Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 97 (2016) 194 – 201

Energy Procedia

European Geosciences Union General Assembly 2016, EGU
Division Energy, Resources & Environment, ERE

Initial Assessment of Public Perception and Acceptance of Geothermal Energy Applications in Çanakkale, NW Turkey

Ziya Sedat Çetiner[a,*], Can Ertekin[b,c], Berrin Gültay[d]

[a]*Geological Engineering Department, Çanakkale Onsekiz Mart Unversity, Terzioğlu Campus, Çanakkale 17020, Turkey*
[b]*Graduate School of Natural and Applied Sciences, Çanakkale Onsekiz Mart Unversity, Terzioğlu Campus, Çanakkale 17020, Turkey*
[c]*Aegean Regional Directorate of Mineral Research and Exploration, İzmir 35040, Turkey*
[d]*Department of Statistics, Çanakkale Onsekiz Mart Unversity, Terzioğlu Campus, Çanakkale 17020, Turkey*

Abstract

The aim herein is to identify and analyze the public awareness and acceptance mechanisms for the successful deployment of geothermal investments in Çanakkale using geological, social and economic constraints in a well-defined questionnaire. The study employed a sequential explanatory survey to explore public perception and acceptance. The research results show that the geothermal energy resources in the Biga Peninsula, in particular, have significant potential for different uses; however they indicate that there are insufficient knowledge levels related to both what geothermal energy is and its environmental effects.

Peer-review under responsibility of the organizing committee of the General Assembly of the European Geosciences Union (EGU)

Keywords: Public Acceptance; Public Perception; Geothermal Utilization; Çanakkale; Turkey

* Corresponding author. Tel.: +90 -286-2180018; fax: +90-286- 2180541.
E-mail address: ziyac@comu.edu.tr

Peer-review under responsibility of the organizing committee of the General Assembly of the European Geosciences Union (EGU)
doi:10.1016/j.egypro.2016.10.052

1. Introduction

Geothermal heat or thermal energy has been used since ancient times by humans, in particular at places in which it emerges to earth surface by hot springs easily obtainable. At the onset of the last century, the exploitation at a commercial scale carried out in Italy (in Larderello in 1911) firstly and the following countries in Europe; Iceland (1928), New Zealand (1958) by using geological situation near tectonic plate boundaries [1]. The heat is transported from subsurface flow paths to the surface by not only water but also steam or gases. They occupy zones of structural weakness into plates or magmatic intrusions emplaced the crust apart from tectonic boundaries. Favorable geologic conditions and engineering solutions supports using geothermal energy, especially for energy production to demand energy needs.

Growing need of energy in global scale has resulted in increasing number of research and development of geothermal energy technologies or renewable energy technologies in the broader context. Turkey, being very rich in the renewable energy resources, has recently paid special attention to accelerate utilization of these resources to reduce the carbon based energy cost. Among these, geothermal energy resources in the country (Fig. 1a), mainly utilized in district heating and balneological applications, has been shifted toward harvesting electric energy in the shed of recent incentives. While these developments are happening at the policy level, the knowledge and the perception of the public is important to shape the future policies and acceptance of such resources in daily life [2]. In light of these developments, the aim of this study is to identify and analyze the public awareness and acceptance mechanisms for the successful deployment of future and ongoing geothermal investments in Çanakkale using geological, social and economic constraints in a well-defined questionnaire.

2. Geologic and Tectonic Context of The Biga Peninsula and Its Geothermal Resources

The Biga Peninsula is affected by the western extension of the North Anatolian Fault and the West Anatolian Graben System (Fig. 1a). The peninsula has a critical location due to current tectonic activity linked to the West Anatolia Graben System (WAGS) to the south, the North Anatolian Fault Zone (NAFZ) and North Aegean Transform (NAT) to the north. The fault zone is about 1500 km long and extends from Karlıova in eastern Turkey to the Greek mainland in the west (Fig. 1a). The NAFZ is a transform fault forming part of the boundary between the Eurasian and Anatolian plates (Fig. 1a). The western part of the NAFZ splits into three strands and they extend towards the Marmara Sea and the northern Aegean region [9]. Therefore the width of the NAFZ ranges from 10 km to 110 km with the Biga Peninsula in the south [10, 11]. The northern strand passes Marmara Sea (Fig. 1a). The central strand follows the line from Geyve, Pamukova to the southern coast of Marmara Sea. The southern strand of NAFZ consists of the Bursa Fault, the Uluabat Fault, the Manyas Fault, the Yenice-Gönen Fault, the Evciler Fault, the Edremit Fault and the Kestanbol Fault in the Biga peninsula [12, 13, 14]. In addition to the tectonic characteristics of the Biga Peninsula listed above, the peninsula contains a wide variety of both rock types and formation ages.

A wide time interval from Precambrian to Quaternary is represented without significant interruption in the peninsula. It is possible to find all types of lithologies from metamorphic rocks and ultrabasic to acidic magmatic rocks (Fig. 2). The geological basement of the region is formed by a variety of types and ages of metamorphic rocks. These are Kazdağ massif rocks in the south of the Biga peninsula (1-15 on Fig. 2) and the Çamlıca Metamorphics and Kemer Metamorphics (16-26 on Fig. 2) in the north. The metamorphic rocks in the Kazdağ are assessed as being pre-Triassic [15]. The Çamlıca and Kemer metamorphic rocks in the north are Late Precambrian-Early Paleozoic age [16, 17] with a tectonic contact above the Kazdağ Metamorphics [17, 18]. Above this basement complex of advanced degree metamorphics, the Karakaya Complex units (27-33 on Fig. 2) are found above a tectonic contact. All these metamorphic assemblages brought together by tectonics, are covered by a Jurassic-Cretaceous age limestone-dominant sedimentary sequence (33-36 on Fig. 2).

The Late Cretaceous to Paleocene period is represented by blocky complex assemblages such as the Bornova Flysch (42 on Fig. 2) and Yayla Mélange (43 on Fig. 2) in the south and the Balıkkaya formation (41 on Fig. 2) in the north. From the Middle Eocene this orogenic mosaic of rock assemblages with different rock types and sources is covered by a thick volcano-sedimentary assemblage. This volcano-sedimentary assemblage is occasionally cut by discordance but forms a thick sequence continuing until the Pliocene (44-92 on Fig. 2). The volcanic rocks in the sequence vary from rhyolite to basalt and these are accompanied by volcaniclastics. From the Eocene to Oligo-Miocene, granitic magmatic assemblages were emplaced in the Biga Peninsula (45 and 64 on Fig. 2). Eocene aged granitic plutons are mainly observed in the northern section of the peninsula, while Oligo-Miocene age plutons are found in more southern areas, with both cutting all older units and causing contact metamorphism in the surrounding rocks. The current morphotectonic features of the region are the result of neo-tectonic activity developing from the Miocene to the present day [14, 19, 20, 21, 22].

The geologic conditions of Turkey are favorable for geothermal system development through the plate boundaries, in particular NAFZ, and inner plate locations where structural weakness (e.g. fault) or magmatic emplacements are explicit (Fig. 1b). When zooming the Biga Peninsula (Fig. 1b), it is visible that the northern strand of NAFZ passing Marmara Sea and the southern strand of NAFZ through the southern seashore (Fig. 1b) limits the peninsula at north-south geographic directions. Geothermal resources emerges near fault segments which are NE-SW direction (Fig. 1b). Among the geothermal sites, Tuzla geothermal field (Fig. 1b) is suitable for energy production so a geothermal power plant was installed [23]. Kestanbol [24] and Hıdırlar [25] fields are featured ones because of having high outlet temperatures following Tuzla geothermal field. Kestanbol geothermal field is utilized for thermal or balneological treatments. In spite of occurring favorable geothermal potential, the public awareness and acceptance mechanisms are questionable in the peninsula. Hence, this study aims to identify and analyze the public perception and acceptance in Çanakkale.

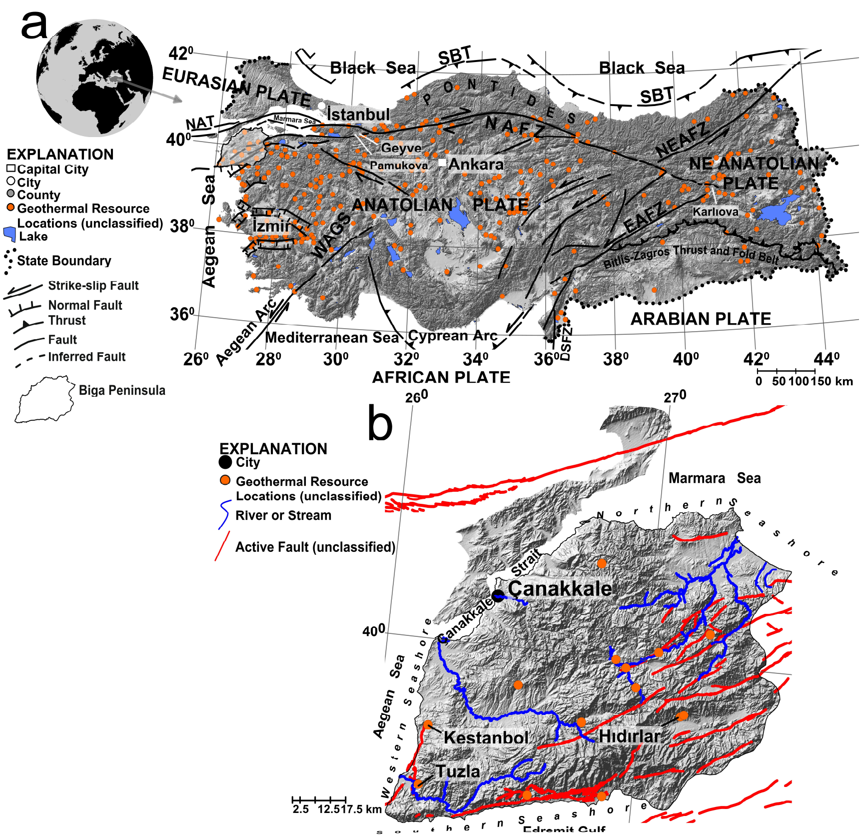

Fig. 1. (a) Young tectonic elements and geothermal resources in Turkey with the relative location of the Biga Peninsula (compiled with [3, 4, 5]). Abbreviations: DSFZ (Dead Sea Fault Zone), EAFZ (East Anatolian Fault Zone), NAFZ (North Anatolian Fault Zone), NAT (North Aegean Transform), NEAFZ (Northeast Anatolian Fault Zone), SBT (Southern Black Sea Thrust), WAGS (West Anatolian Graben System). Faults on the map depicts their tracks, not accurate positions; (b) Fault directions and geothermal resource locations of the peninsula (compiled with [5, 6, 7, 8]). The figures use Lambert Conformal Conic projection with WGS 84 datum.

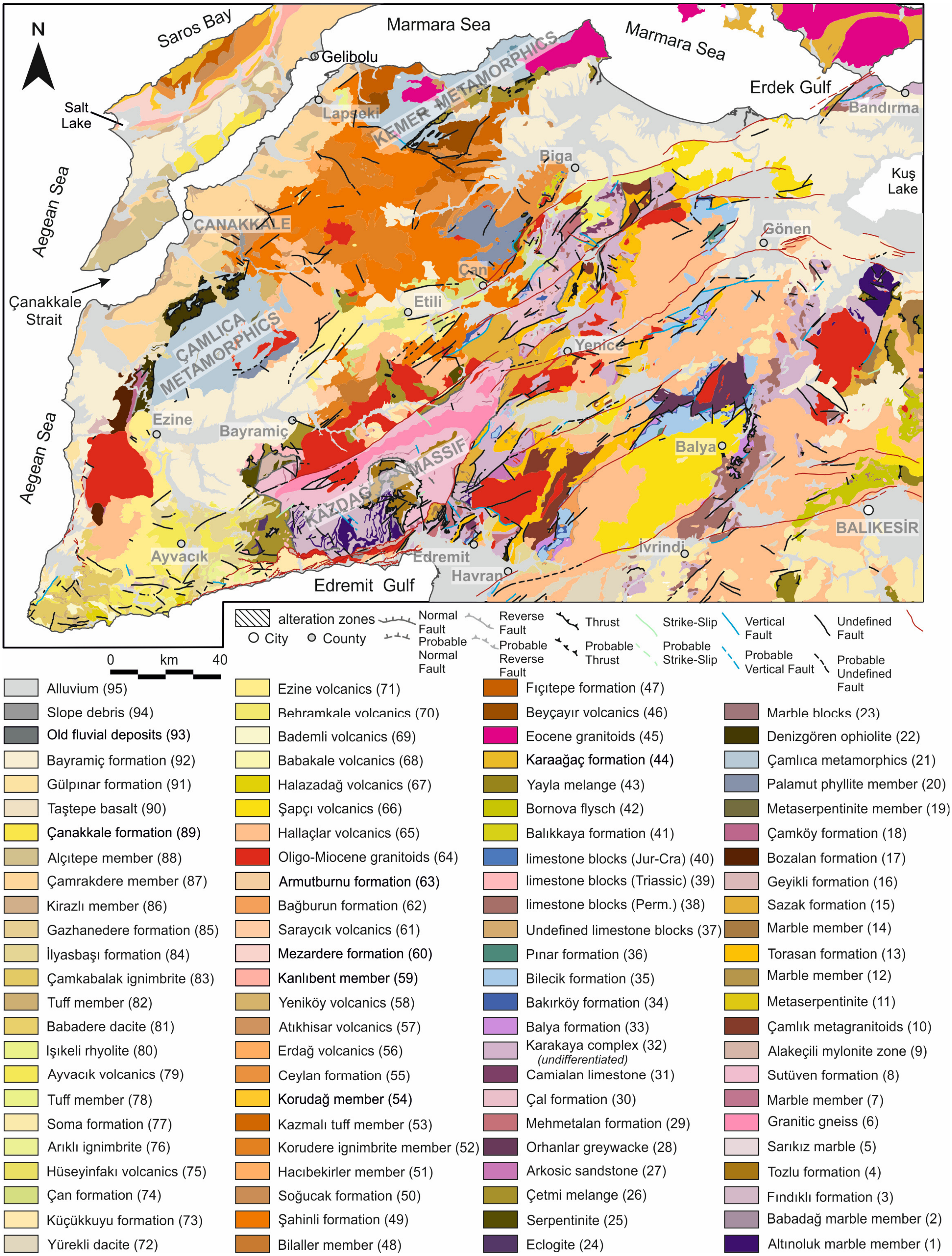

Fig. 2. Simplified geological map of the Biga Peninsula (modified from [26]).

3. Methodology and Results

A survey form was developed comprising three sections to determine the social acceptance and perception of geothermal energy in the Biga Peninsula. The first section of the questionnaire included personal information about the participants. The second section included 27 questions with responses on a 5-point Likert scale (totally disagree, disagree, uncertain, agree, totally agree) aiming to measure the perceptions related to geothermal resources. The final section of the questionnaire contained 6 questions about geothermal energy with multiple choice answers and aimed to determine social acceptance. The Cronbach alpha reliability coefficient was found to be 0.88. This value shows that the scale is highly reliable. The first stage of the study selected university students as the target participants. Under the scope of the study, 3 high school and 101 university students from Çanakkale were interviewed face-to-face and their responses to the questionnaire were noted. Analysis was completed with the SPSS 18® Packet Program [27]. The frequency distribution related to the first section of the questionnaire is shown in Table 1.

Table 1. Frequency distribution of the participants for the first part of the survey.

	Frequency (*N*)	Percent (%)	Cumulative Percent (%)
Gender			
Male	57	54.8	54.8
Female	47	45.2	100.0
Age			
18-25	88	84.6	84.6
26-30	11	10.6	95.2
31-35	2	1.9	97.1
41-45	3	2.9	100.0
Education			
High School	3	2.9	2.9
Associate's Degree	17	16.3	19.2
Bachelor's Degree	72	69.2	88.5
Master's Degree	11	10.6	99
PhD Degree	1	1	100.0
Graduated High School Type			
Science High School	2	1.9	1.9
Anatolian High School	56	53.8	55.8
College	2	1.9	57.7
Healthy Professions High School	8	7.7	65.4
Vocational High School 1	6	5.8	71.2
Vocational High School 2	7	6.7	77.9
High School (unattributed)	23	22.1	100.0

The Likert-type questions in the second section of the questionnaire were created under the headings of geothermal resources as a type of energy (Fig. 3a), purpose of geothermal resources (Fig. 3b), environmental effects of geothermal resources (Fig. 4a), promotion of geothermal resources (Fig. 4b) and state policies related to geothermal resources (Fig. 5).

A significant portion of participants (73.1%) were of the opinion that geothermal resources are a form of energy. Of participants, 73.1% thought that geothermal resources were a natural formation and 71.2% thought that geothermal resources were hot water. Additionally 76.9% of participants thought that geothermal resources were unnecessary (Fig. 3a). Participants had significant levels of information in terms of geothermal resources being a type of energy. Of participants, 52.9% thought geothermal energy was used for tourism, 71.2% thought it was used for treatment and 56.7% thought it was used for central heating. A significant section (41.3%) did not know that one of the uses of geothermal energy was agriculture. According to the questionnaire results, 78.9% of participants reported that hot dry rocks were a type of geothermal energy resource (Fig. 3b).

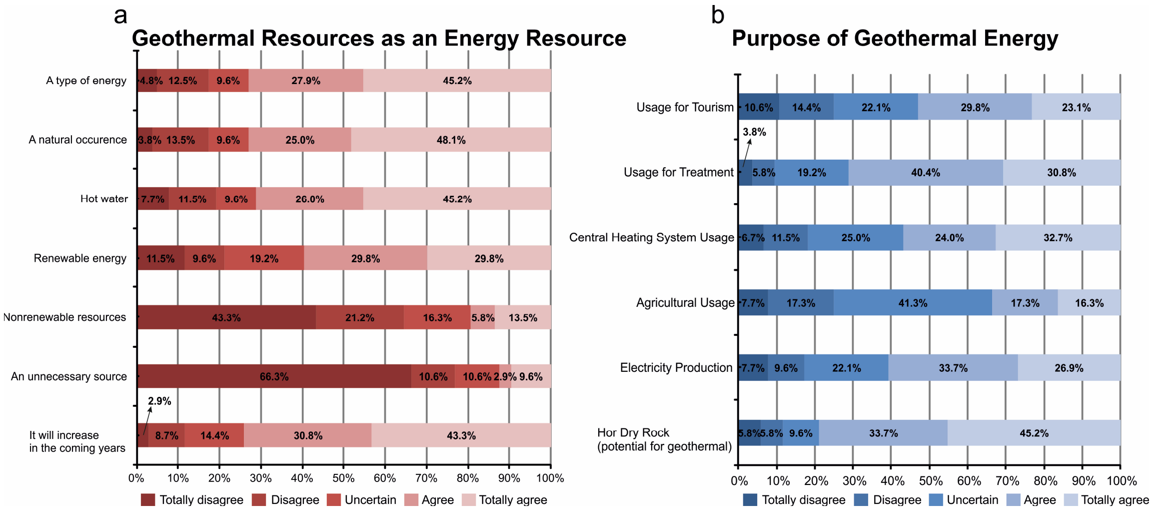

Fig. 3. (a) Geothermal resources as an energy resource (left); (b) Purpose of geothermal energy (right).

In terms of environmental factors questioned on the survey, participants did not have high levels of knowledge. Of the students 23% concluded they did not know whether geothermal energy affected the environment positively or negatively. However, 25% were against the idea that it had negative effects on the environment. One of the important results of the study was that 75.9% of participants thought that geothermal energy triggered earthquakes (Fig. 4a).

In terms of promotion of geothermal energy, 66.4% of participants thought visual media were effective and 74% thought it provided significant contributions to cultural tourism. However 45.2% of participants thought that training and seminars to promote geothermal energy were not beneficial, showing the need for studies to be performed on this topic (Fig. 4b). Participants accepted that geothermal heating had appropriate cost (74%). Of participants 67.3% advocated for state grants to support geothermal energy (Fig. 5).

According to the answers given in the final section of the questionnaire, 34.7% of participants used hot water sources for heating. This was followed by 21.4% for energy and treatment, 17.3% for tourism and 5.1% for agriculture, in that order. Of participants 46.7% thought it necessary for the state to support geothermal energy by identifying incentive regions. An important result of the survey was that universities were the most reliable source of information about geothermal energy (51.6%). Other reliable sources were energy companies (18%), local government (17.2%) and state information sources (13.1%), respectively.

When the distribution of answers about technological choices for energy production that will become more important or less important in future years is assessed, two different views were observed. In terms of energy technologies that will become more important, 28.7% of participants said solar energy, 25.7% said geothermal energy, 23.3% said wind energy, 11.4% said nuclear energy and 10.9% said hydrothermal energy. In terms of which resources will become less important, the highest percentage belonged to nuclear energy (78.1%). This was followed by 10.5% hydrothermal energy, 7.6% wind energy, 2.9% solar energy and 1% geothermal energy.

4. Conclusion

This study forms the first stage of a broad scale study to identify the knowledge level and perceptions of different levels of society about geothermal energy use and investment. Within this framework, initially university students were chosen as the target audience. The results of the research found that geothermal energy resources in the Biga Peninsula have significant potential for different uses; however they indicate that knowledge about environmental effects is insufficient.

According to the results of the questionnaire, although geothermal systems are widely accepted as an energy resource (73.1%), there is roughly the same level of acceptance (71.2%) that they are used for treatment.

Interestingly another point is that there is high awareness of technological choices like hot dry rocks that are not used in Turkey (78.9%). Hence, the next steps will involve a factor analysis and expanding the survey to the general public with higher number of participants.

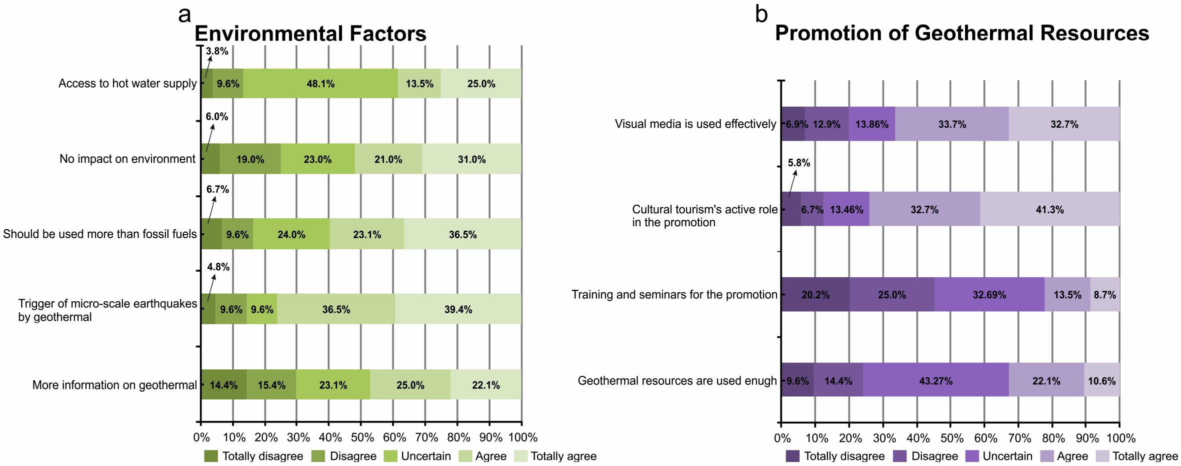

Fig. 4.(a) Environmental factors (left); (b) Promotion of geothermal resources (right).

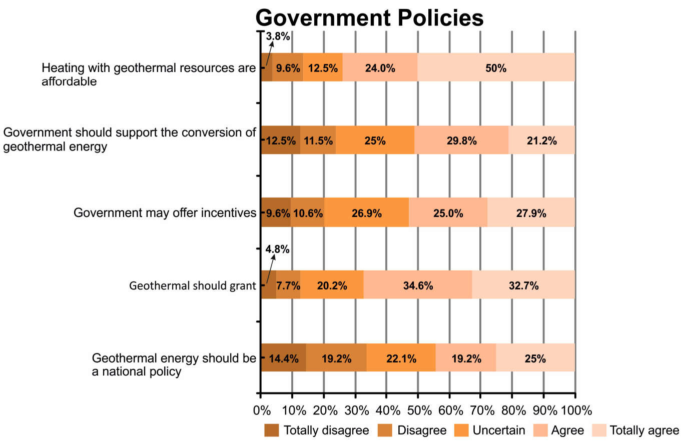

Fig. 5. Government policies.

Acknowledgements

The first version of this study was presented as a poster at European Geosciences Union (EGU) General Assembly on 22 April 2016, one of the respected organizations sharing current geological/geophysical research results in Europe (EGU General Assembly 2016; Session ERE3.3 - Exploration, development and production of geothermal resources; Friday 22 Apr 2016; Poster no: EGU2016-6461).

The data obtained as a result of this study played a key role in the development of the project which is known with the id number (321594) and presented to the Scientific and Technological Research Council of Turkey (TÜBİTAK in Turkish) 3001 program.

References

[1] Bleicher A, Gross M. User motivation, energy prosumers, and regional diversity: sociological notes on using shallow geothermal energy. Geothermal Energy 2015; 3:1-12.
[2] Pellizzone A, Allansdottir A, De Franco R, Muttoni G, Manzella A. Social Acceptance of Geothermal Energy in Southern Italy. Proceedings World Geothermal Congress 2015. Melbourne, Australia.
[3] Yiğitbaş E, Elmas A, Sefunç A, Özer N. Major neotectonic features of eastern Marmara region, Turkey: development of the Adapazarı–Karasu corridor and its tectonic significance. Geol J 2004; 39:179–98.
[4] Akkuş İ, Akıllı H, Ceyhan S, Dilemre A, Tekin Z. Türkiye Jeotermal Kaynakları Envanteri. MTA Envanter Serisi 201; 2005.
[5] CGIAR-CSI GeoPortal. SRTM 90m digital elevation data; http://srtm.csi.cgiar.org. Accessed: 17 April 2016.
[6] Yalçın T. Geochemical characterization of the Biga Peninsula thermal waters (NW Turkey). Aquatic Geochemistry 2007; 13:75-93.
[7] Emre Ö, Duman TY, Özalp S, Elmacı H, Olgun Ş, Şaroğlu F. Active Fault Map of Turkey with Explanatory Text. General Directorate of Mineral Research and Exploration Special Publication Series 30; 2013.
[8] OpenStreetMap. http://www.openstreetmap.org/. Accessed: 17 April 2016.
[9] Şengör AMC, Barka AA. Evolution of escape-related strike-slip systems: Implication for distributions of collisional orogens. 29th Int. Geol. Congress 1992. Kyoto, Japan.
[10] Koçyiğit A. Tectonic setting of the Geyve basin: age and total offset of the Geyve fault zone, E Marmara, Turkey. METU Journal of Pure and Applied Sciences 1988; 21:81-104.
[11] Bozkurt E. Neotectonics of Turkey–a synthesis. Geodinamica Acta 2001;14:3-30.
[12] Kürçer A, Chatzipetros A, Tutkun SZ, Pavlides S, Ateş Ö, Valkaniotis S. The Yenice–Gönen active fault (NW Turkey): Active tectonics and palaeoseismology. Tectonophysics 2008; 453:263-75.
[13] Kürçer A, Yalçın H, Gülen L, Kalafat D. 8 January 2013 Mw= 5.7 North Aegean Sea earthquake and its seismotectonic significance. Geodinamica Acta 2015; 27:175-88.
[14] Avcıoğlu M, Yiğitbaş E, Erginal AE. Beachrock formation on the coast of Gökçeada Island and its relation to the active tectonics of the region, northern Aegean Sea, Turkey. Quaternary International 2016; 401:141-52.
[15] Duru M, Dönmez M, Ilgar A, Pehlivan Ş, Akçay AE. Biga Yarımadası'nın Jeoloji ve Yer Altı Kaynakları Haritası. MTA Yayınları; 2012.
[16] Tunç İO, Yiğitbaş E, Şengün F, Wazeck J, Hofmann M, Linnemann U. U-Pb zircon geochronology of northern metamorphic massifs in the Biga Peninsula (NW Anatolia-Turkey): new data and a new approach to understand the tectonostratigraphy of the region. Geodinamica Acta 2012; 25:202-25.
[17] Yiğitbaş E, Şengün F, Tunç İO. Pre-Neogene tectonic units in the Biga Peninsula (NW Anatolia) and new view to their geodynamic evolution. TÜBİTAK Report, Project No:110Y281 2014 (unpublished).
[18] Yiğitbaş E, Tunç İO, Şengün F. Kazdağ Masifi'nin Düşük Dereceli Metamorfik Zarfı; Sakarya Zonu'nun Tektonik Gelişimi İçindeki Anlam ve Önemi. 67. Türkiye Jeoloji Kurultayı 2014. Ankara, Turkey.
[19] Gökaşan E, Ergin M, Özyalvaç M, Sur Hİ, Tur H, Görüm T, Ustaömer T, Batuk FG, Alp H, Birkan H, Türker A. Factors controlling the morphological evolution of the Çanakkale Strait (Dardanelles, Turkey). Geo-Marine Letters 2008; 28:107-29.
[20] Gökaşan E, Tur H, Ergin M, Görüm T, Batuk FG, Sağcı N, Ustaömer T, Emem O, Alp H. Late Quaternary evolution of the Çanakkale Strait region (Dardanelles, NW Turkey): implications of a major erosional event for the postglacial Mediterranean-Marmara Sea connection. Geo-Marine Letters 2010; 30:113-31.
[21] Avcıoğlu M, Erginal AE, Kıyak NG, Kapan-Yeşilyurt S, Yiğitbaş E. A Preliminary Note on Depositional Characteristics and Optical Luminescence Age of a Marine Terrace, Strait of Çanakkale, Turkey. Journal of Coastal Research 2013; 29:225-30.
[22] Avcıoğlu M. Gökçeada, Bozcaada ve Çanakkale Boğazı Kıyılarının Kuvaterner Jeolojisi ve Jeomorfolojisi. Dissertation: Çanakkale Onsekiz Mart University; 2016.
[23] OpenEI. http://en.openei.org/wiki/Tuzla_Geothermal_Power_Plant. Accessed: 28 May 2016.
[24] Baba A, Ertekin C. Determination of the source and age of the geothermal fluid and its effects on groundwater resources in Kestanbol (Çanakkale-Turkey). IAHS publication 2008; 324:148-55.
[25] Ateş Ö, Tutkun SZ, Baba A, Woith H, Özden S. An example of geothermal systems: Hıdırlar Geothermal Field, Biga Peninsula, NW Turkey. EGU General Assembly Conference Abstracts 2010; 12: 3257.
[26] Ekinci YL, Yiğitbaş E. Interpretation of gravity anomalies to delineate some structural features of Biga and Gelibolu peninsulas, and their surroundings (north-west Turkey). Geodinamica Acta 2015; 27:300-19.
[27] SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc.