

# 1 Exploring Critical Success Factors for Geothermal 2 Investments

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6 **Abstract.** The number of geothermal energy investments has been increasing  
7 every year to satisfy the growing demand for energy. Determining the success  
8 factors in geothermal energy investments is crucial to ensure project success.  
9 This research aims to identify the critical success factors and their effectiveness  
10 rate for geothermal energy investments in Turkey. To achieve this objective, an  
11 extensive literature review was performed to determine the critical success  
12 factors associated with geothermal energy investments, and a questionnaire  
13 survey was conducted to assess the effect of each success factor. The results show  
14 that the three most important success factors are “feasibility of the project”,  
15 “energy demand” and “tariff rate”. These findings can help the investors to  
16 successfully implement a geothermal investment.

17 **Keywords:** Public-Private Partnership (PPP), geothermal, renewable energy,  
18 critical success factor (CSF), project

## 19 1 Introduction

20 Energy is a vital for countries and economies. A large amount of the world energy  
21 demand is supplied from fossil fuels such as coal (%27), oil (%32), and natural gas  
22 (%22) [1]. These reserves are now in critical levels and have been decreasing day by  
23 day. In addition, the world energy demand will increase more than %25 until 2040  
24 according to the International Energy Agency [2]. Therefore, finding different sources  
25 to satisfy the increasing energy demand is an important issue for countries. As the fossil  
26 fuels have been decreasing in recent years all over the world, renewable energy sources  
27 can be a potential solution to satisfy the increasing energy demand. Geothermal energy  
28 which is a type of renewable energy has been increasing its popularity due to its low  
29 maintenance cost and cleanliness. It has many advantages over the non-renewable  
30 energy alternatives. One of the main advantages of geothermal energy is not causing a  
31 rise in CO<sub>2</sub> level in the atmosphere as it doesn't involve any burning process while  
32 producing electricity. It uses the heat energy, which has already been in the earth, and  
33 uses a fluid such as hot water, vapour, and gas which is accumulated and compressed  
34 with the motions of earth crusts and magma in the depth of the earth.

35 Turkey is one of the developing country that gives importance to the geothermal  
36 energy in order to satisfy the energy demand. After United States, Philippines, and  
37 Indonesia, Turkey has the 4<sup>th</sup> largest available installed geothermal power plant  
38 capacity in the world [3]. Although the number of geothermal investments has been

39 increasing day by day, the installed geothermal power plants satisfy only 2.1% of  
40 Turkey's energy demand [4]. Turkish Government believes that this ratio is very low,  
41 and encourages investor to invest new geothermal power plants. The investments were  
42 performed by using Public-Private Partnership (PPP). PPP is a cooperation between  
43 government and private sector to provide public services in different areas such as  
44 health, energy, transportation, infrastructure. Investors intend to make geothermal  
45 energy investments, however, they don't have enough information to pay attention to  
46 which factors in order to ensure project success. Therefore, this paper concentrates on  
47 critical success factors (CSFs) and their degree of effectiveness for geothermal energy  
48 investments carried out using PPP model in Turkey. For this purpose, an extensive  
49 literature review and a questionnaire survey were performed.

## 50 **2 Literature Review**

51 Critical success factors for projects have been recently getting the attention of the  
52 researchers. Several research studies have been conducted to identify the critical  
53 success factors (CSFs) for different types of projects. These studies can be clustered in  
54 two main groups as 1) CSFs for construction projects [5], [6], [7], [8], 2) CSFs for PPP  
55 investments [9], [10], [11], [12], [13], [14]. In order to ensure construction project  
56 success, it is important to identify CSFs and their effects [7]. Baccarini and Collins [6]  
57 identified 15 CSFs for construction projects by administering a survey with 150  
58 members of Australian Project Management Institute. Ika et al. [5] conducted a survey  
59 in order to determine world bank project success factors. Chen et al. [7] identified 62  
60 CSFs for construction projects by performing a literature review. They also showed the  
61 interrelations between the success factors. Han et al. [8] identified CSFs for  
62 international construction projects. In addition, several research studies were performed  
63 to identify CSFs for different types of investment in different countries carried out using  
64 PPP. For instance, Chan et al. [9] identified 18 CSFs for PPP infrastructure projects in  
65 China. By performing an extensive literature review, Chou and Pramudawardhani [11]  
66 identified the CSFs for Taiwan, Singapore, China, and the United Kingdom. Zhen-Yu  
67 et al. [14] determined 31 success factors for PPP thermal power investments in China.  
68 Although there have been several research studies related to CSFs for different types of  
69 PPP investments, there is not any specific study in the literature that focuses on CSFs  
70 for PPP geothermal energy investments in Turkey. Therefore, this research identifies  
71 CSFs and their degree of effectiveness for PPP geothermal energy investments in  
72 Turkey.  
73



CSF18	Management level of the company	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CSF19	Cooperation of the stakeholders			•				•	•	•									
CSF20	Financial structure of the company	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CSF21	Well-defined responsibilities and roles	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CSF22	Experience of the company																		•
CSF23	Experience of the designer																		•
CSF24	Performance of the designer																		•
CSF25	Experience of the contractor																		•
CSF26	Performance of the contractor																		•
CSF27	Construction techniques	•		•	•														
CSF28	Experience of the operator																		•
CSF29	Performance of the operator																		•
CSF30	Operation productivity																		•

81 In the second step, a questionnaire survey that includes two parts was performed. The  
82 questionnaire survey was conducted to 10 participants from 10 different companies, the  
83 renewable energy experience of the companies varies from five to twenty years. 80%  
84 of the participating companies have experience in renewable energy more than ten  
85 years. The information about companies is presented in Table 2. According to Table 2,  
86 all companies have geothermal investments in the different regions of Turkey. It should  
87 be noted that Turkey has 7 different regions, so the variety of the location of  
88 investments can help to obtain more consistent results. In addition, all companies have  
89 different energy investments apart from the geothermal energy investment.

90 In the first part of the questionnaire, the participants were asked to give  
91 information about profile of their companies such as “experience of their companies”,  
92 “types of their renewable investments”, “other renewable investments and their  
93 production capacities”, and “locations of their investments”. In the second part, the  
94 participants rated the effectiveness of critical success factors with 1-5 rating scale.

95

**Table 2.** Profiles of the Companies

Company Name	Geothermal Energy Production Capacity	Location of the investment	Experience (years)	Other renewable investments and their production capacities (MW)
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	(MW)	(Number of different regions)		Solar	Wind	Hydropower	Biomass
Company 1	7,5	3	13	5	25	19	-
Company 2	9	4	14	3	6	8	-
Company 3	12	6	10	12	22	42	2
Company 4	5	6	17	12	35	9	-
Company 5	11	5	19	3	7	8	-
Company 6	5	3	7	10	10	10	5
Company 7	6	4	15	6	15	17	7
Company 8	3	3	6	4	5	5	-
Company 9	15	4	17	15	36	29	-
Company 10	9,5	6	12	11	13	15	3

96 After all the critical success factors for geothermal investments were rated by the  
 97 participants, the average values of their evaluation were calculated as an effectiveness  
 98 rate of critical success factors. The average values and corresponding percentage  
 99 values are depicted in Table 3.

#### 100 **4 Discussion of Results and Conclusion**

101 According to the results, “feasibility of the project”, “tariff rate”, and “energy demand”  
 102 are listed as the three most important critical success factors with 100% effect to the  
 103 project success. The participants were also asked to rank these three most important  
 104 critical success factors. “Feasibility of the project” was ranked as first most important  
 105 critical success factor by all the participants. The feasibility of the project is a study that  
 106 performed before starting to the project, predicts the operationability of the project  
 107 taking into account the past datas and cashflow calculations related to the project. It  
 108 should be performed as accurate as possible in order to ensure project success. “Tariff  
 109 rate” was ranked as second most important critical success factor by 60% of the  
 110 participants and third most important critical success factor by 40% of the participants.  
 111 In addition, “energy demand” was ranked as third most important critical success factor  
 112 by 60% of the participants and second most important critical success factor by 40%  
 113 of the participants. The participants also noted that there is a strong positive correlation  
 114 between “tariff rate” and “energy demand”. An increase in energy demand causes an  
 115 increase in the tariff rate, so they can be combined, and consolidated as a single factor.

116 In summary, this paper presents an overview of global energy demand. The  
 117 importance of the renewable sources have increased recently, as the countries have to  
 118 find new energy sources. Geothermal energy is a type of renewable energy that  
 119 countries have gave importance in order to supply their energy demand. In this research,  
 120 the critical success factors and their degree of effectiveness were identified for  
 121 geothermal investments carried out using PPP in Turkey. For the identification process,  
 122 an extensive literature review was performed, and in order to determine the

123 effectiveness of factors, a questionnaire was conducted to 10 different participants from  
 124 10 different companies. For further research, a different model that shows interrelations  
 125 between critical success factors can be constructed.

126

**Table 3.** Effectiveness of Critical Success Factors

Critical Success Factors	Average	Percentage of Effectiveness (%)
CSF 1- Feasibility of the project	5.00	100
CSF 13- Tariff rate	5.00	100
CSF 6- Energy demand	5.00	100
CSF 14- Scope of the project	4.90	98
CSF 30- Operation productivity	4.80	96
CSF 29- Performance of the operator	4.70	94
CSF 22- Experience of the company	4.60	92
CSF 23- Experience of the designer	4.60	92
CSF 25- Experience of the contractor	4.50	90
CSF 28- Experience of the operator	4.40	88
CSF 11- Interest rate	4.00	80
CSF 26- Performance of the contractor	4.00	80
CSF 8- Well-organized public agency	3.90	78
CSF 20- Financial structure of the company	3.90	78
CSF 10- Exchange rate	3.80	76
CSF 27- Construction techniques	3.70	74
CSF 4- Operation/Construction cost	3.50	70
CSF 5- Construction quality	3.50	70
CSF 2- Public support to project	3.40	68
CSF 7- Government support	3.40	68
CSF 9- Political stability	3.40	68
CSF 16- Organization of the company	3.40	68
CSF 12- Favorable legal framework	3.20	64
CSF 15- Government control mechanism	3.10	62
CSF 17- Effective risk assessment	3.10	62
CSF 24- Performance of the designer	2.50	50
CSF 19- Cooperation of the stakeholders	2.40	48
CSF 18- Management level of the company	2.30	46
CSF 21- Well-defined responsibilities and roles	2.20	44
CSF 3- Complexity of the project	1.40	28

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