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# Development Of An Android-Based Application To Be Used In The Calculation Of Biogas And Electrical Energy Potentials Of Different Livestock Manure

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**Abstract:** Today, in parallel with the increasing world population, the amount of waste and energy deficit is growing steadily. In order to ensure the sustainability of the resources available in this process, the environmental damage of waste should be minimized and innovative approaches should be undertaken. Especially recently, biogas production from organic wastes has been considered as an alternative for the effective use of resources. Since organic wastes are used in the biogas production process, not only the wastes are removed from the production facilities but also the energy acquisition makes waste management systems necessary. Data operating environments are important sources for demonstrating different capacities and alternatives in waste management. In this context, an application has been developed on the MIT App Inventor 2 platform that can calculate biogas and electrical energy potentials according to the characteristics of 7 different farm animals' manure including dairy cattle, beef cattle, calf, sheep, goat, laying hen and broiler. As an example, biogas potential was calculated using the dairy and beef cattle data in Biga district of Çanakkale.

**Key words:** Manure management, biogas generation, environmental quality, smart devices, Android programming.

# Farklı Hayvan Gübrelerinin Biyogaz Ve Elektrik Enerjisi Potansiyellerinin Hesaplanmasında Kullanılacak Android Tabanlı Bir Uygulamanın Geliştirilmesi

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**Özet:** Günümüzde, artan dünya nüfusuna paralel olarak atık miktarı ve enerji açığı giderek büyümektedir. Bu süreçte, mevcut kaynakların işlevselliğini sağlamak için atıkların çevreye verdiği zararlar en aza indirilerek yenilikçi yönelimlere girişilmelidir. Özellikle son yıllarda, kaynakların etkin kullanımı için organik atıklardan biyogaz üretimi bir alternatif olarak değerlendirilmektedir. Biyogaz üretim sürecinde organik atıkların kullanılması nedeniyle atıkların üretim tesislerinden uzaklaştırılmasının yanında enerji elde edilmesi atık yönetim sistemlerini gerekli kılmaktadır. Atık yönetimi konusunda farklı kapasitelerin ve alternatiflerin ortaya konulması için veri işletim ortamları önemli kaynaklardır. Bu bağlamda süt sığırı, et sığırı, buzağı, koyun, keçi, yumurta ve et tavuğu gibi 7 farklı çiftlik hayvanının karakteristik özelliklerine göre biyogaz ve elektrik enerjisi potansiyellerini hesaplayabilen MIT App Inventor 2 platformunda bir uygulama geliştirilmiştir. Örnek olarak Çanakkale'nin Biga ilçesinin süt ve besi sığırı varlığına göre biyogaz potanisyeli hesaplanmıştır.

**Anahtar Kelimeler:** Gübre yönetimi, biyogaz üretimi, çevre kalitesi, akıllı cihazlar, Android programlama.

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## 1. Introduction

Depending on population growth, there is an increase in the amount of organic waste. It is necessary to dispose of these wastes which have harmful environmental impacts. In search of new

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energy sources, it is becoming highly important to dispose of organic wastes as well as to use them as alternative energy sources in the production of biogas. Energy production from organic-based waste reduces fossil fuel use while eliminating environmental impacts (Tınmaz, 2017). Biogas production may help securing energy and reducing greenhouse gas (GHG) emissions throughout the world. Thus, biogas will soon be one of the important energy sources to ensure demand and energy supply (Özer, 2017).

Biomass is an important organic-based resource for biogas production. The term biogas refers methane ($CH_4$) that makes it a valuable heat and electricity resource (Abdullah et al., 2007). The main source of $CH_4$ emissions, released through ruminant eructation, is the enteric fermentation (Murray et al., 1999). Emission of $CH_4$ may be generated from various manure management systems including barns, storage units, and application of manure to land and defecations of livestock in pastures. The management of manure from production phase to final use needs to be carefully evaluated when evaluating the effects of entire process on emissions and nutrient recycling and recovery. Manure management provides alternatives to better understand the nutrient content in it (Hou et al., 2017). The production of biogas from animal manure is achieved through the efficient use of manure management systems. For this reason, manure management systems should be used effectively and innovative technological approaches should be used in order to ensure the disposal of manures in animal production utilities and to meet the energy needs.

One of these technologies is mobile applications that are compatible with smart devices. Agricultural mobile applications are generally capable of providing the most convenient access to information that can be used in trade, finance, shopping, and production (Qiang et al., 2011). Some examples of using mobile applications for agricultural purposes may include calculating the amount of crops, specific agricultural information according to the location, reaching the practices of leading farmers who obtain better crops, determining the amount of seed, fertilizer and medicine to be thrown into the unit area more accurately and easily etc. (Hacıyusufoğlu and Guler, 2016). In this context, new approaches and technologies in animal manure systems require the use of mobile networks and applications that will significantly reduce the workload (Herbut et al., 2017).

Android is an operating system used on mobile devices and is also the most widely used application development platform for smartphones. The most important advantage of Android is that it provides an open source development platform for application developers. In this study, an Android-based mobile application which can calculate the total manure produced during storage

period, the biogas ratio, and the potential income equivalent of the biogas produced in consideration of the characteristics of 7 different farm animals' manure is developed.

## 2. Material and Method

### 2.1. Development of Android application

The mobile application was developed by using MIT App Inventor 2 web-based platform. MIT App Inventor 2 allows users to develop applications for the Android operating systems (Pokress and Veiga, 2013). It provides a graphical user interface that allows developers to use visual drag-and-drop objects instead of coding. The block-based coding environment provides a useful and creative tool which is highly powerful for developers to create different mobile applications (Tempel, 2013).

Android applications are presented as package files with apk extension. This package contains all the resources of the application (source codes, image files, fixed values, etc.). Android applications are developed using the Java programming language. However, it is implemented in a virtual machine called Dalvik Virtual Machine (DVM) (Pocatilu, 2011).

### 2.2. Models used in the application

The first issue to be addressed is the removal and preservation of the liquid manure produced during the storage period. The high moisture content of liquid manure, which has more stickiness and retention, makes it ideal for biogas production than dry manure. When calculating the amount of collectible liquid manure, some assumptions are used such as average daily manure production per animal and the rate of useful collected liquid manure (Yağlı and Koç, 2019). In the developed Android application, the values that show the average daily manure production per animal and collectible liquid manure rates for 7 animal species are provided. The amount of useful collectable liquid manure and the volatile solids in liquid manure were calculated using the following Equations (1,3).

$$CLM = DMP \times CLMu \times NoA \times SP \quad (1)$$

$$SMR = CLM \times CLMr \quad (2)$$

$$VMR = SMR \times VMRs \quad (3)$$

Where; CLM is amount of useful collectable liquid manure (ton), DMP; daily manure production per animal (kg), CLMU; the rate of useful collectable liquid manure (%), NoA; number of animals, SP; storage period (day) SMR: amount of solid matter rate in liquid manure (ton), CLMR; rate of useful collectable liquid manure (%),VMR; amount of volatile matter rate in solid matter (kg), VMRS; volatile matter rate in solid matter (%).

The most common animal wastes for biogas production in the world are; cattle, sheep, goats, pigs and poultry manure. Off those manure types, cattle manure is the most important source of animal-based biogas production. The most important reason for this is that the amount of manure per day is more than other types. The ratio of solid matter in the manure of beef cattle is higher than dairy cattle. Since the content of water and fiber in dairy cattle manure is high and the fiber is highly resistant to decay, a lower rate of methane gas is obtained (Marañón et al., 2012). When goat and sheep manure are mixed with poultry and pig manure with similar chemical characteristics, anaerobic decay time is prolonged and biogas production is less. As a result of mixing goat and sheep manure with cattle manure, biogas production is more efficient (Cestonaro et al., 2015). The Equations (4,5) used in calculating the amount of methane to be obtained from useful manure and the energy equivalent of methane are given below.

$$\text{TMP} = VMR \times DMeR \quad (4)$$

$$\text{EEM} = TMP \times TVM \quad (5)$$

Where; TMP is total amount of methane production ($m^3$), $DM_eR$; daily methane production ($m^3\ kg^{-1}$) , EEM; energy equivalent of methane (MJ), TVM; thermal value of methane ( MJ $m^{-3}$).

### 2.3. Obtaining electrical energy from biogas

The conversion of biogas into electricity takes place in two ways. These are combustion and gasification techniques. In combustion-based production, chemical in the combustion operation, fuel to heat energy is transferred to heat and secondary fluid expands in the heat exchanger and heat exchanger produces mechanical energy in the turbine or similar system. In gasification-based production, a controlled amount of oxygen and stream reacts without combustion at high temperatures and fuel called syngas is produced (Spliethoff, 2010.)

The energy equivalent of the methane produced was found in MJ and the amount of electrical energy production was calculated by using 1 MJ = 0.2778 kwh equality. The monetary

equivalent of the generated electrical energy was found by taking into account the current cost of 1 kwh in TL (Equations 6,7).

$$\text{EEP} = EEM \times 0{,}2778 \quad (6)$$

$$\text{GEE} = EEP \times \text{Vkwh} \quad (7)$$

Where; EEP is electrical energy production (Mwh), GEE; TL equivalent of the generated electrical energy (TL), Vkwh; TL value of 1 kwh energy.

Methane released from animal manure has 23 times more greenhouse gas effects than the same amount of $CO_2$ ( Kaya et al., 2009). It is considered that 1 kWh electricity saving corresponds to approximately 0.58 kg $CO_2$ emission ( Koç et al., 2019). The following Equation (8) is used to calculate the blocked $CO_2$. The flowchart of the application is given in Figure 1.

$$BCO_2 = EEP \times 0.58 \quad (8)$$

Where; $BCO_2$ is amount of blocked $CO_2$ (ton). Using the above mentioned methods, the flowchart of the application is given in Figure 1.

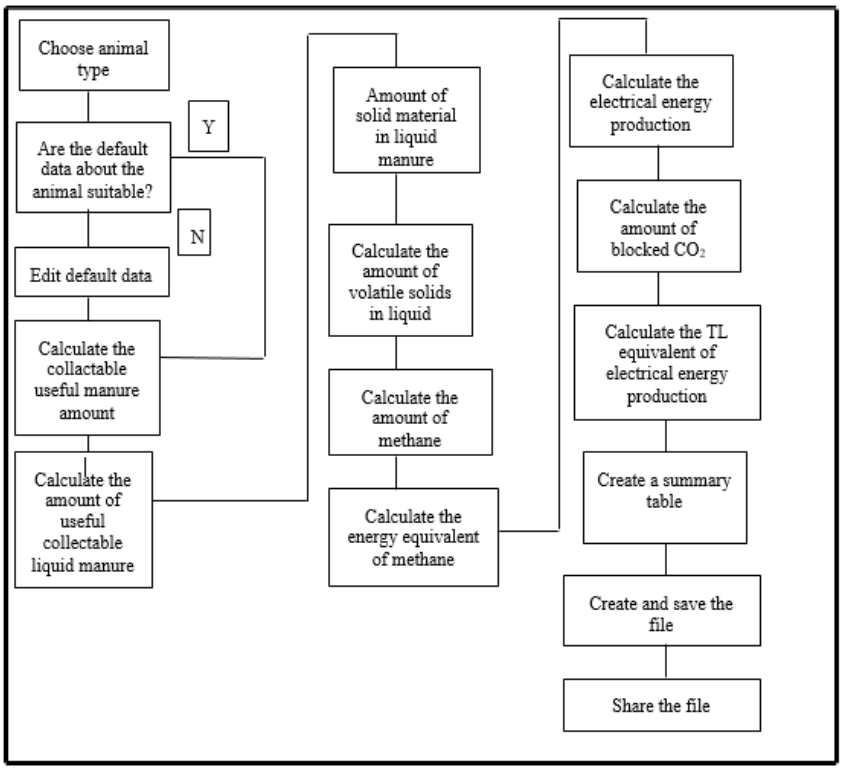



Figure 1. The flowchart of the application

## 3. Results and Discussion

With the application developed, biogas and electrical energy calculations can be made only by entering the number of animals and storage time by clicking the "Calculate" button. The green default values can be changed by the user; the yellow values have been found as a result of calculations and cannot be changed. The first step is selection of animal species given in Figure 2.

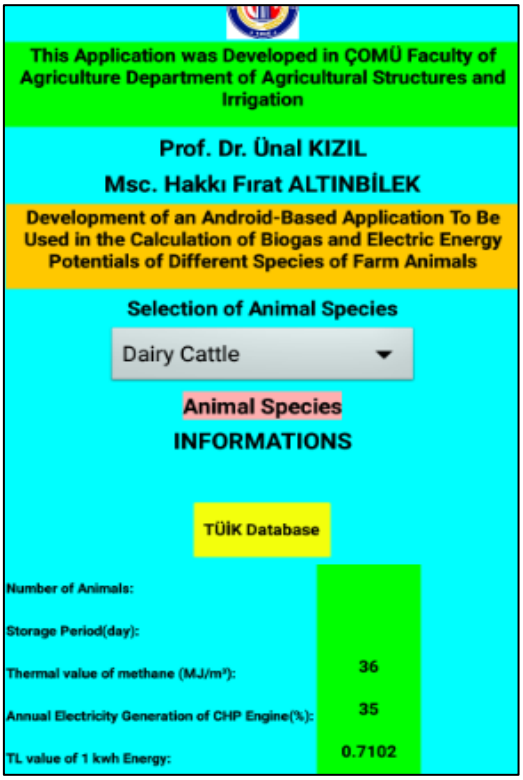



Figure 2. The selection of animal species

In the developed application, by clicking the "TÜİK Database" one can reach the Turkish Statistics Institutes' (TÜİK) database to get the number of animals that are raised in a particular region of Turkey. In our case study numbers of dairy and beef cattle obtained from TÜİK's 2019 data for Biga district of Çanakkale to demonstrate an example. Accordingly, Biga's biogas and electrical energy calculations for 25963 dairy and 5832 beef cattle and assumptions used in these calculations are given in Figure 3 and 4, respectively.

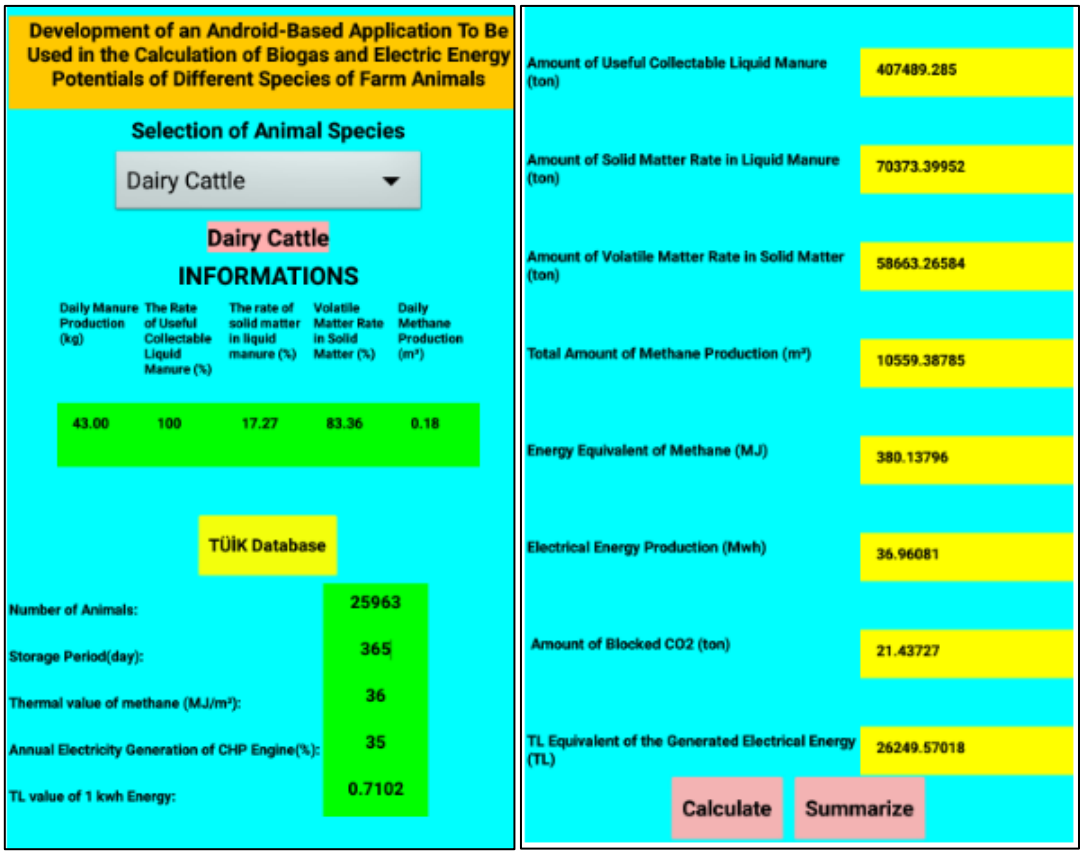



Figure 3. Example of dairy cattle biogas and electricity potential

As it is seen, in the pulldown menu, dairy cattle were selected and the default values for the selected animal was shown below in the “Informations” section. By clicking “Calculate” 407,489.29 tons of collectible useful liquid manure, 10,559.39 $m^3$ methane, 36.96 Mwh electrical energy and potential income would be 26,249.57 TL for a 365-day storage period was calculated.

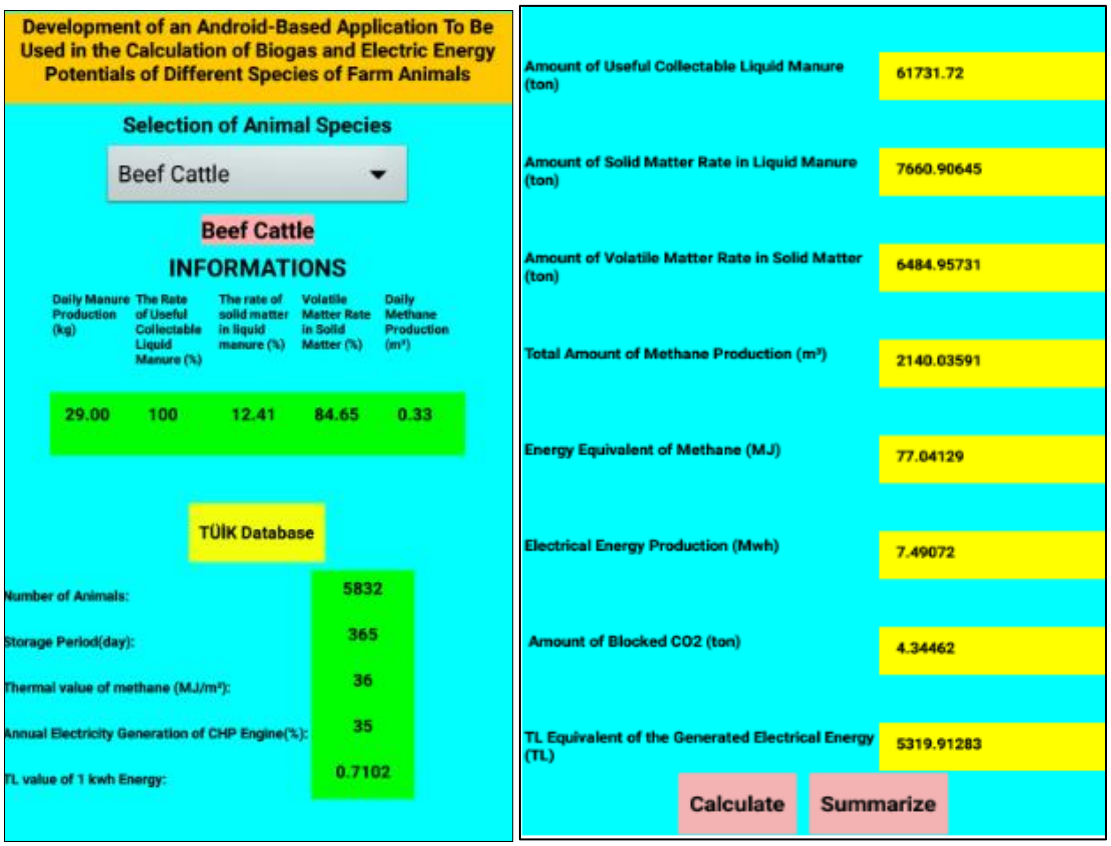
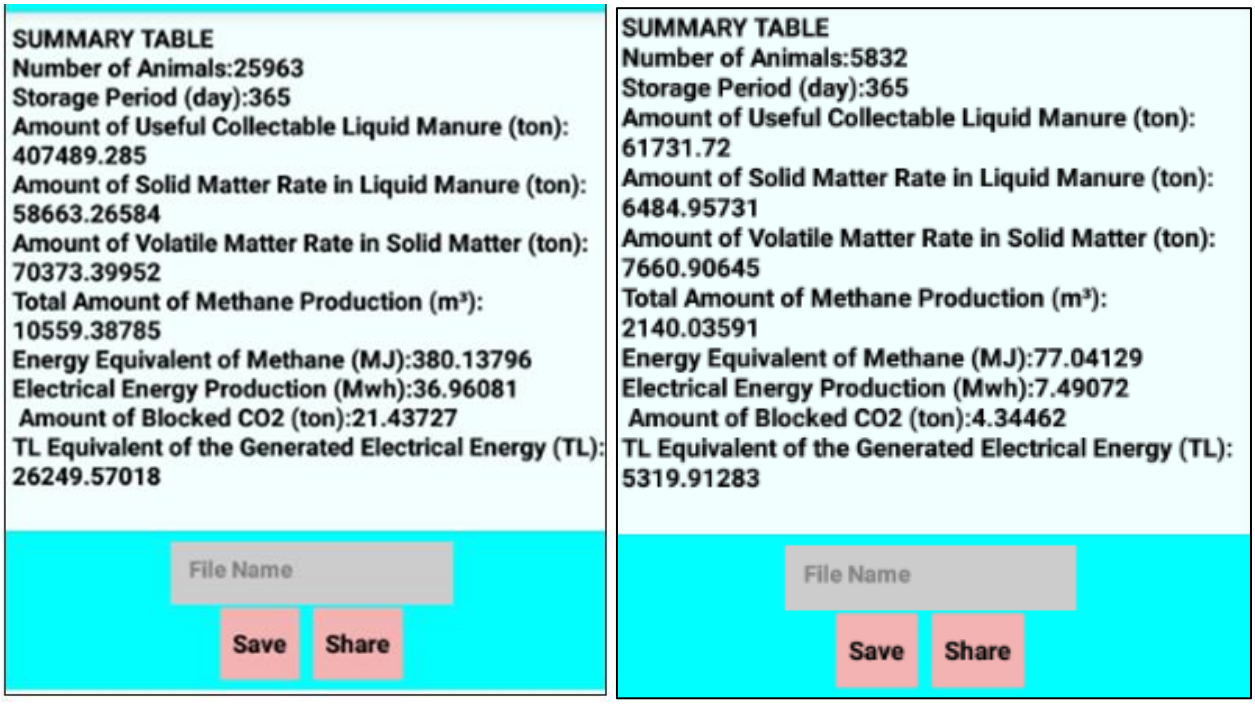



Figure 4. Example of beef cattle biogas and electricity potential

Similarly, in the pulldown menu, beef cattle was selected and the default values for the selected animal was shown below the “Informations” section. Total of 61,732.72 tons of collectible useful liquid manure, 2,140.04 $m^3$ methane, 7.49 Mwh electrical energy and potential income from this biogas production of 5,319.91 TL for a 365-day storage period was found by clicking “Calculate” button.

In the last stage of the application, it is provided to display the information and data of all calculations as a summary. Finally, by clicking the "Summarize" button, a summary of all the information calculated in the above steps is provided. In this way, all the information can be seen and checked at the same time. Figure 5 shows the summary table for dairy cattle calculations and beef cattle calculations.




(a) (b)

Figure 5. Summary tables for dairy cattle (a), and beef cattle (b) calculations

In order to save the calculated results in a single file user first need to enter a file name. Followed by entering a file name by clicking the Save button, all the summary table information is saved as a csv file into the mobile device's memory. There is a "Share" button right next to the "Save" button. When the Share button is clicked, it is asked to choose which application to share on the screen. Sharing the csv file is provided by selecting any of the applications installed on the device such as WhatsApp, Gmail, Hotmail.

## 4. Conclusion

The popularity of biogas which is one of the renewable energy sources is increasing day by day. The biogas obtained from animal manure not only enables the sustainable control of animal manure but also reduces dependency on fossil fuels. In order to practically calculate and evaluate the biogas production potential of a region or operation, an Android application is developed. Thus, a data analysis platform was created for biogas calculations and the opportunity to share information with other users was provided. With the application developed, electrical energy production of Biga which has 25,963 dairy cattle according to 2019 data is approximately 36.96 MWh and its potential income is 26,249.57 TL. On the other hand electrical energy production of

Biga which has 5,832 beef cattle according to 2019 data is approximately 7.49 MWh and its potential income is 5,319.91 TL. In the developed application, since the cost varies depending on the location, condition and annual use of the facility the cost expenses were excluded when performing biogas calculations.

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