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Original Research Article

Ecovillage Design and Applicability to Akçalar District of Bursa

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ABSTRACT

Today, with the change in consumption habits, the decrease in natural resources causes concerns about meeting future generations of these resources. Ecovillages, which are the representatives of self-sufficient life culture and ensuring the sustainability of natural resources, stand out as an important initiative in preserving the natural balance and ensuring a sustainable nature-human relationship. In this study, successful ecovillage initiatives in the world and our country have been examined, and the applicability of ecovillage in Akçalar District, located in the Nilufer-Bursa, has been evaluated in terms of the biogas energy potential that can be obtained from animal wastes. It has been determined that 730 cattle waste in the farms located in the neighborhood, which is developed in animal production, have a daily biogas potential of 1505.625 m^3. This potential in electricity generation can be provided annual electrical energy of 2547517.5 kWh.

Keywords: Ecovillage, Sustainability, Energy, Biogas, Electricity

INTRODUCTION

With the development of technology, industrialization, urbanization, and rapid population growth in the last century we live in, the increasing need for natural resources leads to excessive depletion of these resources. In parallel with industrialization, the rapid development of cities creates a great pressure on the world by causing many environmental problems such as air pollution, water pollution, waste problem, noise, unplanned urbanization, global warming, forest destruction, loss of fertile soil layer (Deniz 2009). It is essential to adopt a life culture that consumes less natural resources and adheres to sustainability, equality, and cooperation to ensure the continuity of human well-being and leave a more livable world for future generations. With the creation of small-scale settlement areas called ecovillages as a sustainable living space in harmony with nature since the 1970s by communities acting in line with this purpose, human needs have begun to be met in a way that will cause minor damage to nature (Zeybek 2015).

Ecovillage is defined as sustainable settlements where people live in harmony with nature and other living things and are self-sufficient. Living and production areas are planned in a balanced way, where renewable energy sources are used, and waste management systems are applied (Yaban and Karatopuk 2017). Ecovillages are traditional settlements or newly established conscious communities located in rural or urban areas in developed and underdeveloped countries, aiming to combine participatory and supportive social structures with environmental design practices and green technologies (Adalılar 2012). Ecovillages stand out as a promising initiative to restore the deteriorated world balance (Zeybek and Arslan 2019). The main environmental benefits of ecovillages include maintaining ecological principles, making cities suitable for the climate and environment by planning them as natural cities, preventing environmental pollution, protecting flora and fauna, using rainwater, reducing greenhouse gas emissions, reducing the use of fossil energy resources, generating electricity, as well as electricity generation utilization of renewable energy resources in transportation and industrial activities, dissemination of clean and ecological transportation systems, production of solutions for public transportation, waste recycling, harmony with nature, energy efficiency, protection of biological diversity and endangered species (Yıldız 2016; Kılıç and Iscan 2019).

Different economic activities can be carried out on a sustainable scale in ecovillages. These activities include biological agriculture, tourism activities, ecological product production, education, art, construction

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activities, labor-intensive works. When the differences between the existing villages and ecovillages are examined, it is seen that the environmental sensitivity in the existing villages is very low compared to the ecovillages, the solidarity and cooperation between people at the point of producing and developing typical value is at a higher level in the ecovillages. The local economic structuring is more planned and well-managed in the ecovillages than in the existing villages (Kılıç and Iscan 2019). In order to be able to develop in ecovillages and reduce their ecological footprints, the energy needs of the community can be reduced by the use of high technology that shows low energy needs (Köse *et al.* 2017).

Ecovillages are divided into two groups according to the way they are formed. The first of these is establishing ecovillage settlements in an empty area. The other is the conversion of the existing settlement into an ecovillage. The choice of location in ecovillage formations is one of the most critical parameters for the success of the ecovillage. It plays an essential role in the ecological, economic, social, and cultural sustainability of the ecovillage (Zeybek 2020). There are 1030 ecovillages registered in the Global Ecovillage Network, which works to connect ecovillages and ecovillage communities and strengthen these initiatives. It is reported that 358 of them are located in the European Region (Ciğerci and Öğlek 2021).

In this study, examples of ecovillages in the world and our country have been extensively examined. The applicability of ecovillages in Akçalar District of Bursa has been evaluated in terms of the biogas energy potential produced from manure wastes originating from the livestock sector.

EXAMPLES OF ECOVILLAGE FROM THE WORLD AND TURKEY

Ecovillage examples from the world

Auroville Ecovillage: Auroville Ecovillage located in Tamil Nadu State of South India, was opened on February 28, 1968 (Figure 1). All 88% of the campus where it was established is reserved for nature formations, agriculture, and farm areas. The population of the ecovillage, which was home to 322 people in 1974, reached 3273 people in 2021. There are people from 59 nationalities on the campus (Kara 2014; URL-1 2021). In order to meet the energy needs of the campus, significant steps have been taken in the use of windmills, biomass, and solar energy, and the Auroville ecovillage has become an example throughout the country in the use of renewable energy. Auroville, which alone provides about 15% of India's renewable energy production, meets the energy needs of more than 150 houses from photovoltaic energy systems. All of the ecovillage's milk needs and nearly half its fruit and vegetable needs are produced on the campus. An extensive seed bank with tree and vegetable seeds in the ecovillage (Dawson 2006; Kara 2014).

Figure 1. A view of the Auroville ecovillage (URL-2 2021).

Ithaca Ecovillage: Ithaca, the most famous ecovillage in North America, is considered an urban ecovillage (Zeybek 2020). Ithaca ecovillage, one of the largest communal housing communities globally, consists of 3 neighborhoods on an area of 175 decares and is home to more than 200 people in 100 houses. There are several working farms, office spaces, community gardens, meadows, ponds, and woodlands. More than 80% of the 175-decare area in the ecovillage is planned as open green space (URL-3 2021). Large windows and glass walls were used on the south facades of the buildings to make the most of the sun. Every neighborhood in Ecovillage was built using new technologies (Zeybek and Arslan 2019). Figure 2 shows a view of Ithaca Ecovillage.

Figure 2. A view of the Ithaca ecovillage (URL-4 2021).

Solheimar Ecovillage: Solheimar, which was founded in Iceland in the 1930s, is known as the oldest ecovillage in the World and Europe (Figure 3). Creating an environment where individuals can live, work, and socialize to meet their social needs has been seen as one of the main goals in the ecovillage. Approximately 100 people live in Ecovillage. In the ecovillage, organic greenhouses and woodland are used to grow vegetables and plants. The geothermal system supports the hot water and heating system on the campus. Ecovillage has a commercial electricity network that provides 80% of its energy from geothermal and hydraulic energy. The use of natural light is maximized thanks to the windows used. There are workshops where various activities are carried out on the campus where products such as candles, ceramics, weaving and carpet making, fine arts, paper making and soap, shampoo, and lotion are made (URL-4 2021; URL-5 2021).

Figure 3. A view of the Solheimar ecovillage (URL-6 2021).

Crystal Waters: Crystal Waters was established on 650 acres of land in Australia, the ecovillage has rich flora and fauna. In the ecovillage, which hosts educational tours, training is provided on the history of the ecovillage, permaculture design, introducing the houses, gardens, and agricultural fields to the participants and explaining their functions (Zeybek 2014). The ecovillage, which has the world's first permaculture village title, does not form a real community (Figure 4). Ecovillage, which won the World Habitat Award in 1996 in sustainable living, is not allowed to enter cats and dogs to protect wildlife. There is a market area where local products, herbs, and handicrafts are sold (Bartu 2020).

Figure 4. A view of the Crystal Water ecovillage (URL-7 2021).

Mbam and Faune Ecovillages: These villages, which are two communities located south of Dakar, the capital of Senegal, aim to be sustainable in areas such as culture, economy, health, and spirituality. Mbam ecovillage is located in the Sine-Saloum delta, 100 km from the capital, while Faune ecovillage is located further south in the Casamance Region. The reason that distinguishes Mbam and Faune from other communities in the region and makes it an ecovillage is the presence of a group of influential people at the community center. These people are

determined to control the future of the community. Thanks to these people who applied to GEN, the Global Network of Eco-villages, they were able to take place in the group classified as eco-villages today. Today, both communities have become research and application centers for the surrounding regions. They continue to name for themselves with some of the social studies they have done (Dawson 2006; Köse *et al.* 2017). Figure 5 shows a view of Mbam Ecovillage.

Figure 5. A view of the Mbam ecovillage (URL-8 2021).

Ecovillage examples from Turkey

Although there were few in our country in the beginning, it is stated that there are many ecovillage initiatives in almost all geographical regions today, and it is reported that Hocamköy, which was established in Kırıkkale in the late 1990s, is the first ecovillage experience in our country (Asımgil 2017). The project, which aims to find viable solutions to the ecological problems faced by Anatolia, together with the villagers and farmers of the region, and to offer a self-sufficient model to the Anatolian villagers, was carried out in the field studies in 1997 and 1998, improving the soil with permaculture methods, agricultural activities and building adobe houses. Although the project ended in 1998 without reaching its goals, the organizational model and goals set an example for the following ecovillage initiatives (Adalılar 2012). Figure 6 shows the distribution map of ecovillages in our country.

Figure 6. Distribution map of ecovillages in our country (URL-9 2021).

Belentepe Permaculture Farm: Belentepe Permaculture Farm was located in the Belentepe region southwest of Uludağ, was established on a 14-decare land. The farm is owned by a single family and has no members. In the context of ecological sustainability, the farm includes activities such as permaculture designs, ecological farming practices, soil improvement and improvement, organic food, and clean energy production. The fertilizer requirement of the land is met with organic waste compost and worm manure. In the farm, which provides electricity needs from photovoltaic panels and wind energy, the need for hot water is met by solar energy. In order to increase the water-holding capacity of the farm where water is harvested for irrigation of agricultural fields, crevices and ditches have been created in the soil. The water used in the buildings is recycled; gray water is collected in ponds and used for agricultural irrigation. Belentepe founders host different groups on their farms and provide them with information about ecological awareness and sustainable living models. Participants can learn about ecological agriculture and permaculture designs and experience ecological farm life (Ciğerci and Öğlek 2021). Figure 7 shows a view of the Belentepe farm.

Figure 7. A view of Belentepe farm (URL-10 2021).

Latif Yalçıner Farm: It is located in the Kemaliye district of Erzincan. It is possible to participate in the farm as a volunteer or guest for 12 months, where accommodation is available for the guests. Certified ecological agriculture has been practiced since 2005 on the 15 decares of land on the farm (URL-11 2021). Pruning of fruit trees, grafting, weeding in March and May on the farm; irrigation in June and October, making pickles, syrups, and jams from picked fruits, harvesting mulberries, drying, making pulp and molasses; lambs, goats, and chickens are cared for throughout the year, and active participation of volunteers in these activities is possible (Şekerli 2018). Figure 8 shows a view of Latif Yalçıner farm.

Figure 8. A view of Latif Yalçıner farm (URL-12 2021).

İmece House Natural Life and Ecological Solutions Farm: This farm was established as an ecological camp in the Menemen district of İzmir in 2007, the ecovillage has gained the characteristic of an ecological farm over time. On the farm, which is cultivated with permaculture and natural agriculture principles, products such as olives, tomatoes, and figs are grown, and organic products such as olive oil, cheese, yogurt, and soap are sold. Economic income is also provided through the accommodation services offered in the ecovillage, which has significant potential in terms of ecotourism (Arıcan 2014). Figure 9 shows a view of the İmece house.

Figure 9. A view of the İmece House (URL-13 2021).

Dadalı Ecovillage: Dadalı ecovillage, which is connected to Düzce province Akçakoca district, has been declared a nationwide model ecovillage with the support of the East Marmara Development Agency (MARKA) with its project titled "Dadalı Village's Branding and Quality Management in Tourism" prepared by the Akçakoca Hazelnut and Chestnut Producers Association. Located next to the Düzce-Akçakoca highway and surrounded by agricultural fields, hazelnut groves, and leafy forests, the village consists of approximately 90-100 households. The village, where agricultural activities are carried out intensively, is located on podzolic soils. Dadalı ecovillage is located close to the ecotourism resources spread all over Düzce, with waterfalls, streams, plateaus, recreation areas, festivals and festivities, Genoese castle, etc. It is among the places that tourists who come to Dadalı ecovillage can visit. It is stated that there is accommodation opportunity in the village where organic products are sold. However, these activities do not contribute to the village economically due to their unplanned nature. It is stated that the village can be more successful in its activities carried out with a planned visitor system as a cultural tourism point (Gültekin and Gültekin 2017). Figure 10 shows a view of the Dadalı Ecovillage.

Figure 10. A view of Dadalı Ecovillage (URL-14 2021).

Güneşköy: Güneşköy Ecovillage, which was established on 75 decares of land in Hisarköy, which is connected to the Yahşihan district of Kırıkkale, was formed voluntarily and the number of members is 9. In Güneşköy, various studies are carried out in sustainability for ecological farming practices, renewable energy resources, the production of ecological solutions in architecture and transportation, the development of recovery systems, and the restoration of the deteriorated natural balance (URL-15 2021). Figure 11 shows a view of Güneşköy Ecovillage.

Figure 11. A view of Güneşköy Ecovillage (URL-16 2021).

MATERIALS AND METHODS

Study area

Within the scope of this study, the applicability of ecovillage in Akçalar District of Bursa was evaluated in terms of biogas production from cattle manure. Located on the shore of Uluabat Lake, 34 km from Bursa city center, the area around the neighborhood has been declared an industrial zone and continues its activities intensively. Many farms in the studied neighborhood and livestock activities are widely carried out as an essential source of livelihood (Kaplanoğlu 2021). With the increase in industrial facilities, the neighborhood population, which has been heavily migrated in recent years, has reached 6820 in 2020, which was 2921 in 2013 (URL-17 2021). Figure 12 shows the satellite image of the Akçalar.

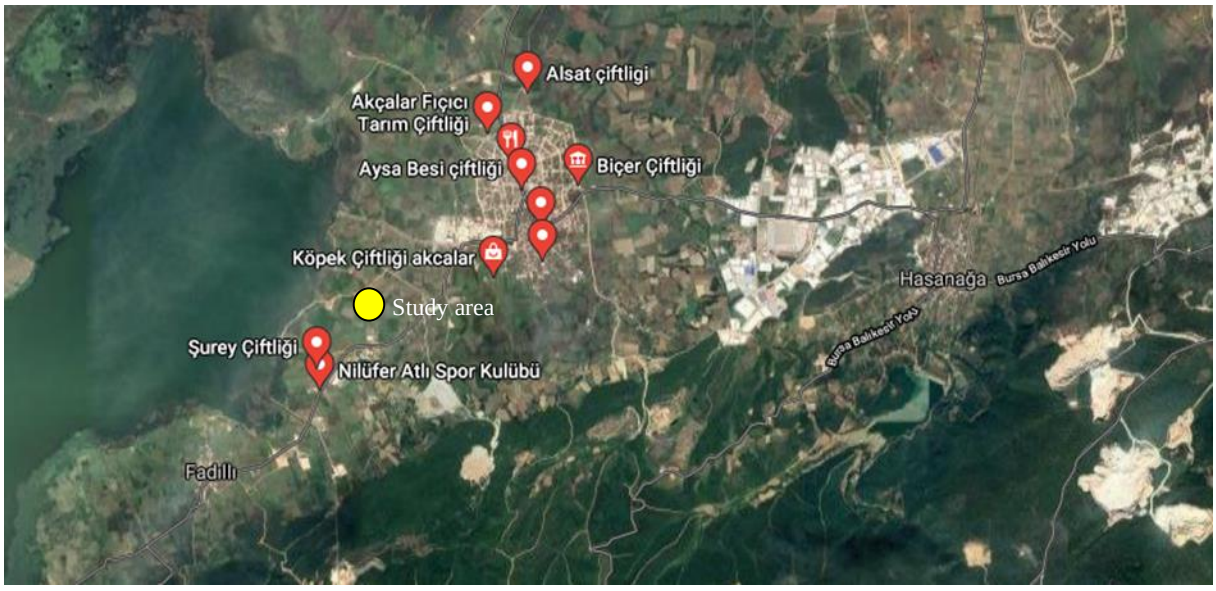

Figure 12. Satellite image of Akçalar (URL-18 2021).

RESULTS AND DISCUSSION

Ecovillage Applicability to Akçalar District

Akçalar Distrcit has an important historical value. As a result of the archaeological studies carried out within the boundaries of the neighborhood, Aktopraklık Mound, which is considered the oldest settlement of Bursa with a history of 8500 years, was unearthed and declared as a protected area and turned into an archaeopark (URL-19 2021). The neighborhood also has an important tourism potential due to its proximity to Uluabat Lake, which was declared a Wetland of International Importance (Ramsar Area) in 1998 and taken under protection (URL-20 2021). It is planned to establish a tent camping area in order to host local and foreign tourists and gain experience in farm life in the ecovillage, and it is thought that the energy need of this area will be met with biogas energy. It is envisaged to create a common ecological structure that also offers visitors the opportunity to cook, laundry, meet and train. The tent camping and common area design that is planned to be established is shown in Figure 13.

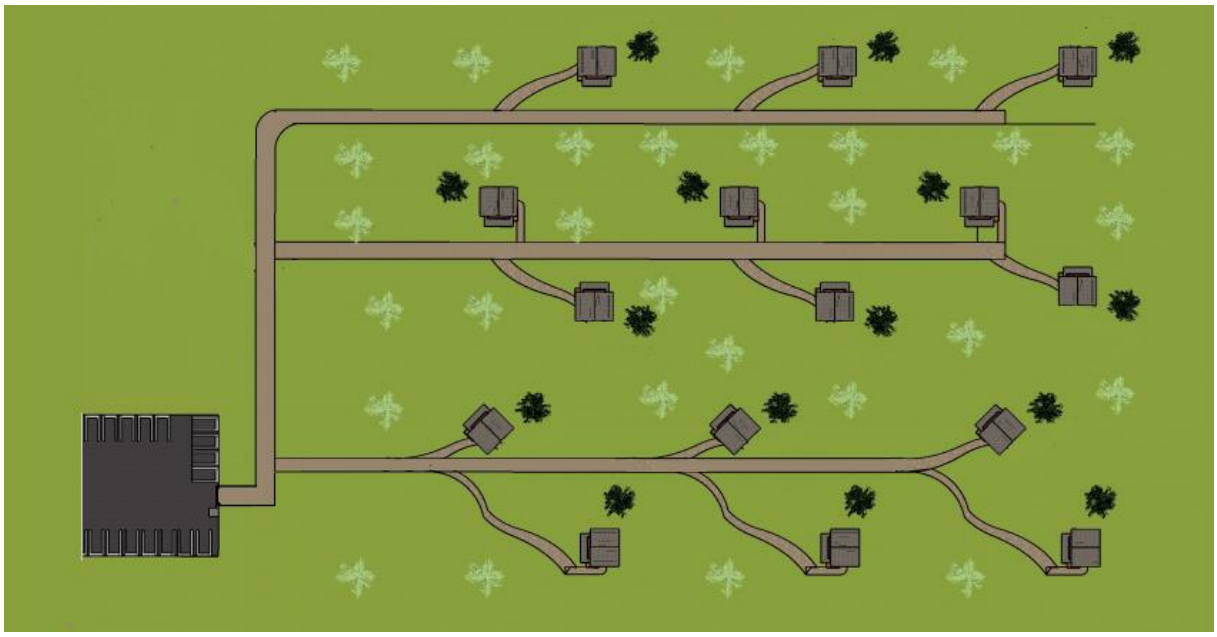

Figure 13. Design of tent camp and common area planned to be established.

Providing the Energy Requirement of Ecovillage with Renewable Energy

It is planned to carry out ecological agriculture works on a 10-decare land located in the rural area near the cattle farms of the neighborhood, and at the same time, it is considered to establish a biogas production facility on the land in order to reduce the effects of the manure formed in the farms on the environment and to meet the organic fertilizer requirement in ecological agriculture. The production of biogas and organic fertilizer from animal wastes is of great importance in preventing important environmental problems such as odor caused by wastes, and ground and surface water pollution. The maturation of the fertilizer in the biogas production process prevents the reproduction of parasites and pathogenic microorganisms, preventing the negative effects of the waste environment on the environment and human health, and the final product obtained can be used as an efficient soil conditioner (Gümüşçü and Uyanık 2010). The high amount of daily manure from cattle, when compared to other farm animals, increases the use of this waste source in energy production worldwide (Yagli and Koç 2019). In this study, the electrical energy obtained at the facility will be used to meet the energy needs in ecological agricultural production. The cultivation of agricultural products suitable for the soil structure and the use of local seeds will be ensured in production. Gray water, which is not contaminated with chemicals or feces, will be purified and used in agricultural irrigation. Similar to this study, 80 tons of cattle waste, 40 tons of

chicken waste and 5 tons of grass waste are processed daily in the biogas facility established on a 15-decare land in the Oğuzeli district of Gaziantep province and converted into organic fertilizer (URL-21 2021).

The applicability of ecovillage in Akçalar District has been evaluated in order to both protect the natural and historical beauties nearby and to evaluate the biogas potential it contains. The livestock operations in Table 1 are located near ecovillage. The amount of livestock manure used for biogas production in the ecovillage planned to be established in Akçalar District is given in Table 1. In line with the data in Table 1, the biogas and electricity production potential of Akçalar District was determined.

Based on the amount of fertilizer formed, the following assumptions were made for the biogas potential and the electricity production values to be obtained.

Admissions:

• 1 m^3 biogas = 4.7 kWh electrical energy equivalent (Gümüşçü and Uyanık 2010; Öztürk 2005)

• 275 m^3 biogas/ton organic solids (Gümüşçü and Uyanık 2010)

• Daily manure production = 50 kg/LU.day (LU: livestock unit)

Solid matter content = 15%

Daily Manure Amount by Number of Cattle

There are 730 cattle in total on the farms.

Accordingly, the daily amount of manure;

Daily amount of manure for 730 animals = 730 * 50 kg / day = 36500 kg / day of manure is formed.

Table 1. Amounts of manure from cattle production in Akçalar District.

Operation no	Field (da)	Barn Area (m^2)	Waste Area (m^2)	Number of Animal	Amount of manure (kg/day)
1	65	250	100	25	1250
2	30	250	100	25	1250
3	40	250	100	25	1250
4	24	250	100	25	1250
5	20	250	150	25	1250
6	24	250	100	25	1250
7	110	200	150	40	2000
8	35	210	100	35	1750
9	15	250	100	25	1250
10	55	240	150	40	2000
11	25	250	100	25	1250
12	4.5	180	100	30	1500
13	4.4	180	100	30	1500
14	4.3	180	100	30	1500
15	4.5	180	100	30	1500
16	4.5	180	100	30	1500
17	55	120	100	20	100
18	10	150	100	25	1250
19	100	600	200	70	3500
20	20	210	150	35	1750
21	25	250	150	25	1250
22	45	240	100	40	2000
23	30	800	100	50	2500
TOTAL				**730**	**36500**

Solid Matter Amount

The daily solids amount according to the total number of cattle with the solid matter ratio as 15%;

36500 kg / day * 0,15 = 5475 kg solid matter / day

Biogas Potential

Total Biogas production : 5475 kg solid matter / day * 0.275 m^3 biogas/kg solid matter = 1505.625 m^3biogas/day

Electrical Energy
With the assumption of 1 m^3 biogas = 4.7 kWh electrical energy equivalent;
According to the total amount of biogas;

Daily Electricity Production
1505, 625 m^3 biogas /day * 4. 7 kWh = 7076,4375 kWh / day

Monthly Electricity Production
7076,4375 kWh / day * 30 day = 212293,125 kWh / month

Yearly Electricity Production
212293,125 kWh*12 month = 2547517,5 kWh / year

Table 2 shows the amount of energy that can be obtained according to manure formation.

Table 2. The amount of energy that can be obtained according to the manure formation.

	Energy production
Total solid matter	5475 kg solid matter / day
Biogas production	1505. 625 m^3 biogas /day
Daily Electricity Production (kwh)	7076.4375 kWh / day
Monthly Electricity Production (kwh)	212293.125 kWh / month
Yearly Electricity Production (kwh)	2547517. 5 kWh / year

In a study carried out similar to this study, it was determined that approximately 87,645 m^3/day biogas could be produced from cattle, sheep, and poultry manure in Malatya (Koçer and Kurt 2013). In another study evaluating the biogas potential of manure originating from cattle, sheep, and poultry farming in the province of Erzincan, the annual amount of biogas that can be obtained was calculated as 15 511 011 m^3, the amount of electrical energy 38 025 864 kWh and the amount of heat energy 35 818 027 112 kcal. As a result of the biogas power plant scenarios created for electricity generation, it has been determined that an annual carbon emission reduction of 124,577 tons can be achieved (Badem 2017). In another study evaluating the biogas energy potential of our country from cattle manure, it was determined that there is an annual biogas production potential of approximately 3.7 billion m^3 and when this potential is used to obtain electrical energy, annual production of 8.9 billion kWh can be achieved and 10.3 billion kWh of heat energy can be obtained. (Tekeli 2014).

CONCLUSIONS

Although the developments in industry and technology have made human life easier in many ways, the intense consumption of raw materials and energy resources in the world and the pollution caused by these resources have created tremendous pressure on the world. They have brought critical environmental problems on a local and global scale. In order to overcome these problems, rational planning of consumption habits and less environmental impact on the world should be the common goal of humanity. Ecovillages, which offer an ecological life experience, offer a functional living space that aims to produce in peace with nature by consuming fewer resources and causing minor damage to nature, contrary to the immediate consumption approach brought by the age, with the activities carried out with an understanding of nature.

In this study, the evaluation of Akçalar, located in Nilüfer district of Bursa, as an ecovillage and the usability of its biogas potential in electricity generation were examined. As a result of the study, it was determined that the wastes from cattle breeding have a daily biogas potential of 1505, 625 m^3, and with this potential, 2547517, 5 kWh electrical energy can be obtained annually.

Wastes from animal production cause critical environmental problems such as air pollution, water pollution, and odor problems. Making use of the energy potential of these wastes and making them harmless to the environment is essential in reducing the need for fossil fuels and creating healthier living spaces. Although

there is a high biogas energy potential in our country, which has a significant added value in the livestock sector, it is seen that there is not enough work in this field. As a result, it is thought that the use of animal wastes in biogas energy generation is of great importance in ensuring energy efficiency in small settlements such as ecovillages.

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