7th TAE 2019
17 - 20 September 2019, Prague, Czech Republic

THE EFFECT OF THE CHANGE IN THE COMPOSITION OF THE SUBSTRATE IN THE AGRICULTURAL BIOGAS PLANT ON THE LOGISTICS OF MAIZE CHAFF

Sylwester BOROWSKI[1]

[1]*UTP University of Science and Technology, Faculty of Mechanical Engineering, Al. prof. S. Kaliskiego 7, 85-796 Bydgoszcz*

Abstract
The paper presents the effect of changing the composition of the substrate on the transport of maize chops to the agricultural biogas plant. The new substrate composition reduced the demand for maize from 25,000 tons to 12,000 tons. Apart from the obvious reduction in the number of transports and the distance traveled, a new delivery model was used. The change in the composition of the sub-plants allowed the reduction of the maize area for the biogas plant. This situation has reduced the maximum transport distance from over 30 km to 25 km in 2017. Maize straw was supplied by an external company with larger transport units. The use of larger transport sets in 2017 resulted in a decrease in the number of kilometers driven even by 59% for a distance of 5.1-10 km. This is directly relevant to the amount of CO_2 *produced by biomass transport. However, this solution may cause dissatisfaction among farmers who have previously earned money on biomass transport.*

Key words: *transport; biogas power plant; substrates; transport units.*

INTRODUCTION

Biomass of various origins can be used to produce biogas. It must, however, contain more than 30% biodegradable organic matter. The selection of biogas substrates has a significant impact on a number of important factors determining the kinetics of the fermentation process. Maize silage is a particularly useful biogas substrate. The advantage of silage as a substrate for biogas plants is to obtain a relatively large green yield from 1 ha. Not without significance is good susceptibility to ensiling and a large yield of biogas and methane in the anaerobic digestion process. This makes the plant used for energy purposes. The most important positive feature of maize silage is that in the operation of agricultural biogas plants, it ensures biogas production at a stable level and stable operation of the cogeneration unit (*Szlachta & Tupieka 2013*). However, its main disadvantage is the cost of growing corn and producing and transporting chaff (*Borowski et al., 2016, Zastempowski et al., 2013*)
The availability of substrates as close as possible to the installation should determine the size of the biogas plant and the power of the energy equipment. The assessment of raw material resources, their composition and biogas potential is the first step undertaken by the investor. The smallest distance from the installation can be considered for obtaining raw materials with low efficiency, low bulk density or low content of dry matter. In turn, the transport of substrates from larger distances is rational, provided they have a high biogas productivity. According to the Myczko (*2011*) assessment, the profitability of supplying substrates occurs within a radius of 10-30 km from a biogas plant. In turn, Podkówka et al. (*2012*) state that a distance greater than 4 km from a biogas plant means that the cost of transporting maize accounts for over 40% of the total costs of obtaining this substrate.

Each type of biomass requires a different logistic process and raises other problems related to harvesting, processing, storage or delivery. With other devices and barriers, you have to deal with solid biomass processing, and with others with liquid substrates. These difficulties result from the diversity of substrates processed for biogas. For this purpose, the change in the composition of the agricultural biogas plant substrate through the addition of waste is applied. However, such a change may cause a decrease in the quality of biogas (*Kaszkowiak et al., 2017*).
Technologies in the field of biomass use for energy purposes due to its low energy density should be related to distributed generation. The production of electricity and heat should develop in small generating units that use energy crops and agricultural waste (*Jasiulewicz & Janiszewska, 2012*).

This is related to the general trend to limit energy expenditure on biomass production for energy purposes (*Zastempowski et al., 2013, Zastempowski & Bochat, 2016*).
The ideal situation would be to use the raw material at its place of origin. In many cases this is impossible, therefore the transport distance should be as small as possible.
The maize biomass is harvested using a high-efficiency forage harvester, which allows to obtain the grinding of the raw material at a level of approx. 4 mm. Such good fineness allows for high biogas yield and satisfactory organic matter distribution. Maize chop is transported from the field using at least 3 farm tractors and 3 trailers.
The aim of the analysis was to determine the impact of the use of waste biomass from the production of gelatine on the cost of transporting maize biomass due to the reduction in demand for it. The real transport of biomass was taken as the basis for the research.

MATERIALS AND METHODS

Agrarian biogas power plant has been buying raw material (substrate) from farmers from the area around Rypin (Poland). It is maize and slurry. Slurry is collected from pigs farms. Farmers delivering products for biogas generation may in exchange receive postfermentation substance free from harmful substances which can also be used for fields' fertilizations.
Maize for biogas generation, is harvested from about 300 hectares. On average, from 1 ha of corn cultivation about 40 tons of green fodder may be harvested what gives the total sum of about 12000 tons. Demand for maize fell by 50% compared to the previously described situation *(Borowski et al., 2016)*. This situation is caused by the use of waste after the production of gelatin as substrates.
The raw material is colected at the turn of September and October. The harvest and transport of biomass in 2017 were carried out by a commercial external company, independent of the biogas plant. This is a significant difference from the situation in 2013. In that year, transport units were used for transport. In 2017, transport units with a capacity of 23 tons (average) were used for transport.
Then, ensilage is prepared at the territory of the biogas power plant.
Maize ensilage is prepared by green fodder's shredding and pressing. The process of ensilage's forming lasts for about 6 weeks, when by appropriate coverage and cutting off air, earlier prepared corn undergoes the process of ensilaging.
The study analyzed data on changes in the transport of maize biomass in 2017 as compared to 2013. Due to the reduction in the quantity of maize purchased, it is not possible to directly compare changes in the field of transport organization. In 2013, about 25,000 tons of maize chaff were purchased. It was transported by various transport units that belonged to farmers. In 2017, 12,000 tons of maize chaff were purchased. It was transported through large, identical transport units that belonged to one company.
In order to analyze the impact of the organization of transport on the number of transports and the number of kilometers traveled, it was decided to simulate. The simulation consisted in making for 2013 calculation of the number of transports and kilometers driven for the weight of maize chaff purchased in 2017.

RESULTS AND DISCUSSION

The analysis for the purposes of the article was carried out in accordance with the previously described methodology (*Borowski et al., 2016).* For the analysis the field of which was collected biomass was divided because of the distance from the biogas plant. Determined ranges about the size of 5 km.
The amount of the collected biomass (percentage of the total weight) is shown in Fig. 1.
As shown in Figure 1 in 2017, the largest amount of biomass expressed as a percentage was collected within the distance of 5.1-10.0 km from the biogas plant. This result coincides with that obtained in 2013. For 2013, the total amount of purchased biomass was about 25,000 tons. Biomass has been purchased in the entire range of transport decays. In 2017, the total amount of purchased biomass was 12,000 tons. The reduction of the demand for biomass from maize resulted in the rejection of the location above 25 km from the biogas plant.

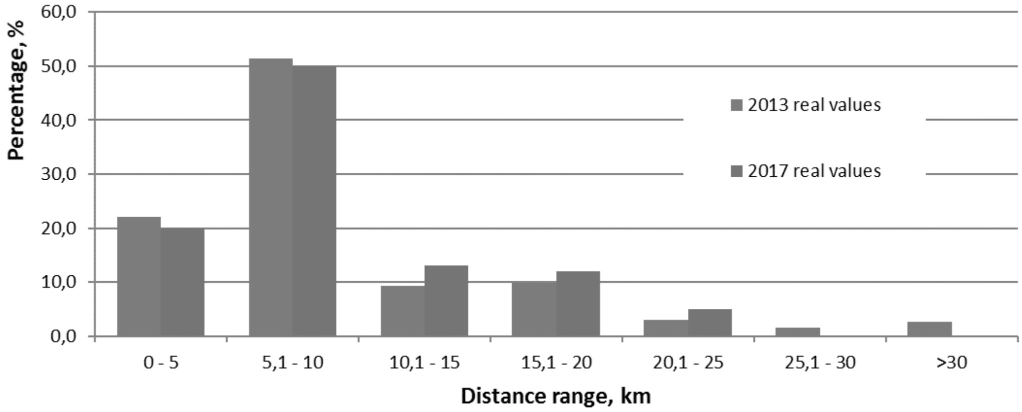

Fig. 1 The amount of biomass collected depending on the transport distance

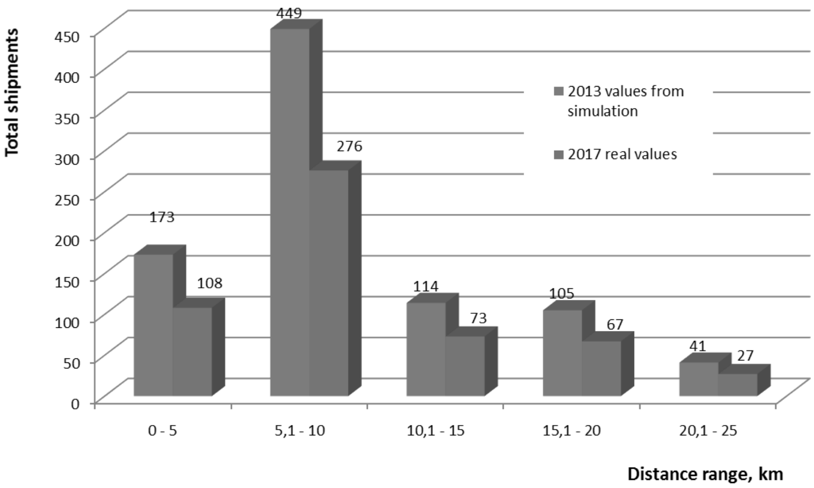

Fig. 2 Comparison of the number of shipments

As can be seen from Figure 2, the use of larger transport units has resulted in a significant reduction in the number of passes. The largest reduction to 59% occurred in the range of 15.1-20 km. This is due to the largest number of fields on which maize was harvested.

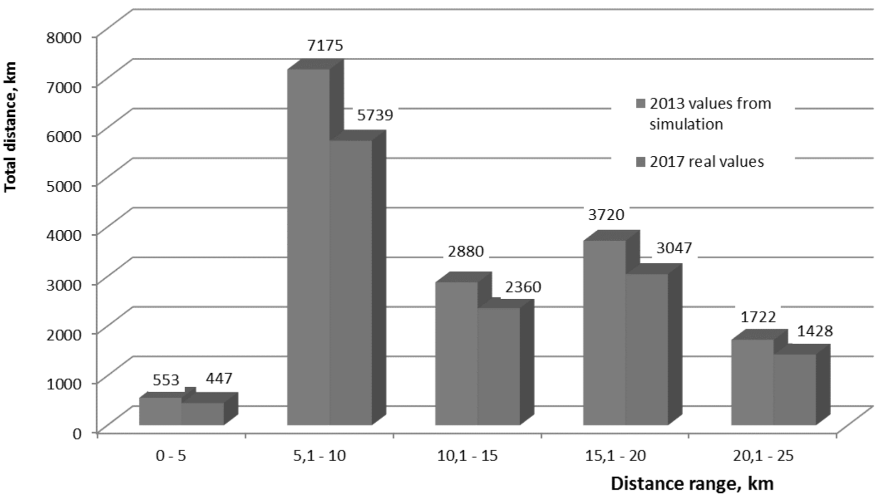

Fig. 3 Comparison of the number of distance

Figure 3 shows the reduction in the number of kilometers driven. In all compartments, the use of a larger transport unit has allowed to reduce the number of kilometers driven to around 80% of the value from 2013.

CONCLUSIONS

The use of waste from gelatin caused a change in the composition of the agricultural biogas plant substrate. In 2017, the amount of purchased biomass from maize was reduced from 25,000 tons to 12,000 tons. This situation has reduced the maximum transport distance to 25 km. A quick delivery model was also used, which involved using an external company to harvest and transport maize chaff. The company has the same, larger transport units. Their use results in a significant reduction in the number of transports and the distance traveled. Any changes introduced had a positive effect on the reduction of CO_2 emissions. However, the calculation of this reduction will constitute a separate scientific work.

REFERENCES

1. Borowski, S., Knopik, L., Markiewicz-Patalon, M., & Brzostek, A. (2016). Assessment of transport substrates for selected agricultural biogas plant. In *Proceedings of 6th international conference on trends in agricultural engineering* (pp. 76-80).
2. Divišová, M., Herák, D., Kabutey, A., Šleger, V., Sigalingging, R., & Svatoňová, T. (2014). Deformation curve characteristics of rapeseeds and sunflower seeds under compression loading. *Scientia agriculturae bohemica, 45*(3), 180-186.
3. Kaszkowiak, J., Borowski, S., Dorszewski, P., & Markiewicz-Patalon, M. (2017). Influence of composition of biogas on selected engine oil values. In *Proceedings of 58th international conference of machine design departments* (pp. 150-153).
4. Myczko A. (red.). (2011). *Budowa i eksploatacja biogazowni rolniczych*. Warszawa-Poznań: ITP.
5. Podkówka, W., Podkówka, Z., Kowalczyk-Juśko, A., & Pasyniuk P. (2012). Biogaz rolniczy – odnawialne źródło energii. Warszawa: PWRiL.
6. Szlachta, J., & Tupieka, M. (2013). Analysis of profitability of maize production designated for silage as a substrate for a biogas plant. *Agricultural Engineering, 3*(145), 375-386.
7. Zastempowski, M. & Bochat, A., (2016). Innovative constructions of cutting and grinding assemblies of agricultural machinery. In *Proceeding of 6th international conference on trends in agricultural engineering 2016* (pp. 726-735).
8. Zastempowski, M., Borowski, S., & Kaszkowiak, J. (2013). New solutions in harvesting plants for power purposes. In *Trends in agricultural engineering 2013* (pp. 673-676).

Corresponding author:
dr inż. Sylwester Borowski, UTP University of Science and Technology, Faculty of Mechanical Engineering, Al. prof. S. Kaliskiego 7, 85-796 Bydgoszcz, e-mail: sylwester.borowski@utp.edu.pl