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Earth Air Thermoelectric Generators

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Anahtar Kelimeler

Termoelektrik
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Graphical/Tabular Abstract (Grafik Özet)

Earth-Air Thermoelectric Generator ((EATEG)) has been studied theoretically and experimentally. In addition to the TEG theory, a mathematical model for (EATEG) has been skipped using a theory that considers both the thermal processes in the soil and the thermoelectric generator working in accordance with these processes as a whole. / Toprak- Hava Termoelektrik Jeneratör (THTEJ) teorik ve deneysel olarak incelenmiştir. TEJ teorisine ek olarak hem topraktaki ısıl proseslerin hem de bu proseslere uygun çalışan termoelektrik jeneratörü bir bütün olarak ele alan bir teori kullanarak THTEJ için matematiksel model geçiştirilmiştir.

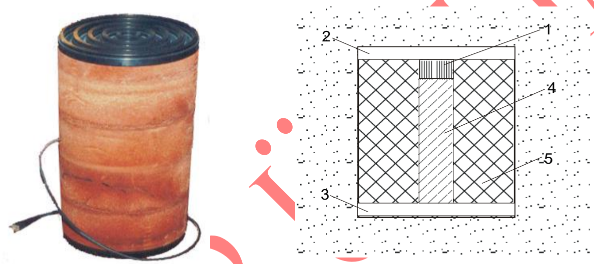

Figure 1: *Earth-Air Thermoelectric Generator (EATEG) /* ***Şekil 1:*** *Termoelektrik Toprak-Hava Jeneratörü(THTEJ)*

Highlights (Önemli noktalar)

- *Yeşil teknoloji / Green technology*
- *Yenilenebilir enerji / Renewable energy*
- *Termoelektrik yarı iletken teknoloji / Semiconductive thermoelectric technology*

Aim (Amaç): *Earth-Air Thermoelectric Generator (EATEG) has been studied theoretically and experimentally. / Toprak -hava termoelektrik jeneratörün (THTEJ) teorik ve deneysel olarak incelenmisidir.*

Originality (Özgünlük): *For the first time, an Earth-Air Thermoelectric Generator EATEG was investigated as a whole, both theoretically and experimentally. / İlk kez bir Toprak-Hava Termoelektrik Jeneratörü THTEJ bir bütün olarak ele alınarak teorik ve deneysel olarak araştırıldı.*

Results (Bulgular): *Obtained experimental and theoretical results were compared. Theoretical and experimental results were equal with an error margin not exceeding 5%. / Elde edilen deneysel ve teorik sonuçlar karşılaştırılmıştır.Teorik ve deneysel sonuçlar %5 geçmeyecek hata payıyla eşit çıkmıştır.*

Conclusion (Sonuç): *This study analyses and examines the Earth-Air Thermoelectric Generator (EATEG) both theoretically and experimentally, which works with earth temperature and is recommended to be used peculiarly in safety systems. To examine how EATEG functions in natural conditions, temperatures at soil surface and inside the soil depth of which is equal to the length of the generator are measured, and* ΔT *temperature differences are modelled throughout the four seasons in five different districts in Ankara. Thus, it is concluded that without any requirements for an electricity cable, it is possible to create a system that can work via EATEG by generating electricity with the help of the earth's temperature in the event of a property violation or other security-related issues to notify the security units. / Bu çalışmada toprak ısısı ile çalışan ve özellikle emniyet sistemlerinde kullanılması önerilen Toprak-Hava Termoelektrik Jeneratör (THTEJ) teorik ve deneysel olarak incelenmiştir. THTEJ'n gerçek doğa koşularında çalışmasını araştırmak için Ankara'nın beş farklı bölgesinde dört mevsimde jeneratörün boyuna eşit olan toprak derinliğinde ve toprak yüzeyindeki sıcaklıklar ölçülmüş,* ΔT *sıcaklık farkları hesaplanmış ve modelleme yapılmıştır. Böylece herhangi bir elektrik kablosuna ihtiyaç duymadan topraktaki ısı yardımıyla kendi elektriğini üreterek alan ihlali durumlarında güvenlik birimlerine haber verme özelliğine sahip bir sistemin THTEJ ile çalışabileceği tespit edilmiştir.*

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Abstract

This study analyses and examines the Earth-Air Thermoelectric Generator (EATEG) both theoretically and experimentally, which works with earth temperature and is recommended to be used peculiarly in safety systems. To examine how EATEG functions in natural conditions, temperatures at soil surface and inside the soil depth of which is equal to the length of the generator are measured, and ΔT temperature differences are modelled throughout the four seasons in five different districts in Ankara. To create the environment to measure and analyse how EATEG functions in natural conditions and design a thermoelectric earth-air generator and calculate its parameters, a mathematical model of EATEG is created based on both thermic processes and the standard thermoelectric generator (TEG) theory. The thermoelectric parameters such as power P(W) produced by the generator based on T, voltage U(V), and current I(A) are calculated using a custom experiment mechanism built specifically for this study, and the results are compared to theoretical results. The outcomes of theoretical and experimental results are in congruence. It is observed that the proposed earth-air generator can provide a reliable safety system. Thus, it is concluded that without any requirements for an electricity cable, it is possible to create a system that can work via EATEG by generating electricity with the help of the earth's temperature in the event of a property violation or other security-related issues to notify the security units.

Toprak Hava Termoelektrik Jeneratörü

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Öz

Bu çalışmada toprak ısısı ile çalışan ve özellikle emniyet sistemlerinde kullanılması önerilen toprak-hava termoelektrik jeneratör (THTEJ) teorik ve deneysel olarak incelenmiştir. THTEJ'n gerçek doğa koşularında çalışmasını araştırmak için Ankara'nın beş farklı bölgesinde dört mevsimde jeneratörün boyuna eşit olan toprak derinliğinde ve toprak yüzeyindeki sıcaklıklar ölçülmüş, ΔT sıcaklık farkları hesaplanmış ve modelleme yapılmıştır. Bunun için klasik termoelektrik jeneratör(TEJ) teorisine ek olarak bir termoelektrik toprak-hava jeneratörü tasarlamak veya parametrelerini hesaplamak için hem topraktaki ısıl proseslerin hem de bu proseslere uygun çalışan termoelektrik jeneratörü bir bütün olarak ele alan bir teori kullanarak THTEJ'n bir matematiksel modeli geçiştirilmiştir. Deneysel çalışmalar için kurulan özel test düzeneğiyle jeneratörün ΔT' ye göre ürettiği güç P(W), gerilim U(V) ve akım I(A) gibi termoelektrik parametreleri ölçülmüş ve teorik sonuçlarla karşılaştırılmıştır. Teorik ve deneysel sonuçlar birbirine çok yakın çıkmıştır. Örnek uygulama olarak özel yapılmış geçek bir emniyet sistemin çalışmasını toprak-hava jeneratörle sağladığı tespit edilmiştir. Böylece herhangi bir elektrik kablosuna ihtiyaç duymadan topraktaki ısı yardımıyla kendi elektriğini üreterek alan ihlali durumlarında güvenlik birimlerine haber verme özelliğine sahip bir sistemin THTEJ ile çalışabileceği tespit edilmiştir.

1. INTRODUCTION (GİRİŞ)

Due to the increasing need for alternative energy source, making good use of these sources is vital in terms of energy efficiency. The vitality of research that aims to produce alternative energy sources in Turkey as well as around the world is unquestionable. Developed countries and countries with sufficient energy supplies focus on this subject. For instance, during 1975–1990, the USA spent

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over 38 billion dollars on alternative energy production. Among many different alternative ways of producing electricity, the "minimum energy sector" which produces electricity directly from heat, occupies an important place. The characteristic features of this method are the absence of moving parts in the thermoelectric modules, durability, high reliability, ease of construction, and compatibility with all kinds of alternative and renewable heat resources. When it comes to thermoelectric generators, the source of heat might be solar heat, all sorts of waste heat, or other heat sources. In recent years, the use of the temperature difference between earth-air systems has been discussed. Due to the research about this system, both the heat processes in the earth and the design, production, and studies related to the physical features of the generators that are suitable to these processes came forward. Hence, the production and research of devices with thermoelectricity generators and systems specially addressing earth-air systems have been started [1]. In this study, one piece of an earth-air thermoelectric generator, which is supplied by TES Ltd., is examined. TEG, the basic structure of which is shown in Figure 1, is buried in the earth and can function in two regimes depending on the weather circumstances. During hot weather or daytime, the heat that comes from the warm layer of the earth is collected in the collector number 2 and transmitted to the thermoelectric module's hot surface, which is located just below the collector. 10% of the heat passing through the module is directly converted into electricity, at most. The remaining heat is transported through heat exchanger 4 with high thermal conductivity or low thermal resistance to collector number 3, where the module is in contact with a cold surface, and then it gets spread to the colder part of the earth under the generator. During cold weather or at night, the heat that comes from the warmer layer of the buried generator is transmitted to the number 3 collector first, then to the module, and to the number 2 collector via the number 4 heat exchanger and dissipates into the air. All the parts that construct TEG are placed in an external cover that is isolated with a number 5 insulator and made of anti-corrosive, anti-biologic, and water-resistant material. Also, the cover that is used to create the generator is undetectable by detectors [2,3].

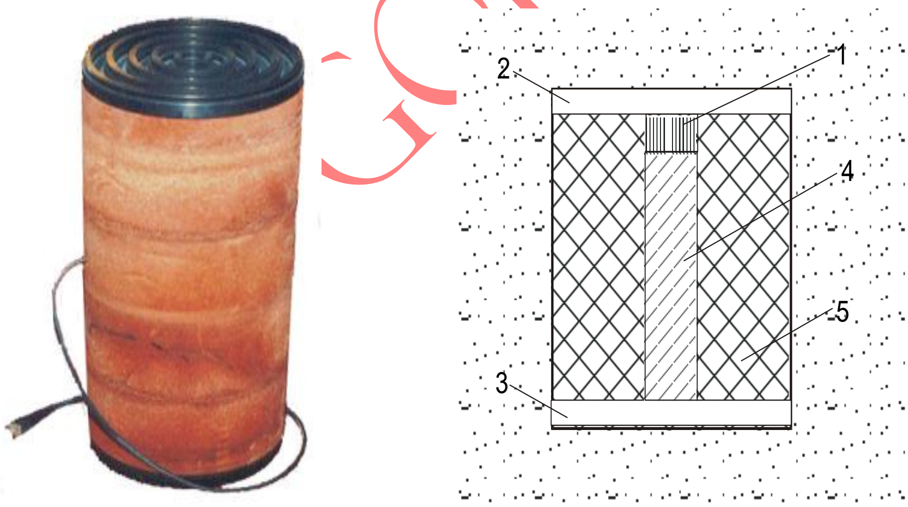

Figure 1. Earth-Air Thermoelectric Generator (EATEG) (Termoelektrik Toprak-Hava Jeneratörü(THTEJ))

2. THEORY (TEORİ)

The operation of a thermoelectric module is explained in Figure 2. A TEG system consists of three main parts: a heating block, a cooling block, and a thermoelectric module [4].

The Seebeck effect causes a decrease in DC voltage in TEG tips when there is a temperature difference between the module's surfaces. P power or I current obtained from TEG depends on the ΔT temperature difference, the features of semiconductive materials, and external R_L charging resistance values.

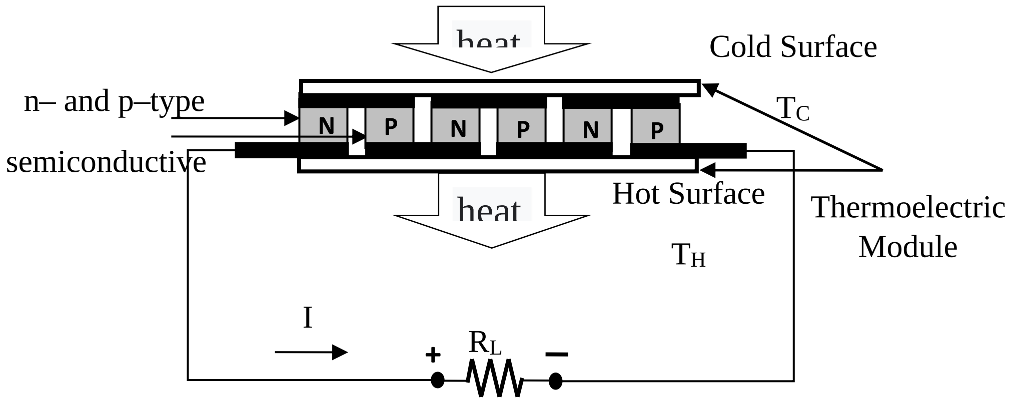

Figure 2. The use of a thermoelectric module as a thermoelectric generator (EATEG) (Termoelektrik modülün termoelektrik jeneratör olarak kullanılması)

The efficiency of a TEG is defined as the ratio of the received power (P_A) to the supplied power (P_V) as follows:

$$\eta = P_A / P_V \tag{1}$$

The semiconductor quality factor (Z) used in a TEG while the power factor ZT of a TEG is as follows:

$$ZT = \frac{\alpha^2}{KR_{in}} T \tag{2}$$

In this formula; T is temperature (Kelvin), α ($\alpha = \alpha_{pn} = |\alpha_p| + |\alpha_n|$) Seebeck constant (V/K), K is thermal conductivity (W/mK). In a TEG, ZT is a function of the temperature difference between the surfaces of the module and ΔT. TEG efficiency is also expressed in terms of Carnot efficiency. The Carnot efficiency for TEGs is expressed as:

$$\eta_{max} = \frac{(T_H - T_C)}{T_H} \times \frac{\sqrt{1+ZT_{ave}} - 1}{\sqrt{1+ZT_{ave}} + \frac{T_C}{T_H}} \tag{3}$$

In this formula; The hot side temperature of TEG is T_H, the cold side temperature of TEG is T_C and their average is the average temperature of TEG, $T_{ave}=(T_H + T_C) / 2$. The highest value of the voltage produced by the TEG is when its terminals are open. The open circuit voltage V_{OC} is expressed as down below:

$$V_{OC} = N(\alpha_p - \alpha_n)(T_H - T_C) \tag{4}$$

TEG open-circuit voltage is directly proportional to the number of thermoelements N, the temperature difference ΔT between the hot side surface temperature of the TEG, T_H and the cold side surface temperature, T_C and The Seebeck constant α_p of the p–type semiconductor material used is proportional to the Seebeck constant α_n of the n–type semiconductor material [4,5].

The power P_L produced on the charge R_L connected to a single module is expressed as:

$$P_L = I_L V_L = I_L[\alpha\Delta T - I_L R_{in}] = \alpha^2 \Delta T^2 \frac{R_L}{(R_{in} + R_L)^2} \tag{5}$$

In the formula, P_L is the output power of the TEG over the load, I_L is the electric current that TEG passes over the charge, and V_L is the voltage created by the TEG on the connected load. When the load resistance R_L is equal to the internal resistance R_{in} of the TEG, then TEG produces the maximum output power, P_{Lmax}, which is expressed as follows:

$$P_{Lmax} = \frac{\alpha^2 \Delta T^2}{4R_{in}} \tag{6}$$

The maximum voltage V_{OC} and maximum current I_{SC} are acquired from the TEG when its terminals are open-circuited and short-circuited. Depending on the value of the connected charge, different amounts of power (P_L) are obtained from the TEG.

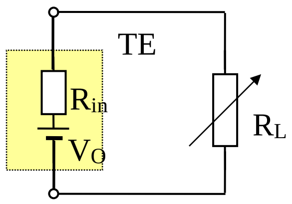

Figure 3. TEG equivalent electric circuit(TEJ eşdeğer elektrik devresi)

A V_{OC} voltage source with a TEG internal resistance R_{in}, which can be obtained from the V_{OC} short-circuits current ISC section (V_{OC}/I_{SC}), can be used to represent a TEG open-circuit equivalent. The open circuit voltage (V_{OC}) is shown here is equal to the product of the temperature difference (T) and Seebeck's constant (α).At a specific temperature difference ΔT, if the TEG short-circuit current is I_{SC} then TEG's short-circuit ends. Figure 3 depicts an analogous electrical circuit connected to a thermoelectric module used as a TEG. The quantity of power obtained from the TEG varies according to the R_L value of the load resistor [5,6]

3. MATHEMATICAL MODEL
(MATEMATİKSEL MODEL)

Many theoretical and experimental studies have been carried out according to the classical theory given above [5-10]. However, they are not enough for a EATEG. To design a thermoelectric earth-air generator (EATEG) or calculate its parameters based on the given information, in addition to the formulas (1) – (6) above, both the thermal processes in the soil and the thermoelectric generator working by these processes should be considered as a whole [1]. As a result of theoretical and experimental research, it is observed that various EATEG parameters are implicitly related to each other. In general, one of the most important EATEG parameters, the produced electric power, P, is expressed as in the formula (7) [1]. $P = f[T(x,y,z,t), \lambda(x,y,z,t), c(x,y,z,t), \sum_1 Bi, Z, L(x,y,z,t)]$ (7)

In this formula, T(x,y,z,t) is the spreading of the temperature in the earth buried inside, λ(x,y,z,t) and c(x,y,z,t) are the thermal conductivity of the earth and the volumetric thermal capacity parameter, the thermal balance of the algebraic total in the earth, and Z is the efficient parameter of the earth thermoelectric generator.

L(x,y,z,t) is a space coordinate that demonstrates the location inside EATEG's geometric dimensions, and t is for time.

$$P = f[T(z,t), \lambda(z,t,T), c(z,t,T), \sum_1 Bi, Z, L(z)] \quad (8)$$

By presuming that the temperature of the earth is a one-dimensional function and the earth's thermal parameters are stable, the output power can be calculated by including the main features that affect how a EATEG functions. To achieve this goal, it is possible to benefit from the chart shown in Figure 4. In this diagram, a EATEG of dimensions D and H is buried at a depth of h. It would be more acceptable in this situation to solve the issue using a cylindrical coordinate system and account for the system's symmetry to determine the electrical power P generated by the earth's thermoelectric generator. The positive Z-axis direction in this instance is defined from the earth's surface, and the r and z cylindrical coordinates are as in Figure 4.

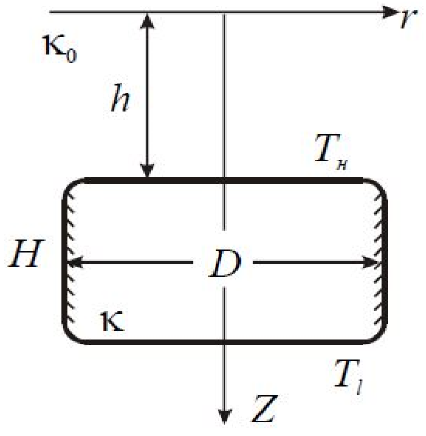

Figure 4. Chart of buried EATEG [1]
(Toprağa gömülü THTEJ'ün şeması)

The solution of the heat conduction differential equation defined below with the temperature distribution function T(r,z,t) in the earth is:

$$\frac{1}{\chi}\frac{\partial T(r,z,t)}{\partial t} = \frac{\partial^2 T(r,z,t)}{\partial r^2} + \frac{1}{r}\frac{\partial T(r,z,t)}{\partial r} + \frac{\partial^2 T(r,z,t)}{\partial z^2} \quad (9)$$

$$-\kappa_0 \frac{\partial T(r,z,t)}{\partial z} = q_0\, coswt, z = 0 \quad (10)$$

$$T(h, r < D/2, t) = T_i(t) \quad (11)$$

$$T(H + h, r < D/2, t) = T_i(t) \quad (12)$$

$$-\kappa_0 \int_S \frac{\partial T(r,z,t)}{\partial z}\Big|_{z=h} dS = 1/R_{EATEG}((T_H(t) - T_l(t)) \quad (13)$$

$$-\kappa_0 \frac{\partial T(r,z,t)}{\partial z} = 0 , h < z < h + H \quad (14)$$

In this equation, χ stands for the soil's heat transmission coefficient and κ_0 stands for the temperature transmission coefficient. $T_H(t)$ and $T_l(t)$ are the temperatures at the upper and lower surfaces of the EATEG that must be determined, and R_{EATEG} is the thermal resistance of the EATEG. q_0 and ω are the amplitude and periodic frequency of the harmonic oscillation of the heat flux density on the surface of the soil. The following equations are the edge conditions of their physical interpretations are as follows: (11) and (12) express that the lower and upper surfaces of the EATEG are isothermic, meaning that their temperatures are constant on all of their surfaces, (13) expresses the thermal stability of the EATEG's heat-receiving surface, and (14) is the requirement for the sides of the EATEG to be adiabatic insulation. Condition (10) provides the heat flux on the soil's surface.

The Rankin's method solution of equation (9)–(14) yields the following formula for the T amplitude of the oscillation of the temperature difference between the two sides of the EATEG for the kvasistosanar, periodic with regard to time and H<h state:

$$\Delta T = \frac{q_0}{\kappa_0}\exp(-\gamma h)\, F\left(k, \frac{H}{D}\right) \quad (15)$$

In this equation, $\gamma = \sqrt{\omega/2\chi}$, $\kappa = 4H / R_{EATEG}D^2\kappa_0\pi$ – EATEG- It is the ratio of the earth piece's heat resistance equal to the volume of EATEG to the generator's heat resistance. It is a complicated function that depends on its variations is $F(\kappa,\frac{H}{D})$. However, with a less than 5% error margin, this function can be stated as follows when these arguments are in the range of 0.1 to 5%:

$$F(\kappa,\tfrac{H}{D}) = 1 + (1-\kappa)/(\kappa+2H/\pi R_{EATEG}) \quad (16)$$

The heat flux function, which is comparable to the Lukosh function used in the theory of eddy thermoelectric currents and it can be used to determine the distribution of the heat flux density in a patch of soil with a EATEG since the issue under examination has a cylindrical (axis) symmetry [1]. The difference between the positions (z, r_1) and (z, r_2) of this function, $r_1 < r < r_2$, represents the entire heat flux through the ring in this case. The heat flux function can be expressed using the following equation:

$$\frac{\partial^2\psi}{\partial z^2} + \frac{\partial^2\psi}{\partial r^2} - \frac{1}{r}\frac{d\psi}{dr} = 0 \quad (17)$$

$$\psi(r,0) = -\frac{1}{4\pi} q_0 r^2\, coswt \quad (18)$$

$$\psi(r, h + H) = \psi(r,h) = -\frac{1}{4\pi} q\, r^2 \qquad \psi(r, h + H) = \psi(r,h) = -\frac{1}{4\pi} q_{EATEG}\, r^2 \quad (19)$$

In this formula: $q_{EATEG} = \Delta T / \pi R_{EATEG} D$. According to this model, the amplitude of the heat flux oscillation on the heat incoming surface of the EATEG for the small ΔT valid in the EATEG

$$q = q_0 \exp(-\gamma h) k\, F(\kappa,\tfrac{H}{D}) \quad (20)$$

and the efficiency of EATEG is:

$$\eta = Z\, \Delta T / 4 \quad (21)$$

Hence, the power produced by a EATEG from formulas (15), (20), and (21)

$$P = V q_0^2 \exp(-2\gamma h) Z k\, F^2(\kappa,\tfrac{H}{D})/\sqrt{2} \quad (22)$$

Based on this formula, the power produced by the EATEG increases in direct proportion to the V-volume of the EATEG, Z, and q_0^2, while it decreases exponentially according to the depth where the EATEG is buried, and changes non-monotonically according to the k and H/D parameters.

4. EXPERIMENT (DENEY)

During the experimental studies, parameters such as power P(W), voltage U(V), and current I(A) produced by the generator were examined, specifically according to T. Throughout four seasons, temperature differences at the soil depth of 25 cm and 50 cm and at the soil surface were equal to the length of the generator, and the temperature differences were measured and modeled in five different precincts in Ankara according to these data and values. Earth generator lab tests are performed based on the obtained wide range of temperature differences. An experimentation mechanism is designed and built specifically for this purpose. Temperature differences were measured at the soil depth of 25 cm and 50 cm and the soil surface in five different precincts in Ankara.

Figure 5. Figure of the thermometer measured the temperature of the earth (Toprak derinliğinden ölçüm alınan termometrenin örnek görüntüsü)

Two examples from extensive field tests are given below.The maximum temperature differences according to the location of the data taken in the four seasons were recorded. An example of these data is shown in both Figure 6 and Figure 7

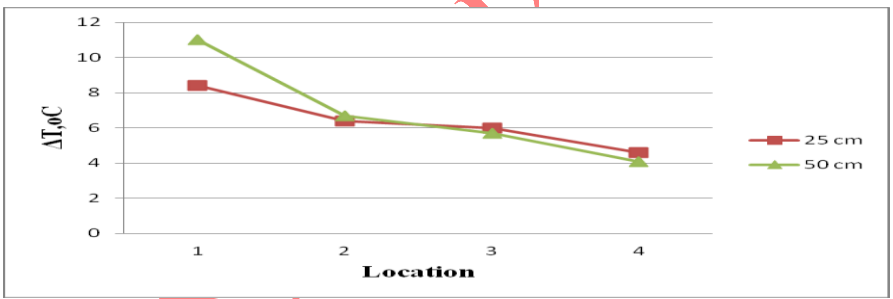

Figure 6. Based on the location of the data obtained in winter, max temperature differences (Kış mevsiminde alınan verilerin konuma göre maksimum sıcaklık farkları)

In this figure, location number 1 is Bağlum, location number 2 is Keciören, location number 3 is Kızılcahamam, location number 4 is Beşevler, and location number 5 is Yenimahalle. The highest T is given depending on the location, either 25 cm or 50 cm soil depth. The highest temperature difference, measured in the Yenimahalle location, is 11 °C.

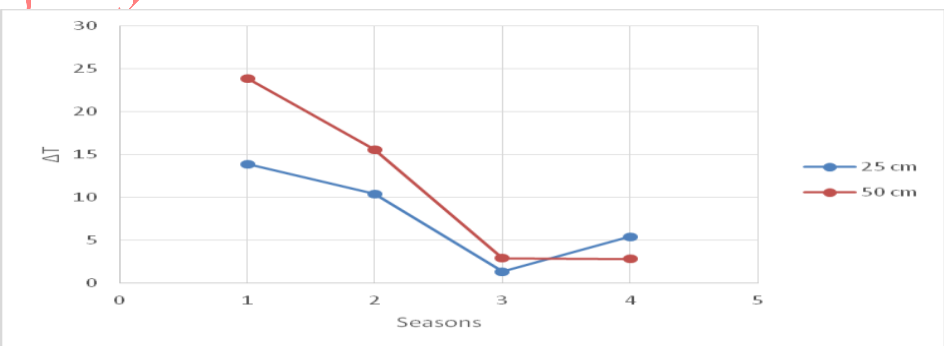

Figure 7. Maximum temperature differences according to seasons in Bağlum Location (Bağlum konumunda alınan mevsimlere göre maksimum sıcaklık farkları)

The highest ΔT graph is created for 25 cm and 50 cm soil depths in the Bağlum location, according to seasons. Number 1 represents spring, number 2 represents summer, number 3 represents fall, and number 4 represents winter. In spring, the largest temperature difference was observed.

After completing one year of field research, the obtained maximum and minimum temperature differences are given below.

Table 1. The maximum temperature differences in the four seasons (Dört mevsimdeki maksimum sıcaklık farkları)

Data	ΔT_{max} °C 25cm	ΔT_{max} °C 50cm
Spring	-13,9	-23,9
Summer	10,4	15,6
Fall	2,2	-6,4
Winter	-8,1	-10,9

The parameters of EATEG for ΔT, also including the real temperature differences measured in the field were simulated in laboratory studies. The custom experimental setup that was created for this goal is given below [2,3,7].

Figure 8. TEG Test Mechanism (TEJ Test Düzeneği)

In this experimental setup, custom-made linear heating devices were used to create a temperature difference between the surfaces of the generator. A plate-shaped heater with A=8 cm B=5 cm, AxB, operating with 220 V AC, was used in the experiment. The total resistance of the heater, including the cable, was measured at 0.564 kΩ with a T-YAN MY-64 type multimeter. According to this data, the thermal power produced by the heater is $P = U^2 / R$, and the heater's power value is $P = (220)^2/564 = 85.815$watts.

The earth-air generator designed by TES Ltd. was tested and approved in terms of what temperature difference and what value of power is enough to launch (to create the example application for) a safety system. When the EATEG is measured, it is at 21.4 volts when it is unloaded and at 5 volts when it is loaded. It is observed that the safety system is working during the measurement phase when EATEG is neutral at 21.3 volts and when it is charged at 5 volts.

5. RESULTS AND DISCUSSIONS
(BULGULAR VE TARTIŞMALAR)

For ΔT that includes the temperature differences calculated during field studies, EATEG parameters are calculated experimentally and compared to theoretical results. During theoretical calculation, for a real EATEG's H=25cm, D = 9,6cm, ΔT = 8°C, the output voltage 1,5 V, power 1,2mW and for the thermoelectric module, Z = 2,6*10^{-3} / °C values are used. Both theoretical and experimental results are identical, with an error margin of not more than %5. These findings are shown in Figure 9.

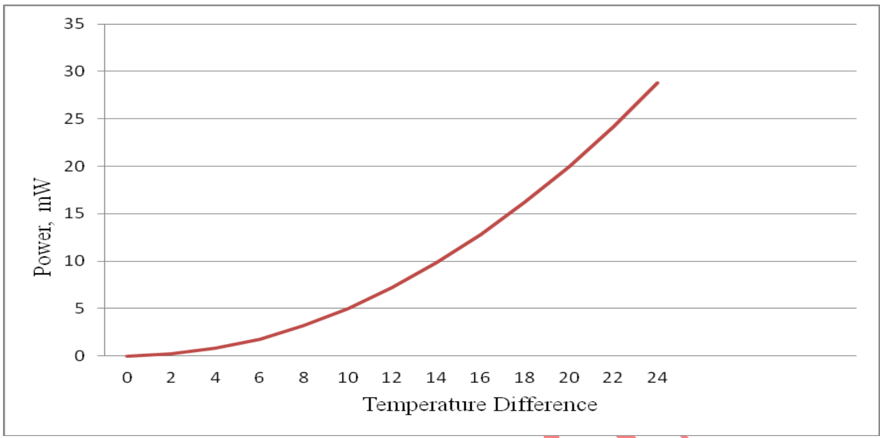

Figure 9. Power Chart of EATEG (THTEJ'ün Güç Eğrisi)

Voltage-power-current features of EATEG are gathered and compared to theoretical results. The findings are shown in Figure 10.

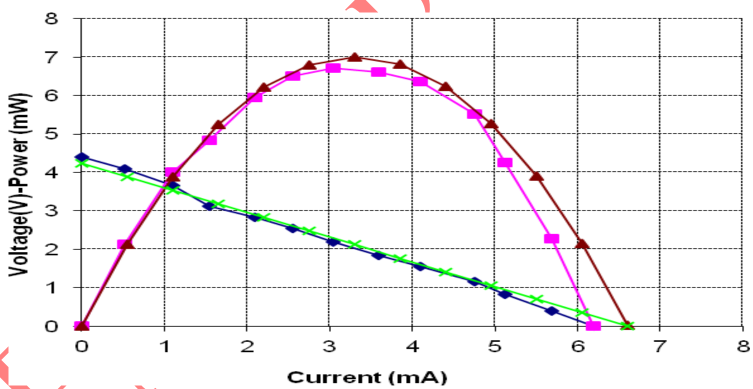

Figure 10. Thermoelectric Features of EATEG (THTEJ'ün Termoelektrik Özellikleri)

As shown in Figure 10, experimental and theoretical results are quite similar[8-10].

6. CONCLUSIONS (SONUÇLAR)

This study analyses and examines the Earth-Air Thermoelectricity Generator (EATEG) both theoretically and experientially, which works with earth temperature and is recommended to be used peculiarly in safety systems. To examine how EATEG functions in natural conditions, temperatures at the soil depth and soil surface that were equal to the length of the generator, and temperature differences between these locations ΔT were measured and modelled throughout four seasons in five different districts in Ankara. T_{max} = 23,9°C and T_{min} = 2,2°C are measured according to the data. To categorize all temperature differences that include these values as well, experimental research is carried out in a EATEG laboratory The theoretical and experimental results obtained were compared to one another. In addition to the standard TEG theory, a mathematical model of EATEG is developed to either design a thermoelectric earth-air generator and to calculate its parameters by using both the thermic processes where the thermoelectric generator works well for these processes. With a custom test setup designed for experimental operation, thermoelectric parameters including power P(W), voltage U(V), and current I(A) produced by the generator are found to be in conformity with the experimental results. Both theoretical and experimental results are identical, with an error margin of not more than 5%. As a prototype application, it was discovered that a specially constructed actual safety system operates with an earth-air generator.

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DECLARATION OF ETHICAL STANDARDS (ETİK STANDARTLARIN BEYANI)

The author of this article declares that the materials and methods used in her studies do not require ethics committee approval and / or legal permission.

Bu makalenin yazarı çalışmalarında kullandığı materyal ve yöntemlerin etik kurul izni ve/veya yasal-özel bir izin gerektirmediğini beyan eder.

AUTHORS' CONTRIBUTIONS (YAZARLARIN KATKILARI)

Günay ÖMER**:** She conducted the experiments, analyzed the results and performed the writing process.

Deneyleri yapmış, sonuçlarını analiz etmiş ve maklenin yazım işlemini gerçekleştirmiştir.

CONFLICT OF INTEREST (ÇIKAR ÇATIŞMASI)

There is no conflict of interest in this study.

Bu çalışmada herhangi bir çıkar çatışması yoktur.

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