developments, and in the aftermath geothermal energy was used both for production processes and to generate electrical power; another example for its systematic exploitation is the use of geothermal energy in Idaho (USA) towards the end of the 19th century, where greenhouses were heated with geothermal energy. A specific case in using geothermal energy for heating purposes as well as power generation is Iceland, whose geographical peculiarities with a rich occurrence of geysers favours the use of geothermal energy [6]. While these examples show that geothermal energy can be harnessed principally worldwide, sufficient heat to run electric generation stations is only found in relatively few places [7].

Attempts to benefit from geothermal energy when the access to thermal energy is constrained due to geological conditions are the innovations subsumed under the term enhanced geothermal systems. These are applications through which otherwise inaccessible heat flow is induced through hydraulic, thermal, or chemical stimulation [8]. While enhanced geothermal systems are rather recent innovations (introduced at the beginning of the 21st century), advances in several other areas have also contributed to an improved exploitation of geothermal energy: Due to developments in drilling techniques, design of pumps, industrial production and methods in generating electric energy over the last 150 years, geothermal energy is used in our days directly for space heating and cooling, in agriculture for greenhouse, soil and pond heating, for bathing and swimming, for snow melting as well as for other purposes. Indirect geothermal energy utilization aims at electricity production. The generation of electricity has led to the development of different power plants: Power can be produced in flash steam power plants, dry steam power plants, binary cycles power plants and

hybrid power plants [9]. Along with an increase in capacity, it is expectable that the importance of geothermal energy will rise [10].

3.2 Technical Aspects of Geothermal Technology

Geothermal energy is the process of extracting hot water from underground which lies at a distance of 3-4 km depth from the drilled wells. When the water reaches the surface, the steam caused from it is utilized to generate energy [3]. Even though geothermal energy is a renewable and sustainable energy source, there are potential impacts of geothermal power plants on the immediate environment. Those impacts are due to the coexistence of hot underground water and occurrence of seismographic activity. For that reason, experts are confronted with the problem that suitable locations for power plants are often areas with high seismicity, and power plants can affect the seismicity of the area where they are built [1].

Disposal of the extracted hot water is another problem of geothermal energy technology. To use this water considering the sustainability and safety values in a cost-efficient manner, the method of reinjection through wells has been developed. The extracted water can include many distinct toxic chemicals such as arsenic, mercury, lead, and the amount of these pollutants is higher in vapour-dominated reservoirs than water-dominated and hot water reservoirs. Since electricity is generated by steam that is separated from the water on the surface, the disposal of the water is realized by reinjection of the water into the source again.

3.3 Risks in Geothermal Energy

Geothermal energy is considered to be a feasible alternative to fossil fuels. In spite of these prospects, geothermal power plants may have negative environmental drawbacks. Among these, air pollution, water contamination, and potential seismic changes leading to changes in the terrain, landslides, or even earthquakes have been reported as severe effects of geothermal power plants on the environment [11]. The environmental risks of geothermal energy generated in power plants are considered to be the most controversial feature: As explained above, plants have the possibility to increase the seismic activity on the geography they have been built. It is, however, rarely reported that an increase of seismic activity is caused by geothermal energy [1].

A further risk reported is the probability that geothermal energy plants can threaten the depletion of the clean surface waters. A news article issued in *The Guardian*, reports on

an incident in which, due to a leakage of a well, the clean water in some parts of New Mexico is under risk of contamination caused by toxic materials in the hot water [12]. Generally, water contamination due to geothermal energy production is considered to be of highest concern in the public. For this reason, prudent policy in introducing geothermal energy is critical, and there are technical procedures at hand to avoid freshwater contamination [1]. Air pollution is another environmental risk, but plants usually comply with the standards established by organizations such as the World Health Organization (WHO); therefore, even if there is a minimum amount of air pollution risk, it can be regulated by local organizations [1].

Another aspect that can be considered are the social risks of geothermal energy. These differ as geothermal energy can affect the lives of those people who have the land rights where a plant is going to be built, or there may be a general lack of social acceptance for a project foreseeing to establish a plant. Refusal of social acceptance appears to be the greatest risk to the development of geothermal energy. The response of local people and authorities is important for a project's success; therefore, the risk of the public being misinformed by the media should be prevented [13]. According to survey research in Turkey, people care more about affordability, in which the third most important issue is clean and environmentally-friendly energy. Taking this into consideration, there is a risk that people refuse the establishment of a power plant if they feel the apprehension that geothermal energies cause higher consumer expenses for energy [13].

3.4 Stakeholders in the Industry & Public Perspective

The introduction and utilization of any form of energy production is challenged by divergent interests of community members who, for example, seek to benefit by running energy production and, thus aim at profit, who promote a form of energy production for environmental or other reasons, and who are affected because production sites are built in their immediate environment or new forms of energy require the loss of routines when, for example, devices are no longer available. The latter interest, leading to protests and potentially jeopardizing the introduction of sustainable forms of energy in the form of concrete projects, is known as the 'not in my backyard (NIMBY) mechanism [14]. In spite of objectively existing advantages, individually perceived disadvantages lead to resistance against technological innovations. On the other hand, groups in society can function as catalysts by initiating technological developments, by promoting the implementation of

technological innovation or by setting directions in transition processes [15]. Concerning transition processes to introduce or implement technological advances of geothermal energy, a growing body of case studies reports on local reactions and pathways undergone to implement innovation practices [16]. Depending on governmental systems, members of the public, citizens individually or organized in non-governmental groups are likely to have a word in transition processes, and legal frameworks are further factors that may have an impact on processes; in democratically organized societies, legal regulations and expectable political debates encourage policymakers, investors and developers to include the public in decision-making processes, especially when the novelty of a technological innovation creates uncertainties or is not well understood by the public, as it is the case in the implementation of geothermal energy [17].

Moreover, the perceived usefulness and potential of geothermal energy and the identified challenges in exploiting geothermal energy require technological progress that needs to be guided in communication between stakeholders. An example of an attempt to establish communication between stakeholders in the European Technology & Innovation Platform on Deep Geothermal (ETIP-DG) whose mission is "to foster overall cost reduction, including social, environmental, and technological costs" [18]. Bringing together members of the industry, research, and business, and acknowledged by the European Commission, the platform seeks to provide a geothermal innovation policy by offering research contributing to the development of deep geothermal technology in order to compensate for the abolition of CO2-based energy forms**.**

The information delivered by the management of geothermal power plants plays an important role because inaccurate or missing information may threaten the likelihood that geothermal energy is accepted in the public [1]. In various contexts (Turkey, Italy, Australia, Korea), it has been shown that insufficient know-how about geothermal energy and lack of awareness of the potential benefits of geothermal energy affect social acceptance negatively [1], [3], [19]. In particular, as Allansdottir and her colleagues point out, public engagement, as evidenced in specific initiatives and actions, differs based on a variety of factors [20]. This is shown in a study examining public engagement in a decision-making process concerning the implementation of geothermal energy in Switzerland. In this context, the organization of the state in subordinated cantons and municipalities with different legal regulations and cultural peculiarities favors public engagement at the local level; this circumstance allows a rather direct influence of the public. In the concrete case, the public negotiation between the

stakeholders resulted in a change away from planning to use geothermal energy to produce electricity (as favoured by the federal government) towards the use for heat; this example shows that the federal structure within which the public engagement occurred opened up an instance of an "administration (…) learning from what is done in the cantons and the cities" resulting in increased acceptance of geothermal energy [17]. However, in another aspect, it is also noted that the public should receive the necessary knowledge regarding energy issues by a third party rather than the energy company itself. This was confirmed in the VIGOR project that examined the perception of the public in a case located in South Italy [21].

Abundance of local people that do not know the advantages and disadvantages of geothermal energy to their residential area causes many social impacts. According to Melikoğlu (2017), geothermal energy plants in Turkey are not adequate yet for nationwide energy supply but it can bring welfare to the local areas it is planted [22]. For example, farmers in the local areas are able to produce tomatoes in greenhouses heated by the hot water of a geothermal energy plant, supporting the farmers in exporting their harvest and benefitting more during the recent circumstances of the pandemic and economy [23].

3.5 Sustainability

Geothermal energy is needed to be produced and used in a sustainable way which means that utilization of the resources should be compatible with the well-being of future generations and the environment. To produce this energy in a sustainable manner, there are various suggested methodologies, applications and innovations around the world [24].

3.5.1 Best Practices for Sustainability of Geothermal Energy

The need for innovation in geothermal energy has been highlighted against the backdrop of global climate change and the obligation to decarbonize energy and industrial production [17]. The exploitation of geothermal energy is considered to be presenting great potentials as it can be and geothermal energy, so far, has been used in a variety of industrial, agricultural and service sectors, provides energy to use for heating and cooling purposes, and generates electricity or fuels [9]. Innovative developments are nurtured by enhanced (or engineered) geothermal systems that employ thermal, hydraulic or chemical stimulations to access geothermal reservoirs in areas irrespective of the extent to which they are conducive to geothermal energy production [8].

Current innovations aim at increasing reliability, cost-effectiveness, environmental safety, sustainability along with an increase in capacities. In 2020, 130 geothermal power stations were operated in Europe, meaning a 5% increase compared to 2019 [25]. Initiatives encompass seismic and magnetotelluric methods to select geologically safe areas for geothermal investments, the development of drilling and material technologies as well as advances in fluid chemistry or attempts to minimize land occupation and CO2 emission and to supply logistics that avoid long distances to transport steam and water [26], [27], [28]. Showing evidence from the Chinese context, Liu et al. point to the need to establish more efficient monitoring networks, to provide a workforce and equipment that is sufficient to meet the complex challenges of geothermal energy production [29]. Identified problems are in particular due to a lack of well-developed governmental policies and uncertainties concerning administrative responsibilities that appear to be a hindrance to a sustainable exploitation of geothermal energy [30]. These issues demonstrated that there is no global standard in how to manage a geothermal resource in a sustainable way. It is safe to state that the most recent current practice is the Geothermal Sustainability Assessment Protocol (GSAP); still being developed, the protocol allows the evaluation of geothermal power plants based on sustainability criteria (Richter, 2018). In addition, there is a further need to develop legal frameworks for geothermal energy, which are not well-established, even in countries that display an active geothermal industry.[11] Despite these administrative and policy setbacks, there are considerable technical practices around the world to address the sustainability issues in geothermal energy, and they can be listed as engineering and forestry applications.

3.5.1.1. Engineering Applications

Reinjection refers to pumping back parts or the whole amount of the geothermal fluids that were brought up from the geothermal reservoir during energy production.[11] Reinjection is acknowledged as greatly contributing to geothermal development in terms of sustainability and environmental friendliness: Indeed, reinjection is considered to be a key factor in the accomplishments associated with sustainable energy production [31]. Reinjection aims at returning waste thermal water after direct applications in a way that is considered environmentally safe. This procedure avoids or minimizes thermal and chemical pollution of surface waters, and compensates reservoir pressure which is realized because of the mass extraction of the water. Therefore, it additionally contributes to the prolongation of the lifetime of a project. Moreover, geothermal energy projects potentially affect energy use

patterns because of their design and as a consequence of how end consumers use the energy. It can be safely claimed that the efficiency of geothermal plants can be enhanced when waste heat is managed appropriately; furthermore, the resource's resilience against depletion can be enhanced when spent fluids are reinjected, and contamination of waterways with toxic chemicals or heat is prevented [24].

There is general agreement among scientists and operators that reinjection is the optimal method to protect resources and to leave the smallest possible environmental footprint. In other words, reinjection serves a management perspective that is directed to sustainability in the most appropriate way. Against these benefits, one has to keep in mind that reinjection is constrained by several problems and complicating issues surrounding this technology. There is a wealth of reports on reinjection leading to complications related to scaling, induced seismicity and cooling of the reservoir. From an environmental perspective, it would be the most preferable option if all fluids remaining at the end of the production process and their non condensable gases (NCG) would be reinfected by the companies that operate geothermal power plants. The application of an optimized rejection method or a more efficient use of NCGs instead of emitting them into the atmosphere, which would be possible even with the current state of the technological development, would contribute to a decrease of emissions. Even though geothermal power plants (including dry steam and power plants) are not emission-free, they are by far more environmentally friendly than convenient fossil fuel-based power plants [11].

3.5.1.2. Forestry Applications

The utilization of geothermal energy has to be in line with standards set to protect forests as a critical component in the struggle to stop climate change. The World Bank, for instance, recommends a form of development of energy production that does neither cause significant conversion or degradation of natural habitats that are of critical importance. Development in the area of energy production causing adverse effects on non-critical natural habitats should only be continued when feasible alternatives are not at hand and suitable measures serving for conservation or mitigation can be put into practice so that ecological functions of natural habitats such as forests are protected.

There are cases in which geothermal projects explicitly support strategies to protect the environment. Geothermal projects in the Philippines are examples for such kinds of strategies because the integration of the community along with proactive forest protection were

addressed. The Philippine National Oil Company – Energy Development Corporation (PNOC-EDC), a state company, has established frameworks that employed the integrated social forestry (ISF) approach embedded in a set of operations caring for optimized processes and sustainability [24]. Geothermal energy projects that are explicitly linked with projects to protect forests aim at enhancing groundwater recharge—which contributes to the sustainability of the geothermal system, and help provide ground and surface water that can be used by local communities; further contributions of geothermal energy encompass the creation of carbon sinks, the reduction of soil erosion and water sedimentation. [24].

3.5.2. International Policy for Sustainability of Geothermal Energy

The sustainability of geothermal energy can additionally be examined from the perspective of international organizations or government agencies. The World Health Organization, for example, applies standards to energy production processes in order to reduce adverse effects on human health. As a consequence, the energy production of geothermal plants complies with the standards established by WHO [1]. Moreover, the United Nations (UN) generated a framework of classifications for resources (UNCF) that was established due to the lack of globally agreed geothermal standards, guidelines or codes prior to the development of the UNCF [32]. It is believed that the inclusion of geothermal energy within UNFC will facilitate the improvement of global communication in the geothermal sector as part of the larger energy sector. Also, the European Union (EU) has different applications to initiate discoveries, creative ideas, and inventions for a more sustainable world, such as the Horizon 2020 innovation framework program [33]. Similarly, GECO is an innovative EU funded research project which aims to provide a clean, safe, and cost-efficient non-carbon and sulphur-emitting geothermal energy across Europe and the world [34]. Because geothermal energy is considered to be an answer to the challenges posed by climate change, the establishment of an international policy for its sustainability is required [35].

4. Method

When we initially started our term project, we searched for a technology that sought our interest as a group and had a big impact on today's world. Additionally, we were going to select a sector that displayed a variety of innovative practices. Considering this, we started to search on different topics and eventually decided that the energy sector was interesting for us to work on since, over the last century, the energy industry has been a significant engine of

industrial expansion, providing fuel for the whole economy. When our instructor explained to us the project furtherly, we started to search for large companies in this sector in Turkey. One of our group members had a personal connection to an executive in Zorlu Energy which provided us the opportunity to conduct our term project together with managers working for this company.

After we had reached an agreement with the company, we worked on our background research and outlined the project to draw a guideline on how to proceed. After that, we started our preparations to conduct interviews with high level executives at Zorlu Energy to collect data. For that reason, we generated interview questions that would help us to gain the necessary information and perspectives we needed for our project. We conducted interviews with three executives: the Smart Systems Group Manager, the General Manager of Trade and Retail and Smart Systems and, Deputy General Manager of Sales. After completing our interviews, we transcribed them collaboratively and identified themes in the interview data. Based on the identified themes, we conducted a follow-up research by analyzing different sources and interpreting the interviews and company reports which we evaluated as data against the backdrop of Responsible Innovation. We reviewed the course materials during this process and combined our sectoral knowledge with the theories we learned throughout the semester.

5. Findings

5.1. Technology

From the interviews and the background research, geothermal energy has its own important technical characteristics that can be very fruitful for countries' energy production. Parallel to the sustainable future energy policies with the expanding need to decrease the use of fossil fuels in these countries, renewable energy and especially geothermal energy has become a critical renewable energy source. Zorlu Energy focuses hardly on the renewable energy sector and focuses highly on it. Zorlu executives have general know-how on geothermal energy, how the technology is used and why the company chooses to increase their established geothermal energy power plants in Turkey.

Table 1. Finding on Technology from the Interviews

Geothermal	“There is a fluid in geothermal energy, you basically extract this fluid from underground, you pass through the turbines, you give

Energy (Present and Past)	the energy obtained from the fluid passing through the turbines to the system, then you send this fluid back under the ground (reinjection procedure). … Of course, in old technologies, there were issues such as not being buried underground, but they were resolved. Most of the power plants of Zorlu now return this fluidity back to the system." [36]
Geothermal Energy Technology in Turkey	"I am of the opinion that a greater majority of Turkey's potential is not used. It will become much more widespread in Turkey, because there is too much volcanic activity on the land and, fortunately, it is not concentrated at a certain point in the country, but in the east, west, etc. available in different locations." [36] "In addition to Kızıldere 1 Geothermal Power Plant, Turkey's first geothermal power plant, the second unit of Kızıldere 2 Geothermal Power Plant and Kızıldere 3 project, which was put into practice in 2013, was opened in March 2018. Kızıldere 3 geothermal power plant has become the largest geothermal power plant in Turkey and one of the few geothermal power plants in the world. Zorlu Energy, which uses domestically produced ejectors in geothermal power plants, is the first company to receive a domestic production incentive in geothermal energy." [37]

5.2 Zorlu Energy and the Geothermal Energy

Zorlu Energy invests remarkably in renewable energy sources, and its focus is primarily split into solar and geothermal energy plants. In Turkey, most of the demanded power is generated by the Hydro-Electric Power Plants, primarily located in the eastern part of the country. Therefore, as an alternative renewable energy source, geothermal energy plants are eminently chosen to be built in the western part of Turkey as the high seismicity in the western regions gives rise to distinct hot-water resources. Due to the closeness of the immensely populated areas, the costs of transmission of the energy also decrease in geothermal energy plants. Zorlu Energy has the highest electricity production from the geothermal energy plants in Turkey, which stands for 87% of the total production by geothermal energy.

The organization wants to expand its workload in sustainable energy and direct its funds into the companies by investigating their Environment, Social and Governance ratings. Hence, the adaptation process of the company to sustainable systems accelerates. Moreover, Zorlu Energy has a field of business under Zorlu Energy Solutions, which concentrates on establishing charging stations for electric vehicles. This kind of

organizational partner that supports the decrease of greenhouse gas emissions derives the utilization of the more renewable energy sources to be meaningful.

Table 2. Findings on Organizational Aspects

Geothermal Energy Investments of Zorlu Energy in Turkey	"You may know that Turkey's potential in geothermal is one of the three largest countries in Europe, both in terms of potential and installed power. I don't know exactly but I think we may have passed Iceland in this, as installed power. Geothermal capacity is substantial in Turkey. Of course, among other renewables, namely renewable energies, we do not have as much installed power as the installed power of the wind and sun." [36] "About 20% or 25% of the installed power in Turkey appears to be only in Zorlu Energy. Zorlu Energy is one of the companies that offers the leading renewable energy source in Turkey and the largest geothermal energy source in Europe." [36]
Organizational Benefits from the Geothermal Energy	"But considering Turkey, our main electricity source/power plants are HEPPs (Hydroelectric Power Plant). These are on the east side of the country, but consumption is on the west side. There are huge losses in terms of transmission here. Whether it is the dams on the Euphrates River or other dams, it always has to be transferred from the other power plants on the east side to the places where the consumption is high. It also causes unnecessary loads in terms of load. Since geothermal power plants are always on the West side, they are a little more optimal in terms of transportation. A type of power plant in a more central location, but much closer to big metropolises than to the east, and therefore more meaningful in terms of utilization, due to its geographical structure." [37]
Organizational Focuses of the Company	"One of the fields of business of Zorlu Energy is ZES, under the brand name of Zorlu Energy Solutions, and we have started to establish a charging station network, which we have just started in Turkey and in Europe. We have now passed 1100 stations in Turkey. Regarding this, actually we are not an automobile company, we are an energy company. We thought that there are certain actions that energy companies should take regarding both the environment and the efficient use and sustainability of resources." [38] "This was the trend in the world in general, but now we have our own grading in fund flows, especially on the ESG ratings of companies, which Zorlu Energy constantly monitors, on whether to invest in companies based on these grades, and whether to provide fund flow. At the point where you connect the business to

	this point, the people who manage that business have to take this into account, whether they adopt it or not" [36]

5.3 Risks on Geothermal Energy

There are a few types of risks that the interviewees generally point out. One of them is the environmental risks of the geothermal energy plants investigated highly in this project's scope. Geothermal energy plants can cause air and water pollution and may increase the seismic activities in the region where it has been built, according to the background research. In the findings, some of the interviewees touched on water pollution and the risk of seismic activity, however, not on the air pollution.

According to the findings, preventing the water pollution of the underground and surface waters is one of the interests of Zorlu Energy. The company uses a reinjection technique that flows the processed water where it comes.

The second of the risks are social risks. The interviews and the articles clearly indicated a misguidance of geothermal energy in the media to the public. The interviewees also stated this situation as people are not informed well enough about both the renewable energy sector and the geothermal energy plants. Media may affect society without considering too much about the pros of the technology rather than the cons. The lack of awareness and know-how of the public in geothermal energy also affects the social acceptance of the society for geothermal energy.

Moreover, there exist financial risks of geothermal energy. This risk exists due to the other risks. Environmental risks, such as seismic activity, may affect the establishment of the power plant since there are no more hot underground water presence. Another risk that causes financial risk is social. The local people, local governments, or the national governments may interrupt the establishment.

Table 3. Findings on Risk of Geothermal Energy

Environmental Risks	"When I visited there, the most important issue was the return of the hot water drawn from the source to the source. It was explained that most companies do not do this because reinjection is a more difficult and expensive process" [38] "… since the areas that power plants are built on have high

	seismicity, I heard that they may increase seismic activity in the area but this happens very rarely.” [38] “In the past, in old technologies, discharging this fluid directly into the stream bed or transferring it to other channels, sending it from the surface reveals the main problems. The fluid is rich in many minerals, and these minerals can damage the soil, especially on the surface.” [36]
Financial Risk	“you are in an unknown area due to its subject, you seem to be over a fluid underground, although you try to describe the underground source with geophysical measurements, the variable is not stable here either. There are the main factors under the earth's crust and there is memory planning here, there is the Ripple effect, so you do not do business in an isolated geography by yourself, but an activity or activity underground at 50 km 60 km can affect your basic business.” [36] “These are commercial risks, so first, will there be enough energy? The commercial operation… will the income I get when the latter sells this energy outweigh my investment or the cost of capital in my head/shareholder's head?” [36]
Social Risks	“It is extremely significant that the power plants are set up and operated very carefully. There is always the risk that staff members who lack the necessary expertise to apply techniques appropriately cause negative headlines in the media and harm the company's reputation.” [37] “Another issue is social risks. In other words, the possible risks that this power plant may pose to its surroundings in case of any malfunction etc. are valid for all businesses on this geothermal plant, as well as for the factory.” [36]

5.4 Stakeholders in the Industry and Public Perspective

In the Geothermal Energy industry, there exist many stakeholders such as local people, workers, executives, governments, international organizations, etc., as mentioned in the background research. However, for the findings part, there is a lack of data in terms of stakeholders of the technology. Therefore, as an additional company-based source, the sustainability report of Zorlu Energy is used. Nevertheless, local people and investors are mentioned in the findings as to the industry's key stakeholders.

According to the report, the company organizes public visits and meetings with the local communities before beginning the projects. In this context, Zorlu Energy organizes

Stakeholder Engagement meetings to brief its stakeholders about the Alaşehir 2 GPP and Kızıldere 3 GPP projects. Also, a company's investment and operating plans are shaped by receiving feedback from its stakeholders [41]. They develop other projects that support open innovation processes focusing on smart solutions and creative industries to engage external stakeholders in the problem-solving process. They consult their stakeholders to determine the material issues they will focus on, and they regularly conduct stakeholder analyses that enable them to identify the stakeholders' expectations and see how they evaluate their Environmental, Social, and Governance (ESG) Criteria performance. They identified their material issues based on the most recent stakeholder analysis they conducted in accordance with the AA1000 Stakeholder Engagement Standard in 2019 [42].

Table 4. Findings on Stakeholders and Public

Stakeholders and the Public	"it is with a local people at first, this is normally one of the most basic points of the procedures, one of the cornerstones when we make an investment decision, one of the cornerstones is to share this investment decision with the relevant local people, to reveal the positive and negative effects of what they call impact analysis, it is transparent what it will add or take to the region. It has to be shared somehow. Local people are the first stakeholders, the people who feel the impact of the power plant first hand." [36] "You have customers that you share, other stakeholders, customers that supply electricity. The suppliers you cooperate with while building this power plant, the people or institutions you receive products or services from, these are the ones you share. Your employees who built this plant, or also the place you use as service units, these are your stakeholders." [36] "It is important for some investors, especially on the financing side, to show the banks how bankable and feasible this business is … and the relevant financiers can be this bank or your shareholder, that is, your boss as an investor." [36] In 2019, the Environmental Impact Assessment (EIA) meeting organized by the Ministry of Environment and Urbanization and company officials regarding the Tekkehamam GPP-II project planned to be carried out by Zorlu Energy in the Sarayköy district of Denizli was cancelled as a result of the protest of the villagers [39]

5.5 Geothermal Energy and Sustainability

Zorlu Energy values sustainability a lot from many perspectives. The interviewees have shown a deep knowledge of the sustainable view of the company and the sustainable practices that Zorlu Energy implements. The company acknowledges the international policies and events on where geothermal energy is discussed to achieve more sustainable geothermal energy plants. They follow the sustainability goals of the United Nations and follow the recent activities such as Green Deal and COP26. Since 2016, Zorlu Energy has followed the ISO 14046 Water Footprint standard to measure and account for their water usage. Moreover, they regularly report to the CDP Water Security Program and share their water management practices following their transparency policy [40]. Under these policies, the company tries to raise employees' awareness of sustainability.

Table 5. Findings on Policies

International Policies and Company Policy	"When we consider energy production with sustainability, it actually brings about a serious transformation in energy. As Zorlu Energy, our motto is to be the energy of the future, that is, to be the energy company of the future. This is actually a transition from the old energy company concept to the new one. It also brings sustainability to the center during this transition. Using sustainable energy sources more, that 87% of our energy production in Turkey is carried out from renewable sources and in a sustainable way." [37] "We try to act in line with the general approaches within the company and the sustainability goals of the United Nations, taking this into account within the entire holding. Activities are organized to raise awareness of all employees on this issue. For example, in the entrepreneurial ecosystem, we put your impact and sustainability at the forefront and try to give more support to initiatives interested in this field. In brief, we are a company that tries to address sustainability from as many different angles as possible." [37] "There is Green Deal right now, you know, there will be other things like COP26. Among these, there are certain carbon commitments, and Turkey has recently signed the Paris Agreement on the prevention of carbon emissions. When we look at it from that point of view, the renewable side is getting more and more important."[36]

They combine their practices in other areas with renewable energy, such as charging stations supplied by the electricity generated by a geothermal energy plant. As a technical

solution to the disposal of the waters, they use a reinjection system which is more expensive to build in the power plant but more sustainable. Considering that, 83% of the fluid extracted can be re-injected, and the company can utilize the remaining water in heating or cooling systems. Moreover, even if there exists some CO2 emission due to the steam of the water, they direct it to be utilized in the beverage industry. Another technical solution to the utilization of hot water is using it in agricultural facilities such as greenhouses. In the Sarayköy, Denizli, geothermal power plant also benefits in heating the greenhouses. Therefore, the Organized Greenhouse Zones (OGZ) are established considering sustainability approaches in the local area.

Table 6. Finding on Technical Solutions

Technical Solutions	"As you know, the traces you leave in all your activities, from your carbon footprint in the energy sector, are very important. Therefore, our basic sustainability principle is to create an ecosystem for renewable resources. This is true everywhere, in geothermal as well as in charging stations." [38] "Most of the power plants now return this fluidity back to the system. This is actually important for the sustainability of that basin, on the other hand, this fluid has many uses when it comes out. As the fluid is extracted, carbon dioxide comes as an output, carbon dioxide is then used in certain ways, utilizing it in the beverage industry or the chemical industry. In fact, this is not even a by-product, it can also be seen as an unwanted product but we can still benefit from it." [36] "The heating of Sarayköy in Denizli, where we also have a power plant, is provided by our power plant. It offers a sustainable heating service in much more affordable conditions than its other counterparts. Another issue is that with the heat generated by the fluid coming out of this area, activities for greenhouses and greenhouses can increase, especially in Sarayköy, organized greenhouse zones were established, its abbreviation was OGZ, instead of Organized Industrial Zone, greenhouse activities are carried out, especially around a geothermal power plant. It has many functions such as heating for the people of the city, providing a suitable habitat for agricultural activities if the economic activities of that people are agriculture," [36]

The company also focuses on protecting the environment; they investigate, protect, and engage with academics within the area of environmental and social impact assessments because they recognize the importance of biodiversity in the regions they invest in for the

future. Zorlu Energy follows the Sustainable Development Goals of 'Affordable and Clean Energy,' 'Life on Land,' and 'Partnerships for the Goals,' as set forth by the United Nations according to their report on sustainability [40]. In Turkey, preserving natural life is one of their main concerns. They set wild-life monitoring systems to examine the living species around the power plants. In 2020, they introduced the "Biodiversity and Ecosystem Management System" to observe and provide sustainable biodiversity and ecosystem management, considering the national regulations and international protocols. They planted 1600 fig and olive trees in Aydın, where the Kızıldere 3 geothermal energy plant was established. Moreover, within the academic supervision, Zorlu Energy supported the anatomical research of the endemic species such as Yellow Heliotrope found in the location of the Kızıldere1 power plant. [40]

6. Analysis and Conclusion

Using Responsible Innovation Theory in our project, we examined the sustainability of geothermal energy and analyzed the response and perception of the local communities. As we investigated in the interviews conducted with three managers of Zorlu Energy, it is observed that there are different technologies developed around geothermal energy and the effects of the power plants are perceived differently by the local communities. In our project, we mainly examined the effects of the geothermal energy with the fluids and CO2 emissions on the environment and the alternative applications to decrease the adverse effects, while contributing to the sustainability of the systems. Also, we analyzed how the local communities respond to these activities and how Zorlu Energy reacts to the locals by taking initiatives in different manners. To conduct better analysis, RRI theory is used throughout the project by implementing its four dimensions and six lessons. Connecting these six lessons with the four different targeted RRI process dimensions is believed to assist in better analyzing the geothermal energy practices within the Zorlu Energy and how Zorlu Energy implements the responsible innovation practices [4].

As seen, innovations are required at the technological and administrative level, but a further factor in the implementation of geothermal energy production (as well as other energy resources) to generate a sustainable energy transition is social acceptance. Stakeholder engagement plays a crucial role in increasing awareness and social acceptance and therefore involves the public actively participating in decision-making processes to benefit from the energy in reliable, cost-effective, environmentally safe and sustainable ways. As it can be

found in the Findings section, Zorlu Energy organizes Stakeholder Engagement meetings to brief its stakeholders about the Alaşehir 2 GPP and Kızıldere 3 GPP projects. Moreover, a company's investment and operating plans are shaped by receiving feedback from its stakeholders [41]. They develop other projects that support open innovation processes focusing on smart solutions and creative industries to engage external stakeholders in the problem-solving process. Moreover, they identified their material issues based on the most recent stakeholder analysis they conducted in accordance with the AA1000 Stakeholder Engagement Standard in 2019 [42]. Therefore, it can be said that Zorlu Energy acts in line with the emerging trends in responsible innovation, especially for stakeholder engagement.

On the other hand, there are still ongoing public discussions regarding the adverse effects of geothermal power plants on the environment, which shows that the public has not been informed enough to eliminate the confusion. As an example, the protest was carried out by the villagers of Sarayköy district of Denizli for the Environmental Impact Assessment meeting regarding the Tekkehamam GPP-II project of Zorlu Energy [43]. Therefore, it can be said that it is not enough to strategize for stakeholder engagement, but they should also broaden the current assessments to understand the real cause of the protests and to offer a constructive solution by getting to the root of the problem.

To broaden the existing assessment initiative, values and issues addressed through stakeholder engagement sessions should be connected with the reflexivity dimension of the RRI [4]. Reflection on possible social and ethical impacts and values of the product or service can be achieved by scenario-based workshops that will be designed to reinforce trust between publics, stakeholders and institutions, as the concept of public upstream engagement embedded in a RRI approach was designed to restore this trust [4], [21]. As it can be seen in the Background Research, according to the survey conducted with a focus group by the VIGOR Project revealed that respondents complain about the fact that available information about energy issues is mainly provided by the energy companies themselves and ask for interlocutors without conflicts of interest [21]. Therefore, restoring the trust and broadening existing assessment to achieve responsiveness can be implemented better if interlocutors without conflicts of interest can also be invited to the engagement sessions as an objective party. The need for bridging between competencies and roles is fundamental to improve the innovation process and to find a balance between many perspectives, which are often conflicting [20]. Thus, Zorlu Energy can increase the scope of its stakeholder sessions by diversifying the participants. Including external perspectives in the assessments is also related

with the inclusion dimension of the RRI, which also gives an opportunity to experiment for the responsiveness lesson of the RRI.

As it is stated in the Switzerland case, the public is more likely to accept technological transition when residents can discuss potential impacts on their own life; another study on public engagement over geothermal energy from the same context, however, also shows that a situation may be generated in which project managers and the public negotiate the application of geothermal energy from different perspectives, i.e., their understanding of participation differs, and they focus on various aspects: Project managers, for example, favor top-down organized information delivery about drilling sites, while residents prefer formats which are more interactive and in which issues of rather individual interest (heat pumps for private households) are discussed [44]. As an outcome of considerations on how to include a wider perspective in technological and industrial development by addressing immediate stakeholders' and the society's interests, two approaches have been developed: The concept of Corporate Social Responsibility (CRS) calls for business models that are directed towards ensuring social legitimacy, while the concept of Responsible Research and Innovation (RRI) takes stronger the whole society into account by asking in how far innovation processes in technology have an impact on social (in)justice, violate ethical principles and exert negative effects on the environment; this encompasses the involvement of societal actors and immediate stakeholder during all steps of technological innovation [20]. What these concepts and associated models have in common is that a solely techno-economic approach is avoided, and public engagement is desired to increase public acceptance. RRI in particular draws the attention to the need to develop mutual respect and appreciation of divergent perspectives of different stakeholders, but it also emphasizes the need to create an understanding that responsibilities for technical innovation do not exclusively lie with the stakeholders who are in charge of technological development or policy-making [45]. To gain an understanding of responsibilities lying with laymen who are affected by an innovation practice public engagement is essential.

Promoting geothermal energy depends on establishing communication channels between stakeholders in charge of realizing conditions to benefit from this energy form in the techno-economic perspective and between stakeholders and the public who are affected by this form of energy because their immediate environment or routines are object to change. The latter one requires an information policy that provides the public with information so that they can build their opinion about geothermal energy and are eventually enabled to actively

participate in decision-making processes [20]. There is also a need for sustaining the engagement between different parties and monitoring how Zorlu Energy opens new communication channels between the stakeholders. To continue these meetings continuously, Zorlu Energy can develop online forum platforms where citizens can raise their questions and start conversations to share their concerns in order to create a system for democratic rationalization of the new technology that they are developing. This may include not only the online but also off-line communities such as citizen hubs, open research centers, considering both global and local dimensions [20]. As it is seen in the consensus conferences and World-Wide Views on Climate and Energy, democratic rationalization provides unique insights into the technology development processes, and citizens not only increase the legitimacy and transparency but also, they play an active role in taking action [46]. These kinds of applications can also help increase public awareness and social acceptance of geothermal applications.

On the other hand, if the Background Research and Findings are evaluated from the perspective of the technical view, the disposal of the extracted water, which includes various distinct toxic chemicals such as arsenic, mercury, lead, etc, is done by reinjection of the water into the source again. This technique is among the emerging trends in responsible innovation applications in geothermal energy, as it is stated that deep geothermal power of the United Downs site near Redruth can be part of the solution to the UK's search for alternative sources of energy [47]. This approach can also be exemplified in the drilling rig which is anticipated to arrive at the Eden Project in Cornwall [48]. Similarly, Zorlu Energy is also allocating various resources in this respect. This can be seen in Zorlu Energy's future work on the process of pumping non-condensable gasses from geothermal power plants back into the reservoir at four demo sites in Turkey, together with Iceland, Italy, and Germany [36]. The European Union also supported Zorlu Energy's GECO project, as it saw it as an essential innovation [49]. Therefore, it can be stated that Zorlu Energy's current projects demonstrate the alignment of the company's working approach with the trending sustainability improvements based on RRI.

Since geothermal energy has been playing a developing part in Turkey's 2023 Agenda, commercial usage and re-injection of generated CO2 into the geothermal reservoir can bring benefits. Emitted CO2 from geothermal power plants can be monetized by utilizing it directly, as a resource, or as a tool to boost industrial productivity and economic instability to bridge the time until permanent reduction or elimination of CO2 emission from geothermal

power plants becomes economical [4]. Therefore, this can be one of the best practices that Zorlu Energy could implement in the future.

To sum up, it can be said that Zorlu Energy has a solid stand to extend their renewable energy production sustainably and behaves according to the zero-emission targets. They have responsible innovation practices in line with the six lessons and four dimensions. Since they consider the local people as their first stakeholder, it indicates that they value and include the community living around the geothermal power plants. In the interviews, it is stated that the cornerstone of their investment decisions is to share this agreement with the local people. This enables the public to comprehend the pros and cons of the impact analysis which indicates the responsiveness of Zorlu Energy which makes it transparent since the locals are aware and understand its contribution to the region. However, despite the current RRI applications of the company, it can be emphasized that there are various subjects that could enhance their technology and social awareness within the society by diversifying their stakeholder engagements with interlocutors without conflicts of interest to find a balance between various perspectives and create a system for democratic rationalization to reach a better responsible innovation level.

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8. Appendix

8.1 Credits

Merve Öztürk: In our term project, I established communication with our company Zorlu Energy and made the necessary arrangements for the interviews with the related executives. In collaboration with our group, I took part in the preparation of our term project outline and found relevant sources we can use in our paper. Additionally, I attended interviews and transcripted Burçin Açan's interview and translated it into English. Finally, I wrote the Introduction, Theory and Analysis sections and worked together on the different parts of the paper with Görkem and Esin.

İsmail Görkem Yeni: Throughout this project, I contributed to the research stage by reviewing different resources. I conducted interviews with our group members and converted Cüneyt Tınaz's audio into a Turkish transcript and translated it into English. In our report, I wrote the Findings section and entered relevant quotes into the table based on the interview. Besides that, I was responsible for the formatting of the whole paper and made the last revision of our document by making additions to the necessary sections using the findings.

Esin Julia Rathert: In this paper, I researched and examined different articles and resources for our project. I attended interviews and transcriptted İnanç Salman's recording into a text file and translated into English. In addition, I made a comprehensive search focusing on the history and innovative practices relevant to the energy sector and wrote the Background Research and Methodology section as well as revised the Appendix part. Besides that, I contributed to the other sections by collaborating with our other group members.

8.2 Interviews

Appendix 1: Interview 1

Interviewer: Could you please tell us about Zorlu Energy's work in the field of geothermal in general?

Interviewee: You may know that Turkey's potential in geothermal is one of the three largest countries in Europe, both in terms of potential and installed power. I don't know exactly but I think we may have passed Iceland in this, as installed power. Geothermal capacity is substantial in Turkey. Of course, among other renewables, namely renewable energies, we do not have as much installed power as the installed power of the wind and sun. But the same truth exists in this world. Because, as you mentioned, geothermal resources are more niche, underground activities reach a certain maturity and have a certain temperature of fluidity. When we look at the cost-benefit analysis, when we look at the financed projects that we can move as the energy to be extracted versus the cost to be incurred, there is a decrease in the established power compared to other situations. But when we look at the effect of the energy source obtained or consumed on society, which is also the subject of your lesson, renewable energy plants have a much wider impact. There are many reasons for this, in fact, when we look at the installed power, I can be wrong in these figures about the limit of the difficult energy. I need to check it again on the internet because it is not my field of expertise. About 20% or 25% of the installed power in Turkey appears to be only in Zorlu Energy. Zorlu Energy is one of the companies that offers the leading renewable energy source in Turkey and the largest geothermal energy source in Europe. Now, there is a fluid in geothermal energy, you basically extract this fluid from underground, you pass through the turbines, you give the energy obtained from the fluid passing through the turbines to the system, then you send this fluid back under the ground. I am describing such a closed loop, ideal situation. Of course, in old technologies, there were issues such as not being buried underground, but they

were resolved. Most of the power plants of Zorlu now return this fluidity back to the system. This is actually important for the sustainability of that basin, on the other hand, this fluid has many uses when it comes out. As the fluid is extracted, carbon dioxide comes out as a by-product, carbon dioxide is then used in certain ways, in certain aspects, be it the beverage industry or the chemical industry. In fact, this is not even a by-product, it can also be seen as an unwanted product. But there is some benefit here. Another area of use is the heating of the cities around them, so I think there are more than 10 districts in Turkey like this. The heating of Sarayköy in Denizli, where we also have a power plant, is provided by our power plant. It offers a sustainable heating service in much more affordable conditions than its other counterparts. Another issue is that with the heat generated by the fluid coming out of this area, activities for greenhouses and greenhouses can increase, especially in Sarayköy, organized greenhouse zones were established, its abbreviation was OGZ, instead of Organized Industrial Zone, greenhouse activities are carried out, especially around a geothermal power plant. It has many functions such as heating for the people of the city, providing a suitable habitat for agricultural activities if the economic activities of that people are agriculture, of course, you may also have questions about geothermal. One of the topics that are always discussed in the head is the damages that these fluids are thought to cause due to standing on the surface, so here you are minimizing these damages as long as you send the fluid underground after removing it. In the past, in old technologies, discharging this fluid directly into the stream bed or transferring it to other channels, sending it from the surface reveals the main problems. The fluid is rich in many minerals, and these minerals can damage the soil, especially on the surface. But since the new generation power plants, including our power plants, send the fluid to the ground, they are almost non-existent. Of course, there is something that needs to be told, as in all matters. Renewable power plants offer benefits to humanity in many ways. It offers a more sustainable future perspective, but as seen in this latest energy crisis, it is not enough on its own. We are not at this stage yet and the world is not at this stage, it will take a while. But this is the right direction, using its own resources as much as possible wind, solar, hydro or geothermal. The policy based on energy production from these sources is seen as the most sustainable policy. The other one is already open to trade, other types of power plants, the products that come out as output, things like carbon dioxide emission transfer actually harm the environment, there is Green Deal right now, you know, there will be other things like COP26. Among these, there are certain carbon commitments, and Turkey has recently signed the Paris Agreement on the prevention of

carbon emissions. When we look at it from that point of view, the renewable side is getting more and more important.

Interviewer: Which stakeholders are working with you in the geothermal field?

Interviewee: In other words, it is with a local people at first, this is normally one of the most basic points of the procedures, one of the cornerstones when we make an investment decision, one of the cornerstones is to share this investment decision with the relevant local people, to reveal the positive and negative effects of what they call impact analysis, it is transparent what it will add or take to the region. It has to be shared somehow. Local people are the first stakeholders, the people who feel the impact of the power plant first hand. You have customers that you share, other stakeholders, customers that supply electricity. The suppliers you cooperate with while building this power plant, the people or institutions you receive products or services from, these are the ones you share. Your employees who built this plant, or also the place you use as service units, these are your stakeholders. The main purpose is actually in all businesses, whether energy or different, the main stakeholders are clear, that is, employees, customers, suppliers and shareholders, which we call shareholders, this is collectively called stakeholder. All of these actually make up a whole.

Interviewer: What risks do you see here? [You answered in the first question, there are general risks such as greenhouse gas emissions, carbon dioxide or costs, but we are actually wondering about something. What kind of risks exist in the locations right now? After all, we produce this energy, but it stays in a certain area. Are there any risks associated with it? Risks such as diverting energy, increasing costs?]

Interviewee: The issue of risk is also multi-layered. You can call it commercial risk. The output energy has commercial risks in 2 dimensions. First of all, can you supply energy according to the plan you have stated or in your mind, this is a little bit of your power plant, we use a term as "up and running," in a continuous working condition. Secondly, you are in an unknown area due to its subject, you seem to be over a fluid underground, although you try to describe the underground source with geophysical measurements, the variable is not stable here either. There are the main factors under the earth's crust and there is memory planning here, there is the Ripple effect, so you do not do business in an isolated geography by yourself, but an activity or activity underground at 50 km 60 km can affect your basic business. In this respect, these are subjects that you should always work with scenarios. Of course, these are the issues before the energy is sent, and there are commercial risks after you

give the energy to the system, this is the price risk you just mentioned, etc. Renewable energy sources in Turkey are currently secured to a certain extent, there is an incentive mechanism. We know that it will continue until the end of this year and then it will not be defeated or at these prices. Here, the government makes a commitment to supply electricity to the system at a certain price. It is important for some investors, especially on the financing side, to show the banks how bankable and feasible this business is. Otherwise, you have to take the version of risk, which we call market risk, and the relevant financiers can be this bank or your shareholder, that is, your boss as an investor. You may need to convince them that in the medium-long term, the cash flow to be obtained from this will finance the investment of this plant. The incentives given by the government are useful in this respect. These are commercial risks, so first, will there be enough energy? The commercial operation… will the income I get when the latter sells this energy outweigh my investment or the cost of capital in my head/shareholder's head? These are the basics. Another issue is social risks. In other words, the possible risks that this power plant may pose to its surroundings in case of any malfunction etc. are valid for all businesses on this geothermal plant, as well as for the factory. We used to call them FAMA analysis by making impact analyzes to a certain extent.

There is a system based on measuring and monitoring them by conducting such impact analysis. or there are risks at value, there are analyzes made according to where the risk can come from, and according to these, especially occupational safety and occupational health departments work more on this issue. Preventive actions are taken to minimize possible impacts both inside and outside the business. Another 3rd fundamental risk is financial risks. This is a risk that can happen to anyone, from individuals to businesses. Meanwhile, energy prices are always upwards. There are movements in Turkey's specific dynamics in the world, similarly in the world. Considering all these and projecting them into the future as much as possible, this is very difficult. They call it a more corporate approach, the contingency approach. They try to make risk analyzes about what we can do according to such ABC plans, it is a separate issue, but how much institutions do this, but 3 There is fundamental risk: business, social and financial risk. Every company is trying to manage them.

Interviewer: What adjustments do you think have been made or will continue to be made in technology, given stakeholder interests or risks? Actually, you mentioned earlier, you said that while (geothermal) is more harmful to the environment, it is minimized over time. What dimension do you think this will gain in the future in terms of innovations?

Interviewee: This is a fundamental question. Every step and every progress made after the Industrial Revolution made by mankind has an impact on the environment at all times. I don't mean this in a bad way because good or bad can be relative. Maybe you should ask the question like this. How can we ensure technological progress by securing/securing a more sustainable environmental ecosystem without destroying the environmental situation on both sides or the environment that people want to see? It has been said that it is necessary to think about this issue lately, of course, the climate issue has come to the fore a bit here. Now everyone is trying to manage this business through climate. Now, global warming has entered the agenda of the heads of state and companies, and it didn't do anything to be on the agenda. The main issue here is the funds such as ESG, that is, there are the Environment Social and Governance issues, which we call ESG. It would be nice if these used to be a little nicer 3-4 years ago. So let's do it, at least in the eyes of stakeholders, other stakeholders other than capitals, it looked like something to improve our reputation, that is to say, a piece of cake. This was the trend in the world in general, but now we have our own grading in fund flows, especially on the ESG ratings of companies, which Zorlu Energy constantly monitors, on whether to invest in companies based on these grades, and whether to provide fund flow. At the point where you connect the business to this point, the people who manage that business have to take this into account, whether they adopt it or not. But the important thing is whether this will be taken into account in practice, and accordingly, an application must be passed, these have gradually emerged in Turkey. There are issues related to the Green Deal, there are also carbon issues, maybe you don't feel it in your life right now, but most of our exporting companies are currently carbon neutral. In order to prove it, they have to show their suppliers that they have received many certifications, namely energy renewable and renewable sources, otherwise the supplier against them does not buy products, especially European countries, including the USA, and they do not want to buy products. For example, he says that if you used the steam from a coal boiler in the finishing process while producing this towel, I would not buy this towel. Roughly when this happens, they go back and reconsider their investments, review their energy supply, of course, this is a transformation. As always, transformations are a bit painful, on the one hand, you need to create a carbon neutral ecosystem from renewable resources in order to export or sell the product, on the other hand, you have to do this within a certain cost framework and there is cost pressure. In fact, even the initial investment costs of renewable energy sources have now fallen compared to normal convectors. When you look at it that way, there are much more sensible investments. One

component of the cost perspective is whether it provides a secure energy supply, in other words, the sun exists during the day and not at night. Here are battery technologies… We put batteries, will the batteries be enough, will this provide flexibility? So is the wind. Geothermal energy is a significant energy, but it is limited, that is, 1000 megawatts, one in 100 of Turkey's normal 100 000 megawatts. Having very niche projects in very niche areas does not mean that there is an energy source that will meet the energy needs of the whole nation. It is necessary to work on these issues with long-term plans. In the long term, I say, you have to think and plan for 20-25 years, otherwise it doesn't make much sense when you think about 3 years a year in a very short term, for example, it takes 5 years to build a coal mine, and probably 10 years to build a nuclear power plant. Renewables are easier, for example, you can build solar power plants in 1 year, so does wind. You need to make an international plan in the long term that will determine the supply-demand balance, all countries are trying to do this. Trying to do it in Turkey. Technology has to become less harmful to the environment. The biggest driver of this is financial resources, as in every business, if you put a good KPI indicator set from where the money comes from, everyone, especially investors, will take positions accordingly. Otherwise, the things you will do will create such a PR effect and remain as a competitive advantage that will differentiate you more than others, but now this is on everyone's serious agenda.

Interviewer: What arrangements have been made or will be made in geothermal power plants or the technology used here? What is the future of geothermal?

Interviewee: My area of expertise is not geothermal, but due to a certain capacity nature, you cannot find geothermal resources everywhere, but I am of the opinion that a greater majority of Turkey's potential is not used. It will become much more widespread in Turkey, because there is too much volcanic activity on the land and, fortunately, it is not concentrated at a certain point in the country, but in the east, west, etc. available in different locations. It's ubiquitous, but it's a cost issue. The day will come when the cost of extracting this energy is more competitive than other alternatives in terms of cost, those investments will be made. But Turkey is currently below its potential, it has come very quickly in the last 10 years and it still has a long way to go.

Appendix 2: Interview 2

Interviewer: Could you please tell us about the Zorlu Enerji's ongoing work on geothermal in general?

Interviewee: Ok, let's talk in general. It's not very much in my area. We have geothermal investments in Manisa and Denizli, certain investments made recently. Apart from that, our total installed power is currently around 650MW. We make up 87% of this from renewable energy. Our Kızıldere power plant has a total installed power of 165MW. In total, we have a geothermal power of 305MW. I remember that this was close to 20% of Turkey's total production. Frankly, this is the general information I can give about geothermal.

Interviewer: Which stakeholders are relevant for this technology?

Interviewee: I don't have much of that information.

Interviewer: What are the risks in this area?

Interviewee: When I visited there, the most important issue was the return of the hot water drawn from the source to the source. It was explained that most companies do not do this because reinjection is a more difficult and expensive process. In this direction, they informed us that we will re-inject the water to the source again due to social and environmental awareness, so that the source is used more efficiently and there is no harm to the environment. However, since the areas that power plants are built on have high seismicity, I heard that they may increase seismic activity in the area but this happens very rarely.

Interviewer: What adjustments have been made (or will be made) to the technology in response to user/stakeholder interests or risk concerns?

Interviewee: This is again information that a technical person can give. I personally see the process of withdrawing from the source and returning it to the source as the most important value in terms of protecting nature. Thus, we can see from here that the work we do is a bit more unique.

Interviewer: Could you elaborate on the ways you addresses sustainability through technological designs and/or organizational practices?

Interviewee: Obviously, sustainability has become very important lately. This has become very important by Zorlu energy. We even received an award recently, maybe you've followed suit. One of the fields of business of Zorlu Energy is ZES, under the brand name of Zorlu Energy Solutions, and we have started to establish a charging station network, which we have just started in Turkey and in Europe. We have now passed 1100 stations in Turkey. Regarding this, actually we are not an automobile company, we are an energy company. We thought that there are certain actions that energy companies should take regarding both the environment and the efficient use and sustainability of resources. While this automobile transformation was taking place, we decided that we should be involved in this business, and we started to establish this network of charging stations. We established our first station in approximately 2018, and in line with the work we have done in such a long time, we received an award in the sustainability awards of the year. As you know, the traces you leave in all your activities, from your carbon footprint in the energy sector, are very important. Therefore, our basic sustainability principle is to create an ecosystem for renewable resources. This is true everywhere, in geothermal as well as in charging stations. In this direction, we are actually trying to create a more sustainable future that we can leave to new generations like you by realizing new generation technologies, while protecting nature more.

Interviewer: What is the future for this technology?

Interviewee: If these resources are actually operated and built-in accordance with the rules and the book, the benefits for us in the future will be higher, both in terms of sustainability and environmental protection.

Appendix 3: Interview 3

Interviewer: Please tell us about the technology that you are developing.

Interviewee: In addition to Kızıldere 1 Geothermal Power Plant, Turkey's first geothermal power plant, the second unit of Kızıldere 2 Geothermal Power Plant and Kızıldere 3 project, which was put into practice in 2013, was opened in March 2018. Kızıldere 3 geothermal power plant has become the largest geothermal power plant in Turkey and one of the few geothermal power plants in the world. Zorlu Energy, which uses domestically produced ejectors in geothermal power plants, is the first company to receive a domestic production incentive in geothermal energy.

Interviewer: Which stakeholders are relevant for this technology?

Interviewee: I do not have enough information regarding the question.

Interviewer: What are the risks?

Interviewee: It is extremely significant that the power plants are set up and operated very carefully. There is always the risk that staff members who lack the necessary expertise to apply techniques appropriately cause negative headlines in the media and harm the company's reputation. After all, underground resources are the wealth of the country. We need to use underground and aboveground resources in the most efficient way. This also applies to wind and sun. On the one hand, it is said that Turkey is the country of the sun and a serious investment is needed in the solar energy. Yes, that is right. But on the other hand, it is also very efficient in the geothermal field. It may not be something visible to the eye, but we have serious resources here. Just like our mines. If we operate them correctly and get the maximum benefit, we will both increase the economic benefit and develop the country. I

think the biggest risk here is the right business, the right people, the right methods and the right management of this negative PR.

Interviewer: Does the transmission of energy in geothermal pose a problem?

Interviewee: Intelligent systems are much more effective, mostly in switchboards in dispersed structures. In this sense, geothermal is more like old conventional power plants, it is a larger power station at a central point and something that can be managed with a little more control. Of course, within the power plant itself, it is possible to direct the capacity of the power plant with certain systems and to manage the production, but since it is a more centralized power plant, it is closer to a more classical power plant. But considering Turkey, our main electricity source/power plants are HEPPs (Hydroelectric Power Plant). These are on the east side of the country, but consumption is on the west side. There are huge losses in terms of transmission here. Whether it is the dams on the Euphrates River or other dams, it always has to be transferred from the other power plants on the east side to the places where the consumption is high. It also causes unnecessary loads in terms of load. Since geothermal power plants are always on the West side, they are a little more optimal in terms of transportation. A type of power plant in a more central location, but much closer to big metropolises than to the east, and therefore more meaningful in terms of utilization, due to its geographical structure.

Interviewer: What adjustments have been made to the technology in response to user/stakeholder interests or risk concerns?

Interviewee: More arrangements were made on the solar and wind side; I do not know the arrangements in geothermal.

Interviewer: Could you elaborate on the ways you address sustainability through technological designs and/or organizational practices?

Interviewee: Sustainability is a concept that needs to be addressed from different perspectives. Indeed, it is a concept that can be thought of from many different places and can be drawn to many different places. When we consider energy production with sustainability, it actually brings about a serious transformation in energy. As Zorlu Energy, our motto is to be the energy of the future, that is, to be the energy company of the future. This is actually a transition from the old energy company concept to the new one. It also brings sustainability to the center during this transition. Using sustainable energy sources more, that 87% of our

energy production in Turkey is carried out from renewable sources and in a sustainable way. This is actually a concept that we put in the center. We take this into account in every step we take to support sustainability as much as possible. Our investments in electric vehicles are also within this framework. 20% of greenhouse gas emissions come from transportation and transportation is a sector that should be transferred to sustainable sources first. On the other hand, we try to act in line with the general approaches within the company and the sustainability goals of the United Nations, taking this into account within the entire holding. Activities are organized to raise awareness of all employees on this issue. For example, in the entrepreneurial ecosystem, we put your impact and sustainability at the forefront and try to give more support to initiatives interested in this field. In brief, we are a company that tries to address sustainability from as many different angles as possible.

Interviewer: What is the future for this technology?
Interviewee: I do not have enough information regarding the question.

8.3 Media and Other Reports

Appendix 4: ZORLU ENERGY SUSTAINABILITIY REPORT

We Carry the Diversity of Life to the Future

In 2018, we completed the research and development of conservation proposals for the plant Heliotrophium Thermophilum (yellow bambul weed), which is endemic to the Kızıldere I GPP area and is only found in this area globally. In 2019, a master's thesis was written in conjunction with the project studies. We are still working on conservation project proposals in collaboration with Ege University. Simultaneously, at our wind power plant sites in Osmaniye, we continue to actively pursue bat and bird monitoring practices approved by the Ministry of Forestry and Water Affairs. In Turkey, we are concerned about the preservation of natural life. We install fish passes, online lifeline and biological monitoring systems as part of the monitoring of living species in power plant areas in our hydroelectric power plants. We conduct the necessary research by determining whether or not it is possible to reverse these changes, if any, using fish passes, online/online lifeline monitoring systems, and biological monitoring systems. Our methods include identifying endangered and rare species in the IUCN danger categories, as well as species protected by CITES, Bern, and international conventions/national legislation, collecting plant samples of important species in accordance with the method, pressing the collected plant specimens to make herbarium material and/or recording them using digital photography making identification possible.

While determining the routes of the energy transmission lines (ETLs) within the scope of our electricity distribution activities, the route plan is shared with the relevant agencies and opinions are sought. Plans are clarified in accordance with the agency's opinions. In the case

of protected areas in ETLs, a change of route or studies required by the agency are carried out, again taking the agency's opinion into account. According to a report prepared after expert field research and literature studies, isolation materials are required in ETLs at line points where birds are frequently electrocuted. The ecological and ornithological research and evaluation report, as well as the winter period monitoring studies for ETLs near wetland areas, cover the provinces of Afyonkarahisar, Bilecik, Eskişehir, Kütahya, and Uşak, where OEDAŞ operates. The impacts of energy transmission lines in provinces with important conservation areas are assessed. To ensure sustainable biodiversity and ecosystem management within the framework of national legislation, international conventions, and IFC Performance Standards (PS-6), we are continuing our efforts to establish and operationalize the "Biodiversity and Ecosystem Management System," which we began at the organizational level in 2020. Our efforts continue with the goal of developing a biodiversity and ecosystem management plan for the facilities operated and/ or planned to be operated by Zorlu Enerji companies, as well as determining the organizational procedures for management plan implementation, defining monitoring, auditing, and reporting tools, and developing a recording system.

Fruit Tree Transplantation

We transplanted 1,600 fig and olive trees 15 kms before the construction works of our Kızıldere III Geothermal Power Plant in Buharkent, Aydın

Tirebolu Spider (Zodarion tireboluensis danisman at. Al. 2014)

With the help of scientists working on the project, we helped identify and register a new endemic species and as part of biodiversity research activities in the planned Tirebolu Regulator and HPP project in Tirebolu, Giresun

Yellow Heliotrope (Heliotrophium thermophilum)

We identified Yellow Heliotrope as a single point endemic species in the environmental impact assessment studies we conducted for Turkey's first geothermal power plant Kızıldere I. We supported the anatomical research studies of the species by collaborating with Pamukkale and Ege Universities.

Seçmen Fennel (Ekimia ozcan&secmenii)

We identified a new endemic species during our activities in Acıpayam, Denizli between 2009 – 2014. Collaborating with Ege University researchers, we continued species identification projects and registered a new species with the Ekimia ozcan&secmenii name. We notified the Ministry of Agriculture and Forestry and supported the addition of the species to the Biological Diversity Protection Species Action Plan. We returned the project license in 2017 to protect the natural habitat of the region.

Appendix 5- BİR GÜN

Denizli people do not want geothermal: EIA meeting is blocked by protests

The villagers protested the EIA meeting, reacting to the geothermal power plant to be built in the agricultural fields in Denizli Sarayköy. The meeting was canceled after public protest.

Zorlu Enerji Elektrik Üretim A.Ş. is located in the Sarayköy district of Denizli. The Environmental Impact Assessment (EIA) meeting, organized by the Ministry of Environment and Urbanization and company officials, regarding the Tekkehamam GPP-II project planned to be carried out by A.Ş., was canceled as a result of the protest of the villagers.

Villagers from Hasköy, Karakıran, Tırkaz and Acısu villages, who came to the meeting place, said, "We make a living by cultivating the land here. We have seen the damage done by the GPP to the land around us. "said.

Ministry and company officials, who were subjected to intense protest, had to leave the meeting.

8.4 Consent Forms

GE 301 Term Project: Innovation Study

I volunteer to participate in a research project conducted by Bilkent Engineering students . I understand that the project is designed to gather information about innovation practices. I will be one of 3 people being interviewed for this research effort.

1. My participation in this project is voluntary. I may withdraw from the study at any time.

2. I understand that most interviewees will find the discussion interesting and thought-provoking. If, however, I feel uncomfortable in any way during the interview session, I have the right to decline to answer any question or to end the interview.

3. Participation involves being interviewed by Bilkent engineering students. The interview will last approximately 10 to 15 minutes. An audio recording of the interview and subsequent text document will be made. I understand that if I don't want to be recorded, then I will not be able to participate in the study.

4. I understand that the researcher will not identify me by name in the follow up reports which draw on this interview, and that my confidentiality as a participant in this study will be secure.

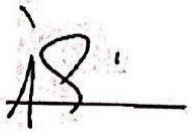
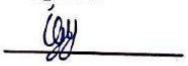
5. If I give my permission, then students may include my comments in a short video, which will accompany the project. The video will only be used for reporting on the study findings and will not be made public.

6. This data will be used for the GE 301 Term Project.

I agree to be recorded for this interview.

İnanç Salman	28/10/2021	
Name of participant	Date	Signature

I agree to be included in a short video for the project.

İnanç Salman	28/10/2021	
Name of participant	Date	Signature
Merve Öztürk	28/10/2021	
Name of researcher/interviewer	Date	Signature
İsmail Görkem Yeni	28/10/2021	
Name of researcher/interviewer	Date	Signature
Esin Julia Rathert	22/10/2021	
Name of researcher/interviewer	Date	Signature

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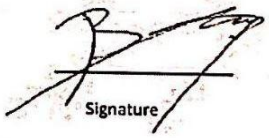
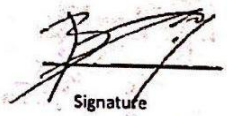
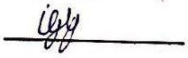
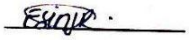
I agree to be recorded for this interview.

Burçin Açan	22/10/2021	
Name of participant	Date	Signature

I agree to be included in a short video for the project.

Burçin Açan	22/10/2021	
Name of participant	Date	Signature
Merve Öztürk	22/10/2021	
Name of researcher/interviewer	Date	Signature
İsmail Görkem Yeni	22/10/2021	
Name of researcher/interviewer	Date	Signature
Esin Julia Rathert	22/10/2021	
Name of researcher/interviewer	Date	Signature

GE 301 Term Project: Innovation Study

I volunteer to participate in a research project conducted by Bilkent Engineering students . I understand that the project is designed to gather information about innovation practices. I will be one of 3 people being interviewed for this research effort.

1. My participation in this project is voluntary. I may withdraw from the study at any time.

2. I understand that most interviewees will find the discussion interesting and thought-provoking. If, however, I feel uncomfortable in any way during the interview session, I have the right to decline to answer any question or to end the interview.

3. Participation involves being interviewed by Bilkent engineering students. The interview will last approximately 10 to 15 minutes. An audio recording of the interview and subsequent text document will be made. I understand that if I don't want to be recorded, then I will not be able to participate in the study.

4. I understand that the researcher will not identify me by name in the follow up reports which draw on this interview, and that my confidentiality as a participant in this study will be secure.

5. If I give my permission, then students may include my comments in a short video, which will accompany the project. The video will only be used for reporting on the study findings and will not be made public.

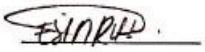
6. This data will be used for the GE 301 Term Project.

I agree to be recorded for this interview.

Cüneyt Öner Tınaz	02/11/2021	
Name of participant	Date	Signature

I agree to be included in a short video for the project.

Cüneyt Öner Tınaz	02/11/2021	
Name of participant	Date	Signature

Merve Öztürk	02/11/2021	
Name of researcher/interviewer	Date	Signature
İsmail Görkem Yeni	02/11/2021	
Name of researcher/interviewer	Date	Signature
Esin Julia Rathert	02/11/2021	
Name of researcher/interviewer	Date	Signature